Executive Summary

The Department of the Interior (Interior), acting through the Bureau of Reclamation (Reclamation), is proposing to develop and implement a protocol for high-flow experimental releases (HFEs) from Glen Canyon Dam to better determine whether and how sand conservation can be improved in the Colorado River corridor within Grand Canyon National Park.

This experimental protocol builds on, and was developed, following analysis of a series of high flow experimental releases, particularly those conducted in 1996, 2004, and 2008. This experimental protocol is the next logical scientific investigation as part of the Department's efforts to improve conservation of limited sediment resources in the Colorado River below Glen Canyon Dam. The information gained through this experimental protocol cannot be developed in any other manner, and is essential to informing future decisions in an adaptive management setting. In the past fifteen years of scientific research and monitoring, scientists have learned much regarding the use of high flow releases from Glen Canyon Dam. This proposed protocol is based on that science and targets future monitoring and research so as to refine our ability to predict the outcomes of future management actions intended to benefit the Colorado River ecosystem.

This protocol will evaluate short-duration, high-volume dam releases during sediment-enriched conditions for a 10-year period of experimentation, 2011–2020, to determine how multiple events can be used to better build sandbars and conserve sand over a long time period. Under the concept of HFEs, sand stored in the river channel is suspended by these dam releases and a portion of the sand is redeposited downstream as sandbars and beaches, while another portion is transported downstream by river flows. These sand features and associated backwater habitats can provide key wildlife habitat, potentially reduce erosion of archaeological sites, enhance riparian vegetation, maintain or increase camping opportunities, and improve the wilderness experience along the Colorado River in Grand Canyon National Park.

The purposes of this action are: (1) to develop and implement a protocol that determines when and under what conditions to conduct experimental high volume releases, and (2) to evaluate the parameters of high-flow releases in conserving sediment to benefit downstream resources in Glen, Marble, and Grand Canyons. This information will be used to inform high-flow experiments over the course of the protocol.

This action is needed to take advantage of future sediment-enriched conditions in the Colorado River with experimental high-flow tests. This action will improve the understanding of the relationships between high dam releases of up to 45,000 cfs and sediment conservation, and it is expected to have long-term benefits for these resources. The information developed through this action will assist Interior in making future decisions on when and how to conduct multi-year, multi-event, high-flow experimental releases and how to evaluate benefits to downstream resources. Reclamation will ensure that other resources would not be unduly or unacceptably impacted or that any such impacts could be sufficiently mitigated.

This protocol for high-flow experimental releases is part of the ongoing implementation of the Glen Canyon Dam Adaptive Management Program (GCDAMP), and is a component of Interior's compliance with the Grand Canyon Protection Act of 1992 (Public Law 102-575, GCPA). Annual release volumes (the volume of water released in a water year[1]) would follow the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead (2007 Colorado River Interim Guidelines; (Reclamation 2007a). In addition, releases will continue to follow the Modified Low Fluctuating Flow (MLFF) preferred alternative as adopted by the Secretary of the Interior and described in the 1996 Record of Decision for the Operation of Glen Canyon Dam (Interior 1996), with the added refinement of steady flows in 2012 as identified in Reclamation's 2008 decision on the operations of Glen Canyon Dam (2008-2012)(Reclamation 2008), and as addressed in relevant U.S. Fish and Wildlife Service biological opinions on the operation of Glen Canyon Dam [2008 Opinion and the 2009 supplemental biological opinion (2009 Supplement)]. The timing of high-flow releases would be March-April and October-November, the magnitude may range from 31,500 cfs to 45,000 cfs, and the duration may range from one hour to 96 hours.

The proposed HFE protocol is a decision-making process that consists of three components: (1) planning and budgeting, (2) modeling, and (3) decision and implementation. First, planning will occur such that an HFE can be conducted if conditions are appropriate. An important aspect of planning is the development and implementation of research and monitoring activities appropriate to monitor the effects of the HFEs as described in a HFE science plan. Second, a hydrology model and sand budget model will be used to evaluate the available volume of water for release from the dam and the sand availability, as delivered primarily by the Paria River, at the onset of each release window. Finally, the decision to conduct an HFE would be based on a determination by scientists and federal managers of the suitability of the hydrology, sediment, and other resource conditions, and a recommendation to Interior.

Impacts of the proposed action were identified and evaluated in comparison to an environmental baseline for four resource categories – physical, biological, cultural, and socio-economic. The impacts were assessed relative to the timing, magnitude, duration, and frequency of HFEs. The predicted impacts of the high-flow experimental release protocol on these resources are summarized as follows:

Water Resources.—The pattern of monthly releases from Glen Canyon Dam would differ slightly from no action, depending on the frequency of high-flow releases, but water year releases would comply with Glen Canyon Dam Operating Criteria (*Federal Register*, Volume 62, No. 41, March 3, 1997), the Record of Decision – Glen Canyon Dam Final Environmental Impact Statement (October 1996) and the Record of Decision – Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (December 2007). An HFE would only be conducted if it would not alter annual water

[1] A water year is the 12-month period from October 1 through September 30. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. For example, the year ending September 30, 2007 is called the "2007 water year."

deliveries or the operational tiers or elevations that would have otherwise been dictated by the 2007 Interim Guidelines in the absence of an HFE.

Water Quality.—HFEs are expected to have minor short-term impacts on water quality of Lake Powell and the Colorado River below Glen Canyon Dam. Dam releases will cause a slight reduction in downstream temperature and a slight increase in salinity, as well as a temporary turbidity increase from scouring. Because effects of an HFE on water quality are short-lived, impacts to water quality from two or more HFEs are not expected to be greater than single HFEs. The impact of HFEs on the water quality of Lake Powell will depend on reservoir elevation, but is not expected to affect the long-term water quality of the reservoir or the Colorado River downstream of Glen Canyon Dam.

Air Quality.—Energy generated from coal or gas-fired powerplants likely will need to make up the amount of hydropower lost from releasing water through the bypass tubes. The amount of CO_2 emissions from the proposed HFEs range from a high of 62,535 metric tons to 651 metric tons, which are estimated to be about 0.02 percent to less than 0.002 percent, respectively, of regional emissions. Two HFEs within the same year would result in an amount of CO_2 emissions from these alternative sources estimated to be about 0.05 percent of regional emissions. The long-term impact depends on the number of consecutive HFEs and the total number over the 10-year experimental period, it is not expected to be substantial because the effects to air quality would likely dissipate quickly between HFEs.

Sediment.—Single HFEs are expected to suspend and redeposit sediment on sandbars and beaches up to the magnitude of the HFE, but that material is expected to erode with ensuing flows. Two consecutive HFEs are expected to have a beneficial impact from the additional sediment stored in sandbars and beaches that may better balance the sediment budget. Effects of more than two consecutive HFEs are less certain, but they may have a long-term beneficial impact if there is additional sediment stored in sandbars, beaches, and eddies up to 45,000 cfs stage. More than two successive HFEs would have the potential for better balancing sediment delivery between upstream and downstream reaches and for long-term conservation of sediment to offset ongoing transport and erosion; however, successive HFEs or intervening periods of degradation without HFEs could offset this positive effect if they negatively impact the sand mass balance. Furthermore, this degradation, if extreme, could impact other resources and it is advisable to ensure that the net amount of sand in the river channel is not overly depleted so as to compromise other ecosystem components. Negative impacts of HFEs likely would be greater in Glen Canyon (above the Paria River) because there is no substantial input of sand and fine sediment to that reach.

Vegetation.—Some riparian vegetation would be lost through scouring or burial by sediment transported during a high-flow release. Both emergent marsh and woody vegetation would recover quickly in the months and years, respectively, following the release and return to no action conditions. If high-flow releases are held frequently, recovery of plants may be slower.

Terrestrial Invertebrates and Herpetofauna.—Some habitat and individual animals will likely be scoured and exported, but these are expected to recover quickly with no population level impacts. Frequent HFEs would likely cause animals to relocate further upslope.

Kanab Ambersnail.—The endangered Kanab ambersnail would likely sustain short-term population and habitat impacts at Vasey's Paradise, although the allowable incidental take would not be exceeded.

Aquatic Foodbase.—The proposed action would likely result in a temporary reduction in aquatic foodbase production following HFEs, particularly for the mudsnail *Potamopyrgus antipodarum* and the amphipod *Gammarus lacustris*, in the Glen Canyon reach, with increased drift (organic material suspended by river flows) downstream due to increased suspension from higher volume releases. Spring releases would likely stimulate aquatic foodbase production with full biomass recovery taking from less than 4 months to more than a year for some taxa based on 1996 and 2008 experiences, respectively. Fall releases would also scour the foodbase, but recovery could take longer because of the reduced photosynthesis that would occur in the reduced photoperiod and sun angle during the winter following the HFE. Research will need to be gathered on the impacts of seasonal short-term high flows on the aquatic foodbase. Multiple, consecutive HFEs could reduce forms susceptible to high flows and favor flood-resistant forms, possibly resulting in reduced species diversity.

Humpback Chub.—Adult humpback chub are not likely to be impacted by HFEs. Some young-of-year and juveniles could be displaced by experimental high flows from mainstem nursery habitats near the Little Colorado River into less desirable downstream habitat. These young fish may also experience higher rates of predation and competition from increased numbers of trout as an unintended consequence of the HFEs. These impacts are not expected to affect the overall population of humpback chub in Grand Canyon, although the uncertainty of effect increases with the frequency of HFEs. Periodic HFEs are likely to benefit the humpback chub by reshaping and maintaining habitats, stimulating foodbase production, and reducing numbers of flood-susceptible non-native fish. Effects of HFEs will be assessed through research and monitoring contained in the science plan accompanying this environmental assessment (as well as in the relevant non-native fish control actions and science plan described in the non-native fish control EA). Potential effects of trout predation on humpback chub are discussed separately.

Razorback Sucker.—Razorback suckers have been found spawning in the Colorado River inflow within 10 miles of Pearce Ferry, with a total of 40 larvae caught between Pearce Ferry and Iceberg Canyon in 2000, 2001, and 2010. HFEs could displace larvae in spring, but could also create new productive nursery habitats and delivery large amounts of food for all sizes of fish. The proposed action is not expected to have population-level impacts to the razorback sucker. The USFWS has determined that incidental take of razorback sucker is not reasonably certain to occur because razorback suckers are in very low numbers in the action area.

Non-native Fish.—Non-native fish life cycles would be temporarily disrupted. Backwaters would be reformed and subsequently available for use by native and non-native fish after the

high-flow. Research data would be obtained on the relationships between flow duration and magnitude and backwater formation.

Trout.—It is likely that some trout eggs, fry, and young would be destroyed or lost downstream during HFEs. There is also some short-term risk that the aquatic foodbase would be reduced, subsequently affecting adult trout for a period following a high-flow release. However, research shows that spring HFEs are followed by higher drift rates, increased production, and improvement in foodbase nutritional quality. The impact of a fall HFE on the trout population is less certain due to a lack of data on trout response to the one fall HFE conducted in November 2004. Based on information learned during prior high-flow releases, high-releases in spring (March to April) would likely increase survival and recruitment of rainbow trout in the Lees Ferry reach because of the cleansing effect on spawning/incubating gravels and stimulated production of higher quality food sources, such as midges (Chironomidae) and black flies (Simuliidae). Increased density of trout could result in dispersal of young trout to downstream areas where these fish could subsequently prey on and compete with the endangered humpback chub. A parallel environmental assessment, the non-native fish control environmental assessment, has been developed by Reclamation to identify actions proposed to mitigate or counteract the effects of increased numbers of trout dispersing from the Lees Ferry reach. Proposed actions to address potential impacts to endangered fish, particularly the humpback chub, are further detailed in the non-native fish control biological assessment, which is an appendix to the non-native fish control environmental assessment, and a supplement to both biological assessments, included as part of Appendix C to this document.

Birds.—The proposed action is not likely to adversely impact any bird species, including the endangered southwestern willow flycatcher and California condor.

Mammals.—Wildlife use riparian vegetation as habitat, and some habitat would be temporarily lost during a high-flow release. Patches of bare sand created by the release would add diversity to the new high water zone habitats. Habitat conditions would return to no action levels as riparian vegetation returns to no action conditions. Some loss of young beaver may occur due to flooding of dens during spring HFEs.

Cultural Resources.—Reclamation has determined that historic properties could be adversely affected per 36 CFR 800.6; consultation with SHPOs and THPOs is in progress. Access to sacred sites would be temporarily restricted during the specific period of release of high flows from Glen Canyon Dam, and this constitutes an adverse effect. A resolution of effect for the overall undertaking will be reached by all consulting parties.

Hydropower.—No change to operating criteria for Glen Canyon Dam or 2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead for reservoir operations would occur except during the high-flow release. Many of the HFEs require bypassing the power generating facilities at Glen Canyon with the volume of releases greater than can be passed through the powerplant to produce the high flows and replacement power for the bypassed water must be purchased as a result. Estimated differences

between no action and the proposed action in total cost, including energy cost and capacity cost, ranged from $8.1 to $122.1 million for 10-year periods based on modeling of nine different combinations of hydrology and sand input from the Paria River.

Recreation.—HFEs are expected to increase the area and volume of beaches and sand bars used by river runners for camping. All river-based recreation activities would be affected to some degree by the high-flow release, although little or no impact outside of the flow period is expected. There is some risk of longer-term adverse impacts on trout fishing if high-flow releases are conducted too frequently. A warning system would need to be developed to advise anglers, boaters, and rafters of a planned HFE, particularly if the HFE occurred during the time of a tributary flood as described in the rapid response approach. The Hualapai Tribe has informed Reclamation of potential adverse effects to its commercial operations on the Colorado River. Appropriate monitoring and mitigation measures will be determined as part of the ongoing tribal consultation process.