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Proposed Research of Responses of Resources in the Colorado River below Glen Canyon Dam to High Release Flow Fluctuations and Spike Releases Greater than 45 Kcfs

ABSTRACT

It is proposed that research be conducted to determine system responses in wet years to two release modes: (1) flow variations up to 8,000 cfs when releases are averaging 25,000 cfs or higher; and (2) spike releases in excess of 45,000 cfs.

The Glen Canyon Dam Environmental Impact Statement (GCDEIS) expected that Beach and Habitat Building Flows (BHBF) would occur with a some frequency. The Adaptive Management Work Group (AMWG) recently adopted a "hydrologic triggering" criteria. This criteria results in a greater frequency of BHBFs than was contemplated in the EIS. The greater frequency of these flows may serve to offset the impacts of daily fluctuations.

The reasons for the proposed research are three-fold: (1) the potential that periodic releases exceeding 45,000 cfs through Glen Canyon Dam may more effectively rejuvenate elements of the system by resuspending and redistributing sediments; reintroducing pre-dam flood dynamics to the system; (2) flow fluctuations may have limited impact to the riverine system, given the greater frequency of Beach and Habitat Building Flows (BHBF); and (3) fluctuations may offset the impacts to electrical power generation caused by the greater frequency and magnitude of BHBFs. Moreover, Some suspect that they may be an improvement over very high steady flows with respect to the erosion of sandbars.

This issue paper identifies (a) relevant broad issues that the proposed research would need to

address; (b) questions to be answered by the research; and © suggest or prompt for mitigative or other action to overcome obstacles related to the proposed research.

BACKGROUND

In September 1997, the Adaptive Management Work Group (AMWG) adopted a hydrologic triggering criteria for BHBF and tasked the Technical Work Group (TWG) with continuing to make preparations for a possible BHBF in 1998, and with defining a process and criteria for operations at Glen Canyon Dam (GCD) in response to high inflow forecasts.

The Glen Canyon Dam Environmental Impact Statement (GCDEIS) contemplated BHBFs with a frequency of 1 in 5 years (ROD, Oct. 1996). When the recently approved hydrologic triggering criteria was modeled by the USBR, it was found that BHBFs would be "triggered" in about 1 in 3 years (in which the reservoir was full on January 1).

During AMWG discussion of these topics, two other additional release issues were identified: (1) the impact of flows greater than 45,000 cfs during Beach Habitat Building Flows (BHBF) and (2) corresponding broader fluctuations within powerplant capacity. The latter was identified because higher discharge BHBFs could offset the sediment transport of fluctuating flows, the greater frequency of spills impacts power generation (through the bypass of water) and this may partially offset the impacts to power generation and the fluctuations may be less erosive, on a much coarsened riverbed than very high steady releases. Subsequently, the

AMWG further charged the TWG with beginning the design of a research plan to address these issues jointly.

Based on research and monitoring results of the 1996 experimental flow, it was suggested that future experimental flows be conducted at magnitudes greater than 45,000 cfs. Overall, the 1996 test BHBF had beneficial effects on the riverine system below GCD, and in many cases, resources that had initially been adversely impacted, rebounded to or surpassed pre-BHBF status. Although 45,000 cfs was sufficient to resuspend channel sediment and redeposit it on sandbars and beaches, it was not sufficient to scour the compacted silt floors of backwaters (Parnell, et al; 1997); reduce near shore vegetation (Kearsley, M., et al; 1997); or to achieve greater reworking of debris fans.

In the following pages, important issues and questions related to conducting research on higher BHBFs and load following fluctuations are identified and discussed. The specific focus of this paper is the treatment of issues related to a proposal for a BHBF in excess of 45,000 cfs (60,000 cfs ?) for 2 to 4 days in the late Spring of 1998, followed by a fluctuating flow regime in which fluctuations may go as high as the powerplant capacity but would otherwise be limited to the ROD constraints (e.g; 8,000 cfs maximum per day, 4,500 cfs/hr ramp up, 1,500 cfs/hr down ramp). Despite this focus, the treatment of issues in this paper is meant to be general in nature and should be considered for future years.

NEXT STEPS

The TWG will discuss and attempt to agree to a final proposal. A recommendation will be then forward by the TWG to the AMWG for review and approval. Upon concurrence of the AMWG, a recommendation will be given to Grand Canyon Monitoring and Research Center (GCMRC) to identify the necessary specific questions and objectives for research.

DISCUSSION OF PROPOSED RESEARCH TOPICS

A. Beach/Habitat Building Flow Greater than 45,000 cfs

The following are original parameters and purposes of the BHBF as presented in the Glen Canyon Dam Environmental Impact Statement (GCDEIS):

> *Beach/habitat-building flow would be scheduled high releases of short duration designed to rebuild high elevation sandbars, deposit nutrients, restore backwater channels, and provide some of the dynamics of a natural system.*

The process of planning and scheduling a BHBF was to begin with a recommendation of the AMP, and the BHBF would be scheduled as part of the Annual Operating Plan (developed in the summer for the following water year). BHBF would be recommended in years when sufficient sediment supplies were available, but not following a year in which a large population of young humpback was produced.

Since completion of the GCDEIS and ROD, the AMWG adopted hydrologic triggering criteria with forecast thresholds that would permit a BHBF in a very wet year. Modeling results

indicate that hydrologic thresholds for BHBF may be reached approximately 1 in every 3 wet years in which the reservoir is full (this anticipated frequency is considerably higher than the frequency anticipated by the GCDEIS). Also since the ROD, additional information has been gained in regard to the form and function of BHBFs. Results of the 1996 experimental flow and subsequent analysis generated new ideas about the size, shape, timing, and frequency of spike releases; and some of the original objectives are being re-evaluated.

Hydropower flow fluctuations have impacts on the riverine system below GCD, but have not been assessed to determine specific cause-and-effect relationships. Investigations into the relationships between system resources, particularly the identified issues of concern, and flow variations, would compliment current research. For example, research results may provide insight into the level of system dynamics required to maintain its strength and diversity; and characteristics of suitable flow regimes for life stages of both native endangered fish and non-natives. Moreover, since the BHBF trigger criteria are for wet years, there is a high probability that elevated releases within powerplant capacity would follow a BHBF, similar to post-BHBF operations in 1996. Research and monitoring may be designed to compare sediment transport rates and other resource responses to high steady versus fluctuating releases following a BHBF.

ISSUES AND QUESTIONS

National Environmental Policy (NEPA)

A. <u>BHBF of Magnitudes Greater than 45,000 cfs</u>

Currently, a Biological Assessment (BA) for the Kanab Amber Snail (KAS) is in draft for a spike release less than or equal to 45,000 cfs, for 2-4 days, to occur sometime between May and July of 1998. Economic and hydropower impacts are being assessed, and GCMRC is generating a resource matrix that may be used to narrow the identification of impacts. The BA is behind schedule by about one week, and it is estimated that amending the BA to address a flow greater than 45,000 cfs, for a different duration and time of occurrence, would delay the BA by about one month.

If the resource matrix is presently not available for use, USBR will not be able to complete an evaluation of impacts for NEPA compliance. It is the contention of the Interior Solicitor that the Secretary of the Interior is free to instruct research to be conducted at any DOI dam, and given that, the Secretary of Interior may be petitioned to allow a one-time-only test flow at GCD without NEPA compliance (Morton, A.; personal communications).

B. Fluctuations Above 25,000 cfs

Modification of the NEPA document currently under development would probably be required to address the proposed fluctuations, unless, as stated above, it is part of a "test" which does not legal require that a NEPA document be prepared.

2. **Endangered Species Act (ESA)**

Four of the T&E species in Grand Canyon, Southwestern Willow Flycatcher, Kanab Amber Snail, Humpback Chub, and Razorback Sucker, may potentially be impacted by either a BHBF

greater than 45,000 cfs or fluctuating flows (Stevens, L.; personal communications). Second populations of the KAS and Humpback chub have been recommended, and progress is continuing on introducing a second population of KAS, A second spawning population of Humpback chub has not yet been established.

The hydrologic trigger sets the stage for BHBFs to occur in wet years (and full reservoir conditions) when there is likely to be sufficient, readily available water supply, however, spills are also more likely to occur in wet years. As a result, years with very wet hydrologic conditions and full reservoir conditions, present three possible release scenarios: (1) a scheduled BHBF; (2) a spill from GCD; or (3) a combination of the two.

(1) **Kanab Amber Snail** (Morton, A., and D. Bills; personal communications)

A. BHBF of Magnitudes Greater than 45,000 cfs

Currently, a Biological Assessment (BA) for the KAS is in draft for a spike release less than or equal to 45,000, for 2-4 days, to occur sometime between May and July of 1998. Economic and hydropower impacts are being assessed, and GCMRC is generating a resource matrix that may be used to narrow identification of impacts. The BA is behind schedule by about one week, and it is estimated that amending the BA to address a flow greater than 45,000 cfs, for a different duration and time of occurrence, would delay the BA by about one month.

Establishment of a second population of KAS is an issue. Suitable sites have been selected for

reintroduction of KAS in Grand Canyon, and the reintroduction will require NEPA documentation, which is the responsibility of the National Park Service (NPS). NPS will be conducting an Environmental Assessment (EA) and is anticipated to begin work on the EA in approximately 2-3 months. Experience has shown that on the average, 2-3 reintroduction attempts are made before a population begins to become sustainable.

Separate Section 7 consultation would be required for a proposed BHBF in excess of 45,000 cfs, if it could not be incorporated into the BA currently being prepared.

B. Fluctuations Above 25,000 cfs

Concerns:
Specific potential impacts to the KAS are largely unknown, but there may be questions related to effects to the plants on which the KAS resides, watercress and cardinal monkey flower (GCDEIS, 1995), as a result of cyclic wetting and drying of soils surrounding the plant roots.

Questions:

- What impacts would the proposed research on flow fluctuations have on KAS habitat?
- How may obstacles to conducting research flow fluctuations be overcome?

(2) **Humpback Chub and Razorback Suckers** (Valdez, R.A, and T. Hoffnagle; personal communications, 1997 & 1998)

A. BHBF of Magnitudes Greater than 45,000 cfs

Concerns:

In about March-April, adult humpback chub have migrated up the Little Colorado River (LCR) to spawn. Descent of young humpback chub from the LCR may begin within a relatively short period of time after hatching, such as April or May, but the timing of descent is largely a function of LCR hydrology and density of fish in the LCR. Snowmelt runoff in the spring and monsoon rains increase flows on the LCR and carry young fish downstream to the mainstem. The timing of high LCR flows is a major determinant on when young endangered fish descend to the mainstem, and therefore is a factor in predicting potential impacts to young endangered fish during a BHBF. Several scientists assert that, the later the BHBF occurs in the Spring, the greater the impacts to young humpback chub.

Questions:

- Prior to the construction of Glen Canyon Dam, spike flows usually occurred in the early to mid summer period. How did young humpback chub survive these flows and what implications would this knowledge have regarding the operation of the dam?
- Can a method be developed to estimate the density of endangered fish in spawning tributaries, and to forecast LCR inflows?
- What is the relative importance of backwaters as habitat for young Humpback chub, and does it vary with distance in Grand Canyon and relative quality of the backwaters?
- What role does ponding at tributary mouths due to high mainstem flows play in providing refuge habitat for humpback chub and other T&E fish species (specifically at the LCR)?
- What is the relative importance of near shore habitat types, like talus slopes, to young endangered fish species during BHBFs?
- How do combined effects of water temperature and other parameters, such as discharge magnitude, affect habitat preference, usage, and survival of endangered fish species?

- What actions may be taken to overcome obstacles related to humpback chub and razorback suckers due to BHBFs in excess of 45,000 cfs? (a) Are there ways to forecast descent of young from tributaries? (b) Would creation of temporary low-velocity, low visibility habitat, perhaps at or in the vicinity of tributary mouths promote survival of young endangered fish during a BHBF? © What actions may be taken to relieve pressure from other variables, such as non-native fish, and promote survival of young endangered fish?

- What effects do changes in water quality of releases from Lake Powell during BHBFs that employ use of the spillways have on native endangered fish ?

B. Fluctuations Above 25,000 cfs

Concerns:

Environmental conditions, including high flows, cold water temperatures, predatory fish, and fluctuating flows, have been implicated as factors contributing to the limited survival rate of endangered fish. Occurring separately, a limiting factor stresses young endangered fish, affecting the probability of their survival, but when limiting factors occur in combination, the impacts to survival are compounded. Neither the impacts of individual limiting factors, nor the synergistic or compounding effects of limiting factors in combination with one another have neither been entirely defined nor understood. Knowledge and understanding of the impacts and interactions of limiting factors on endangered fish may be applied in relieving or eliminating stress on endangered fish through remedial or mitigative measures, or operations.

Questions:

- What are the synergistic and compounding effects of limiting factors in combination with one another?

- How may the obstacles to fluctuating flows be overcome?

(3) **Southwestern Willow Flycatcher** (Bills, D., and L. Stevens; personal communications):

A. BHBF of Magnitudes Greater than 45,000 cfs

Concerns:

During the time period January-April, the Southwestern Willow Flycatcher (SWF) is typically absent from Grand Canyon, but return to nest during the period of May-June.

Questions:

- Between the months of about May to July, what actions may be taken to reduce the risk of impact to the Southwestern Willow Flycatcher or are actions necessary, since spike flows occurred naturally with some regularity?
- Are there other actions that may be taken to overcome obstacles related to the southwestern willow flycatcher due to BHBFs in excess of 45,000 cfs?

B. Fluctuations Above 25,000 cfs

Concerns:

The Southwestern Willow Flycatcher may be sensitive to the distance that its nest is from the water, and it has been proposed that there is a minimum distance that the SWF has to maintain, or it will abandon its nest, or not build in nest in the location (Burton, G., personal communications).

Questions:

- How do stage changes due to fluctuations at the tailrace of Glen Canyon Dam translate to stage changes at critical habitat for Southwestern Willow Flycatcher.
- Are impacts to Southwestern Willow Flycatcher habitat due to fluctuations above 25,000 cfs any different than the impacts of fluctuations below 25,000 cfs?
- What is the minimum distance that the SWF needs to maintain between the water surface and its nest?
- Would the proposed research on flow fluctuations encroach on the minimum distance ?

3. **Law of the River** (Jencsok,G.; personal communications)

Concerns:
Issues of legality of BHBF of magnitudes greater than 45,000 cfs have been considered. Under the hydrologic triggering criteria adopted by the AMWG, the water which bypasses the powerplant during a "spike" flow would have likely been bypassed anyway, spike flow are considered legal.

4. **Sediment**

Concerns:
Some sedimentologists worry that insufficient sediment supply during BHBFs may result in excessive scouring, depletion of sediments, and erosion. (GCDEIS, 1995; Randle, T., personal communications, 1997; Rubin, et al, 1997; Parnell, R. et al, 1997;). In addition, the quality of sediment is also a consideration, since the extent of the benefits to riparian and recreational resources is in part a function of redeposition of the finer sediments and sand, respectively (Melis, Ted, personal communications; 1997).

Questions:

- To what degree is the sediment budget in the channel a factor when designing a BHBF?
- Are sediment characteristics (e.g., grain size) factors in designing a BHBF?
- What may be done in order to overcome obstacles related to sediment resources ?

B. <u>Fluctuations Above 25,000 cfs</u>
Concerns:
The high steady releases that followed the 1996 BHBF, although lower in magnitude that the

BHBF, transported more sediment than the BHBF, and in doing so, reduced or eliminated much of sediment redistribution of the BHBF (Shannon, J.P., 1997; Kearsley, L, 1997). Since particular characteristics of fluctuations, such as rapid down ramping, promote beach erosion and transport of sediment, some of the alternatives of the GCDEIS included modified down ramp rates (GCDEIS, 1995).

Questions:

- What is the sediment transport response to the combination of within-powerplant releases and fluctuations?
- How may fluctuations be designed to minimize sediment transport and erosion ?
- Which operation transports more sediment: (1) steady flows between 25,000-33,000 cfs, or (2) high releases with fluctuations above the average release that are within powerplant capacity? For example, average releases of 25,000 cfs and fluctuations of 8,000 cfs.
- Are there options available that will overcome obstacles to the proposed fluctuations, such as sediment augmentation, or temporary protective measures?

5. **Hydro graph Design**

Endangered fish species, the KAS, and sediment resources are among resources that are particularly sensitive to characteristics of a BHBF Hydro graph. As flow magnitudes increase for BHBFs, sediment transport capacity increases, as does capacity for erosion, particularly if there is insufficient sediment in storage in the channel. Depending on the timing of a BHBF, young endangered fish entering the mainstem from tributaries are also susceptible to transport by high flows, unless they can find low-velocity habitat for refuge. A flow magnitude of

about 60,000 cfs approaches a threshold for concern for cultural resources, beyond which addition consultation and mitigative or other actions increase. BHBF Hydro graph design considerations may include in addition to inflow to and storage in Lake Powell, sediment characteristics and budget (GCDEIS, 1995; Melis, T., personal communications); tributary input (Jackson, W.); endangered species (e.g., humpback chub, southwestern willow flycatcher), non-native fish.

6. **Non-Native Fishery** (Cohen, D., and W. Persons; personal communications)

A. <u>BHBF of Magnitudes Greater than 45,000 cfs</u>
Concerns:
The 45,000 cfs BHBF of 1996 did not have extensive or lasting impacts to the trout population, in fact 1996 resulted in a strong year class of trout. Although significant direct impacts to trout are not anticipated as a result of a BHBF of greater than 45,000 cfs, there may be some concerns related to the food base. It is also important that both research items are not combined, otherwise specific cause-and-effect relationships cannot be distinguished from one another. Since both the native endangered and non-native fish populations need to be managed in concert, the life history needs of non-native fish may need to be defined so that adverse interactions between the two can be minimized. The information will improve identification of and better predict responses of the individual species and their interactions as a result of management actions.

Questions:

- What are the life history needs of non-native fish in the Colorado River below GCD?
- What are the effects (direct and indirect, such as food source) of changes in water quality of releases from Lake Powell during BHBFs that are large enough to warrant using the spillways, on non-native fish ?
- What are the effects of release water quality changes during BHBFs that use GCD spillways on downstream productivity ?
- How does using the spillways during BHBF affect water quality (e.g., temperature) in Lake Powell ?

7. **Recreation**

A. BHBF of Magnitudes Greater than 45,000 cfs
Concerns:
(a) Campsites
The BHBF of 1996 (45,000 cfs) resulted in significant increases in the number, size, and consequently, the capacity of campsites in Grand Canyon. Based on sediment transport predictions, a BHBF at a magnitude greater than 45,000 cfs would be expected produce similar kinds of results, only increased. Therefore, benefits are expected for beach-dependent recreation.

(b) Fishing:
Short-term impacts on the sport of fishing would involve a reduction in fishing activity during the high flows, however, although the 45,000 cfs BHBF had longer-term positive impacts to the trout population (Persons, W.; personal communications), impacts of a BHBF greater than 45,000 cfs cannot be predicted absolutely.

© White water rafting:
Results of NPS studies indicated that was no relationship between the magnitude of flow and boating accidents. However, the NPS is interested in reviewing management options so that it

is prepared when hydrological forecasts indicated that a spike flow may be triggered (Jalbert, L; 1997)

8. **Cultural Resources** (Yeatts, M.; personal communications)

A. BHBF of Magnitudes Greater than 45,000 cfs
Concerns:
In general, the potential for impact to archaeological sites and traditional cultural properties (TCP) increases as BHBF discharges increase above 60,000 cfs. Typically there are no compliance issues related to traditional resources unless the traditional resource is a TCP, which would be protected by law. Specific archaeological sites that may be impacted are generally known, however potential impacts to TCP during flows of 60,000 cfs or more are largely unknown, and as a result, more consultation with the Tribes may be expected as the BHBF increases above 60,000 cfs.

Questions:

- What are the potential impacts to TCPs as BHBFs increase above 60,000 cfs?
- What is the estimated lead time required to implement protective measures at archaeological sites?
- How much time would be needed to consult with the tribes on their concerns related to BHBF greater than 45,000 cfs? 60,000 cfs? Greater than 60,000 cfs?

B. Fluctuations Above 25,000 cfs
Concerns:
In general, neither steady nor fluctuating flows up to about 30,000 cfs are not anticipated to impact most sites due to head cutting in the arroyos. However, there may be interest in the effect of the alternating wetting and drying of soils that would follow fluctuations in river

flows.

9. **Lake Powell and the Downstream Colorado River** (Hueftle, S.; personal communications)

A. BHBF of Magnitudes Greater than 45,000 cfs
Concern:
Specific details of effects of a BHBF at a magnitude greater than 45,000 cfs on water quality in Lake Powell largely depend on antecedent conditions reservoir and the current hydrology (i.e., inflows). Changes in release water quality were documented (Marzolf, G.R., et al, 1997; Bowser, D.J., et al 1997) during the 1996 45,000 cfs BHBF, and some impacts on productivity were observed, and others suspected in retrospect (Shannon, J.P., et al, 1997). Changes in productivity, or available food sources, may affect native endangered and non-native fish by impacting their sources of food.

Questions:

- How does using the spillways during BHBF affect water quality in Lake Powell ? Is there any difference, regarding water quality, between a controlled BHBF and an uncontrolled spill?

B. Fluctuations Above 25,000 cfs (Hueftle, S., personal communications)
No additional concerns were identified related to fluctuating flows above average releases of 25,000 cfs except those related to direct connections to downstream productivity, and indirect links to fish populations, both native endangered and non-native fishes.

10. **Aquatic Productivity**

A. BHBF of Magnitudes Greater than 45,000 cfs
Concerns:

Overall, the 45,000 cfs BHBF did not have long-term adverse impacts to aquatic productivity (Shannon, et al, 1997). Since a BHBF greater than 45,000 cfs would require the use of the spillways, release water quality would change and may have an impact on downstream productivity.

Questions:

- How do changes in water quality of releases from Lake Powell during BHBF greater than 45,000 cfs (i.e., use of the spillways) affect downstream productivity?

B. Fluctuations Above 25,000 cfs

Concerns:

Cyclic inundation and exposure, or wetting and drying, of aquatic plants may affect aquatic productivity, particularly if organisms suffer from desiccation, or are sensitive to alternating conditions. As with high flows, impacts to productivity are translated to other aquatic and terrestrial organisms, such as humpback chub, trout, and bald eagles.

Questions:

- How would impacts of flow fluctuations of 8,000 cfs during GCD releases averaging 25,000 cfs affect productivity?
- What steps may be taken to address obstacles to flow fluctuations?

11 **Risk of Spills** (Peterson, R.; personal communications; GCDEIS, 1995)

A. BHBF of Magnitudes Greater than 45,000 cfs

Concerns:

It was recommended in the GCDEIS that scheduling a BHBF during high reservoir conditions be avoided because of increased risk of unscheduled flow greater than powerplant capacity

(GCDEIS, 1995). Since the GCDEIS and ROD, the adopted hydrologic trigger trips when forecasted hydrologic conditions are for very wet conditions in which the reservoir is "full". This eliminates the need for intentional efforts to store water for making special releases; so when the trigger is tripped, the BHBF may be conducted.

While it has been recognized that BHBFs of 45,000 cfs for short durations (2 to 4 days) doesn't pass enough water volume to significantly reduce the risk of a subsequent uncontrolled spill, the volume of water released for a BHBF of a larger magnitude might. This could mean that a BHBF of greater than 45,000 cfs may have the beneficial result of reducing the risk of a subsequent uncontrolled spill.

B. Fluctuations Above 25,000 cfs

Concerns:

Flow fluctuations are not anticipated to affect spillway operations.

12. Electrical Power Generation

A. BHBF of Magnitudes Greater than 45,000 cfs

Concerns:

Water which bypasses the powerplant at Glen Canyon Dam, does not produce electricity. Therefore, a BHBF has an impact. However, the hydrological criteria is triggered in wet years, with a full reservoir, when the risk of spill is very high. If water bypasses the

powerplant in a controlled spill which would have bypassed the powerplant in an uncontrolled spill, there is no impact. However, the hydrologic triggering criteria results in spike flows more often than would be the case without the criteria. This means that a loss in electrical power generation occurs, over the long run, as a result of the adoption of the hydrologic trigger.

B. Fluctuations Above 25,000 cfs

Concerns:

Fluctuations for load following purposes is a benefit to electrical generation. Currently, fluctuations are allowed to up to 25,000 cfs. Higher than this, water released out of Glen Canyon Dam is released in a steady pattern. This steady release patterned occurred following the spike flow of March, 1996 and at the beginning of the year 1997.

The benefits of fluctuations for load following purposes compensate in part for the greater frequency of spike flows as a result of the AMWG adoption of the hydrological triggering criteria.

13. **Monitoring/Research/Funding**

A. BHBF of Magnitudes Greater than 45,000 cfs

Questions: