ATTACHMENT 8

AMWG 1/12-13/99

Resource Analysis

- **Analysis Based on Scenario 2 Flow for Water Year 1999.**

- **Effects become greater for most resources with time.**
  - **April/May is a critical time period in which more resources become negatively effected as time goes by.**

- **Resources negatively affected by BHBF by month (-1 or greater):**
  - **January** – aquatic habitat, trout spawning, larvae, waterbirds (-2), overwintering birds, KAS (-2), Bald eagles foraging, fishing.
  - **February** - aquatic habitat, trout spawning, larvae, waterbirds (-2), overwintering birds, KAS (-2), Bald eagles foraging, fishing.
  - **March** - aquatic habitat, marsh plants, trout spawning, larvae, juveniles, waterbirds, overwintering birds (-2), KAS (-2), Bald eagles foraging, fishing (-2).
  - **April** - aquatic habitat, riparian habitat, larval HBC & FMS, trout larvae & juveniles, waterbirds, overwintering birds, KAS (-2), fishing.
  - **May** - aquatic habitat, marsh plants, riparian habitat (-2), germination of tamarisk, larval HBC (-2) & FMS, trout larvae & juveniles, waterbirds, overwintering birds, breeding birds, KAS (-2), fishing, white water rafting (safety).
  - **June** - aquatic habitat, marsh plants, riparian habitat (-2), germination of tamarisk, larval HBC (-2) & FMS, trout larvae & juveniles, waterbirds, breeding birds, KAS (-2), fishing, white water rafting (safety).
  - **July** - aquatic habitat, marsh plants, riparian habitat (-2), germination of tamarisk, larval HBC (-2) & FMS, trout larvae & juveniles, waterbirds, overwintering birds, breeding birds, KAS (-2), fishing, day rafting, white water rafting (safety).

- Large sediment inputs from the Paria and LCR and ungaged tributaries this summer have increase sediment stored in the channel. A BHBF would have the effect of conserving sediment on Channel margin.

- A BHBF of no greater that 44,000 cfs is recommended based on current knowledge of the system and on current Biological Opinion statement for KAS.

- The BHBF, if it takes place would have less negative effects prior to April due to increasing negative effects on aquatic food base, aquatic and terrestrial habitat, and avifauna.

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RESOURCE CRITERIA DIAGRAM FOR BHBF

1. Annual Resource Monitoring Reports - (September Status Report to GCMRC)

2. Determine if (reach/habitat) will benefit from flooding (bank/bar storage capacity) GCMRC evaluation.

NO → NO BHBF EVENT

YES ↓

3. Purpose and Kind of Flood Flow (e.g., BHBF, habitat maintenance, sediment conservation)

4. Conduct Resource Analysis for all probable months (with feedback to ecologic flow as needed) in accordance with management objectives

5. Resources, Mgmt Objectives and Resource Indicators (see accompanying Mgmt objectives, resource indicators)

Sediment Resources (is there enough sand in the system?)
Sandbars, beaches and backwaters
Terrestrial and Riparian Resources
Kanab ambersnail, Southwestern willow flycatcher
Aquatic Resources:
Aquatic Foodbase, humpback chub, razorback sucker
flannelmouth sucker & other native fish, rainbow trout
Cultural Resources
Archaeological sites, Traditional cultural properties

6. Present Resource Analysis and BHBF recommendation to TWG (December)

NO

YES ↓

7. Hydrologic Trigger Met (Every month Jan-July)?

NO → NO BHBF EVENT

YES ↓

Compliance Issues Met[1]?
(prelim?) BOR

IF ALL YES ↓

8. Make BHBF YES/NO
Go ahead to Secretary of Interior

9. Secretary's Decision to BOR
GO/NO-GO

[1] In the event of a high inflow year when a hydrologic trigger is met, but compliance is not met, then mitigation efforts for sediment (BHBF scenario) will be unlikely to occur and will result in sediment loss downstream of Glen Canyon Dam.

Table 1. Summary of comparison of No Action and BHBF Action for a "January-June Analysis" for Water Year 1999 Flow Scenario 2.

Objectives (based on management objectives)	Resource	No Action	Proposed Action (Scenario 2 for Water Year 1999)
	Hydrologic Scenario	Steady releases of at least 25K to 31K cfs for one month (Jan/June) followed by daily averaged fluctuating releases of 20-25K cfs through July.	Same as no action but with BHBF for 2-4 days at 45K cfs release followed by daily average fluctuating releases of 20-25K.
Increase height and area of existing sandbars	**Sediment**	Continued erosion of sandbars with some accumulation of sand in river channel and eddies. High steady flows increase erosion rates.	Conservation of sediment through sand deposition, especially if eddies storage capacity is full. Sand deposition on sandbars/beaches (3 feet or more), followed by erosion overtime. High steady flows increase erosion rates.
Reform/rework backwaters for native fishes **Displace non-native fish**	**Aquatic resources**	Aquatic food base continues development. Drift loads downstream remain within observed patterns for flow following ROD. Backwater habitats fluctuate in temperature and are likely unavailable due to inundation. Spawning patterns of trout undisturbed. Native -Non Native interactions continue. Stabilized return channels not inundated may favor non-natives.	Potential reduction in food base with increased drift downstream. Recovery of food base becomes delayed **after May** and consequently impact to fish is greater Some disruption of trout fry through displacement **(Mar-May)**. Some backwaters temporarily reformed, or filled-in due to discharge/force dynamics. Potential downstream drift of juvenile or larval native fish, or increased habitat via pooling of tributary mouths **(May-July)**—Needs to be monitored. Native-Non-native interactions temporarily interrupted, but rapidly return to no action conditions.

Table 1 Cont.

Provide water to Old-High Water Zone Vegetation. **Maintain open sandbars for camping**	**Vegetation and Habitat**	Continued woody vegetation development to the 25K cfs shoreline. Marsh areas inundated and some development of emergent marsh vegetation. Replacement of marsh vegetation with transitional riparian plants (e.g., cattails, willows), gradual loss of marsh habitat. Vegetation utilized by riparian bird community. SWWF nesting areas unaffected. Potential transport and establishment of Tamarisk seedlings. KAS habitat inundated to 25K stage possibly to 31K with associated incidental take of snails	Some emergent marsh and woody riparian vegetation lost due to burial. Recovery to no action levels within six months (**Jan-April**) or 1 year (**April-July**). Some wildlife habitat lost with 6 month recovery time. Ground nesting sites may be inundated (April-July). Recruitment of some riparian song birds may be affected, but the extent and species are not known (**April-June**). Nesting sites of SWWF unaffected. Potential transport and establishment of Tamarisk seedlings (**May-July**) .
Not cause significant adverse effects on aquatic food base, trout fishery, endangered species, economics, cultural resources	**Endangered Species and Other Special Status Species**	Endangered species not significantly affected at flows to 25 K cfs. Habitat for native fish remains unchanged. Non-native/native fish interactions remain at current levels given current state of knowledge. Raptors food base not significantly affected. KAS habitat inundated to 25K stage possibly to 31K with associated incidental take of snails.	Possible habitat improvement for native fish or non-native fish (unstable backwater habitats). KAS habitat scoured to 45K cfs stage with incidental take of $\leq$10% of population. Recovery of KAS habitat 1-2 years to 24K cfs stage based on 1996 results. Raptors food base not significantly affected. Potential downstream drift of juvenile or larval native fish (**May-July**) or increased habitat via pooling of tributary mouths--Needs to be monitored.
Protect cultural resources from erosion	**Cultural Resources**	Continued erosion of high terraces containing archeological sites by wind, rain and backward erosion from river channel.	Deposition of sand temporarily reduces erosion rates. Restoration of natural processes generally beneficial.
Preserve and restore camping beaches	**Recreation**	Anglers, day rafters and white-water rafters experience high fluctuating daily flows. Continued reduction of camping beaches. Beach numbers and sizes are still greater than pre-1996 flood event	Recreation activities disrupted for 2-4 days. Downstream safety and available camping areas reduced during BHBF, Safety a greater concern **April- July**. Number and size of beached increased subsequently.
	Hydropower	Operations constrained to high steady flows and moderate fluctuating flow that average 20-25K cfs daily.	More energy is generated during the BHBF, when generating a full capacity, but overall less energy is generated due to the water by-passing the turbines.

Draft Report

Beach Habitat Building Flow Resource Criteria: A Process Document

Developed by:

Barbara Ralston	General Biologist, Grand Canyon Monitoring and Research Center
Robert Winfree	Senior Scientist, Grand Canyon National Park
Barry Gold	Biological Program Manager, Grand Canyon Monitoring and Research Center

Submitted to:
Technical Work Group
December 7, 1998

Resource Criteria and Decision Making Process for Beach Habitat Building Flows for the Months of January to July

Introduction

A hydrologic triggering criteria that would assist in determining when a Beach Habitat Building Flow (BHBF) was possible for the months of January to July was developed by the Technical Work Group and forwarded for approval by the AMWG in July 1998. The criteria are based on the Annual Operating Plan, and Lake Powell inflow forecasts. The hydrologic criteria would provide a method to determine when a BHBF might be possible for a given year, but additional criteria are needed to evaluate the effects of a BHBF on downstream resources. The Adaptive Management Workgroup charged the Technical Work Group to work with scientific and resource managers to develop and put into operation, resource-based criteria for Beach Habitat Building Flows. The implementation and recommendation process for a BHBF is a two-step process that involves meeting the hydrologic triggering criteria, and evaluating impacts to downstream resources. The evaluation of the resources would be done on a yearly basis between the months of October through January for the following year based on the preceding year's monitoring information. The following is a description of the methods and materials available to evaluate the impacts to downstream resources by a BHBF.

Downstream resources are categorized into the following elements: Biological, Cultural, Physical, and Socio-economic. Managers and stakeholders have identified 43 resources within these categories that should be considered when making recommendations concerning operations associated with Glen Canyon Dam. These resources are listed in the resource matrix. Moreover, several of these 43 individual resources were considered "significant" or merited greater weight in the decision making

process regarding BHBF events because the resources are endangered species (e.g., humpback chub, Kanab ambersnail), are valued recreational areas (e.g., Lees Ferry trout fishery), or are an integral part of the downstream resources (e.g., sediment supply). The list of these resources occurs in the management objectives developed by the technical work group and appear on Table 1 (Step 5).

The process of resource evaluation and deciding whether to recommend proceeding with a BHBF is dependent upon 1.) the state of resources, particularly the "significant" resources, 2.) the management objectives for the resources and 3.) the effect of timing, magnitude and duration of the BHBF on resources. Evaluating these elements and coming to a decision is based on a set of supporting documents that point out critical time of year for resources, critical life stages for a resource, or describe stage/discharge relationships associated with physical habitats, structures, or properties with specific geographic locations. The accompanying documents are:

1. The Resource Criteria Diagram (This document. A decision tree and descriptive document detailing the process for recommendations).
2. The Resource Matrix (a table that estimates positive and negative effects on resources for months January to July, based on previous research, e.g., BHBF data or general knowledge associated with a resource). Available for downloading via the internet.
3. The Resource Narrative (a narrative for biological resources that details life history traits on a monthly basis). Available for downloading via the internet.
4. The State of the Resource Report (SCORE Reports) (a yearly report that describes the condition of downstream resources).

5. Resource Analysis Report (A summary and table that provides a comparison of the effects of a BHBF versus no-action on resources).

As stated above, the following provides a description of the process a manager would use to understand the effects of a BHBF.

Resource Criteria and Resource Effects Matrix Interactions

The decision tree (Fig. 1) that accompanies this document represents an overview of the processes, information needs and effects that need to be understood when a BHBF is being considered. The intent is to provide an initial framework by which criteria for each resource can be developed, and subsequent recommendations and decisions made. The criteria that form the basis of decisions are extracted from the Management Objectives, developed and agreed to by stakeholders. The specific criteria require development of values of acceptable loss or gain of resources associated with a BHBF, in accordance with management objectives. For example: management objectives for trout include "producing a self-sustaining population of a least 100,000 Age II+ that achieve 18" in length by Age III ...". Criteria in this case would include, aquatic foodbase, growth rate and population estimates to evaluate of how a BHBF in a particular month might impact management objectives for trout. The following then, is a description of how the process might proceed and the information needed in order to determine the feasibility and effect of a BHBF for the months of January to July. As stated above additional documents that go into the recommendation Process include the Resource Matrix, the Resource Narrative, the State of the Resource Report, and the Hydrologic Triggering Document and the Resource Analysis. These documents are available on the TWG website.

Decision-making Process

1. Annual Resource Monitoring Reports and SCORE Report

The decision-making process utilizes information described and summarized annually from monitoring programs. A summary document, the SCORE Report, provides a synopsis of the status of the resources of concern, including native fish, estimated

available shelf storage for sediment, trout, endangered species, and cultural resources to name a few.

2. The Benefits to Beach Habitat and Sediment Storage from a High Flow.

In addition to the SCORE Report would be an analysis of the current conditions of the bank/bar storage capacity. The analysis would provide an evaluation of the amount of available storage capacity on the channel margin above 20,000 cfs. Variables associated with this evaluation would be time since previous channel margin deposition events (previous BHBF, or Maintenance Flows), sediment input from tributaries, condition of camping beaches, sediment storage in eddys and mainchannel. The evaluation would also consider the effects of no-action within a hydrologic triggering scenario being met.

3. Deciding on the magnitude and duration of a BHBF.

Currently, the GCD-EIS and ROD calls for BHBFs with the intent to manage beaches, sediment, some native fish habitat and vegetation, and not to impact other resources such as cultural properties, endangered species, and economic/recreation aspects. This is one stated set of purposes of high flow and the magnitude of this type of flow was presented as 45,000 cfs for a week in the EIS, and possibly occurring in late March. As knowledge regarding the affects of short duration high flows increases, flows of different duration and magnitude may be proposed with the intent of those flows to be different from that described in the EIS. The critical decision in this step is the timing (January - July), magnitude (32,000 - 45,000 cfs or greater), duration and hypothesized results of a flow above power plant capacity. Subsequent resource assessment is dependent on this determination. In the event that the triggering criteria are met, then the next decision to make is to determine the hydrograph for the flow (i.e., magnitude and duration) and the purpose of the flow[1].

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[1] While the immedieate purpose for flows currently described are to mitigate sediment transport rates during periods of high power plant releases in high inflow years, the original intent of a BHBF was multi-purpose in scope and included affecting, or re-establishing riparian and marsh community processes.

4-6. Resource Analysis, Compliance, Assessment and Recommendations

Resource Analysis is used in the decision-making process. When a decision is made regarding the timing, magnitude, duration and hypothesized results of the high flow, then the recommendation process begins to run in parallel. Compliance issues associated with Cultural Properties and Endangered Species need to be addressed and satisfied, while specific resources need to be assessed and the impacts of anticipated flows considered. The assessment of a resource (Resource Analysis) requires examining the "resource matrix" to determine if time of year may be an issue and to determine if and how specific life-stage aspects associated with a resource (e.g., larval vs adult stages in fish) will be effected. The information gained in the Resource Analysis will be used by Reclamation to meet compliance requirements. Efforts are underway to develop programmatic assessments that reduce the amount of time needed to meet compliance requirements.

Resource analysis of all probable months in associate with Management Objectives and Resource Indictors.

The resource analysis provides an estimate of effects of a BHBF on resources of concern versus the effect of a no-action. The effects are evaluated within the framework of the hydrologic triggering criteria and the proposed flow scenario involving BHBF, currently only recommended for 1999 to be up to 45,000 cfs. Recognizing that other BHBF actions may take place in the absence of the triggering criteria depending on the resource conditions and the interests of the AMWG. Analysis involves using the Resource Matrix, the SCORE Report, and the biological narrative. The information needs and decision-making process is different for each resource for any month and for any year

The resource matrix - The resource matrix is a table that lists 43 resources that may be of concern in the event of a BHBF. The matrix assigns positive and negative numbers to a resource for each month. The construction of the matrix was based on

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Hence the purpose of a flow for sediment mitigation, may have a hydrograph that is different than a flow that has a biological purpose attached to it.

researchers' experience with the previous effects of a BHBF, or on their general knowledge of the resource in question. The matrix is limited in the information it can give concerning a resource.[2] It only points to a resource or component of a resource that might be affected by a high flow for a given time of year. It does not describe the specific magnitude of impact beyond a scale of immediate or longer-term recovery time for biological resources or the immediate impact to resources such as fishing, or power revenues. In effect, the matrix would be consulted to determine resources that need further consideration. Further information about a resource would be obtained by reading the resource narrative and the SCORE Report.

The GCMRC compares the resources against the probable resource effects identified in the Resource Matrix, the Narrative and the SCORE to determine whether the probable effects of a BHBF significantly reverse efforts to achieve the respective Management Objectives. Several of the current Management Objectives lack specificity (i.e., not quantifiable or lack target dates) and additional detail needs to be developed. As stated above, the comparison and analysis of the matrix, narrative and SCORE report is translated into a three column table that lists the objectives of a BHBF, the result of no action and the result of a Proposed BHBF (see table 1).

Sensitive Resources - *Sensitive and High Value Resources as identified by the TWG during their January 20-21, 1998 meeting (**Fig.1 this document**).* As stated previously in this document, downstream resources are categorized into the following elements: Biological, Cultural, Physical, and Socio-economic. Managers and stakeholders have identified 43 resources within these categories that should be considered when making recommendations concerning operations associated with Glen Canyon Dam. These resources are listed in the resource matrix. Moreover, several of these 43 individual resources were considered "significant" or merited greater weight in the decision making process regarding BHBF because the resources are endangered species (e.g., humpback chub, Kanab ambersnail), or are valued recreational areas (e.g., Lees Ferry trout fishery), or are and integral part of the

[2] Of critical importance here is the ability to distinguish the immediate disturbance effect a BHBF may have on resources, versus the recovery time for the resources relative to that effect, and the overall

downstream resources (e.g., sediment supply). The list of these resources occurs in the management objectives developed by the technical work group and in Figure 1 of this document (Step 5).

The status of these sensitive resources can prevent a BHBF unless 1) adequate mitigation measures can be devised or 2) the probability of an emergency release (45,000 cfs or greater) is so high that a BHBF is deemed as the most appropriate protective action. These resources include Kanab Ambersnail (Biological Opinion), Humpback Chub (no acceptable take), Razorback Sucker (no acceptable take), Southwestern Willow Flycatcher (no acceptable take), Cultural (Programmatic Agreement), Trout (Lees Ferry Recreation - tailwater fishery), Other Native Fish. The cumulative and 1-time effect values would require further deliberation.

Recommendations to proceed – Following the presentation of the Analysis to the TWG in Decmeber, the process involving making recommendations and decisions to proceed with a high flow or not, is the next step. This step involves reviewing values that have been agreed to by the AMWG for resources as acceptable losses or gains. Some of these are established in the Management Objectives (e.g., trout numbers). Others may be based on historic figures (e.g., beach numbers immediately following the BHBF in 1996). Included in this review would be the issue of meeting compliance needs. The effects could be grouped into an event having a 1-time effect on the resource, a high flow event causing cumulative effects or a high flow event having an impact on a resource that it exceeds acceptable limits for the resource.

7. Hydrologic Triggering

This step determines if a Beach Habitat Building Flow (BHBF) would occur if the if the hydrologic triggering criteria are met (See Hydrologic Triggering Document). If these are NOT met, then a BHBF would not take place.

8. Making a Final Recommendation

The final recommendation on whether to recommend a BHBF requires integrating effects of the "significant" resources with those remaining and with compliance needs

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importance of the disturbance effect in structuring the ecosystem and related processes.

being met. Considerations are how a BHBF event would either benefit of negatively impact a resource.

This decision tree and the process as outlined provides a path. At best, this process and the accompanying documents can only point out possibilities or potential concerns. An experimental flow of 45K has occurred once on the Colorado River below Glen Canyon Dam, and the effect of a 45K is predictable to some degree for some resources (e.g., sediment will move from the channel bed to the channel margins). For many resources, antecedent conditions and subsequent flow scenarios have equally important effects, and are variables that need to be added to this equation when decisions are being made.

9. Final decision

After the Adaptive Management process and compliance activities are completed, the recommendation to proceed on not with a BHBF will be forwarded to the Secretary for a final decision.

Figure 1

RESOURCE CRITERIA DIAGRAM FOR BHBF

1. Annual Resource Monitoring Reports - (September Status Report to GCMRC)

↓

2. Determine if beach habitat will benefit from flooding (bank/bar storage capacity) GCMRC evaluation

NO → NO BHBF EVENT

YES ↓

3. Purpose and Kind of Flood Flow (e.g., BHBF, habitat maintenance, sediment conservation)

↓

4. Conduct Resource Analysis for all probable months (with feedback to redesign flow as needed) in association with Management objectives

↓

5. Resources, Mgmt Objectives and Resource Indicators (see accompanying Mgmt objectives, resource indicators)

Sediment Resources (Is there enough sand in the system?)
Sandbars, beaches and backwaters

Terrestrial and Riparian Resources
Kanab ambersnail, Southwestern willow flycatcher

Aquatic Resources:
Aquatic Foodbase, humpback chub, razorback sucker
flannelmouth sucker & other native fish, rainbow trout

Cultural Resources
Archeological sites, Traditional cultural properties

↓

6. Present Resource Analysis and BHBF recommendation to TWG (December)

NO →

YES ↓

7. Hydrologic Trigger Met (Every month Jan-July)?

NO → NO BHBF EVENT

YES ↓

Compliance Issues Met[3]?
(yes/no?) BOR

IF ALL YES

↓

8. **Make BHBF YES/NO**
Go ahead to Secretary of Interior

↓

9. **Secretary's Decision to BOR**
GO/NO GO

Resources of Concern, Management Objectives and Measurable Resource Indicators

Sediment Resources

Sandbars, beaches and backwaters

As a minimum for each reach, maintain the number and average size (area and thickness) of sandbars and backwaters between the stages associated with flows of 8,000 and 45,000 cfs that existed during the 1990/91 research flows.

Periodically increase the average size of sandbars above the 20,000 cfs river stage and number and average size of backwaters to the amounts measured during the high period of 1990/91 or the 1996 test of the beach/habitat-building flow in as many years as reservoir and downstream conditions allow.

Resource Indicators

Total number of sandbars above 20,000 cfs, by reach and stage.
Average area of sandbars above 20,000 cfs, by reach and stage
Number of suitable backwater habitats by reach at
specific river stages between 8,000 cfs and 45,000 cfs
Estimated quantity of river-stored sediment available
for redistribution by reach

Terrestrial and Riparian Resources

[3] In the event of a high inflow year when a hydrologic trigger is met, but compliance is not met, then mitigation efforts for sediment (BHBF senaris) will be unlikely to occur and will result in sediment loss downstream of Glen Canyon Dam.

Kanab ambersnail

Protect, restore, and enhance survival of native and special status species (federal, tribal, and state designations). Ensure that the required habitat for these species is preserved.

Sustain populations of Kanab ambersnail wherever they currently exist within the Colorado River ecosystem.

Establish or discover and ensure the continued existence of a second population of Kanab Ambersnail in Arizona.

Resource Indicators, as compared to 1996 pre-flood conditions

Number of known populations of KAS in Arizona
Populated KAS habitat (total area) outside impact zone
Estimated total KAS population outside impact zone
Analysis: Probable BHBF effects on long-term sustainability of known populations (e.g., recruitment, genetic integrity, sustainability of pre-dam habitats)

Southwestern Willow Flycatcher

Protect, restore, and enhance survival of native and special status species (federal, tribal, and state designations). Ensure that the required habitat for these species is preserved

Protect, restore, and enhance survival of native and special status avifauna.

Resource Indicators

Number of SWWF territories expected to be significantly affected by BHBF (describe effect)
Number of breeding pairs expected to be displaced by BHBF
Analysis: Probable effects of BHBF on recruitment (reproduction, nest parasitism, survival of young, etc.)

Aquatic Resources

Aquatic Food base

Maintain and enhance the aquatic food base in the Colorado River ecosystem to support desired populations of native and non-native fish. At a minimum,

maintain continuously inundated areas for *Cladophora* and aquatic invertebrates at or above 5,000 cfs discharge levels from Glen Canyon Dam.

Resource Indicator

Food base species composition, population structure, density, and distribution in Glen and Grand Canyon reaches.

Analysis: Probable effects of BHBF on composition, recovery rates of algal, macroinvertebrates and effects on organic drift.

Humpback chub

Maintain or enhance levels of recruitment of HBC in the mainstem as indexed by size frequency distributions and presence and strength of year-classes. (Focused at young-of-year and juvenile fish, and should include a fish health assessment.)

Remove jeopardy for the HBC in the Colorado River ecosystem *(B.O. 1994).*

Establish a second spawning aggregation of HBC downstream of Glen Canyon Dam (RPM 4).

Razorback sucker

Remove jeopardy for the Razorback Sucker in the Colorado River ecosystem.

Flannelmouth sucker and other native fish

Achieve healthy, self-sustaining populations of flannelmouth sucker, bluehead sucker, and speckled dace in the Colorado River ecosystem, with special emphasis on flannelmouth sucker in Glen Canyon based upon the capability of the habitat to support those fishes.

Attain riverine conditions, including appropriate habitat, that support all life stages of endangered and native fish species.

Minimize, to the extent possible, competitive and predatory interactions between native and non-native fishes.

Rainbow trout

In the Colorado River downstream of Glen Canyon Dam, to the confluence of the Paria river, sufficient ecological conditions (such as habitat, foodbase and temperature) should be maintained, which in conjunction with management by Arizona Game and Fish will produce a healthy self-sustaining population of at

least 100,000 Age II+ rainbow trout that achieve 18 inches in length by Age III with a mean annual relative weight (Wr) of at least 0.90.

Resource Indicators, probable BHBF effect on Native & Non-native Fish:

Number of successfully reproducing populations (including single trout population in Lees Ferry Reach).
Estimated number of successfully reproducing adult fish (creel catch rate; electrofishing catch rate by size class as an index of population size)
Survival of juveniles and subadults
Recruitment
Growth rate
Relative condition (length/weight relationship)

Cultural Resources

Archeological sites

Conserve *in situ* all the downstream cultural resources and take into account Native American cultural resource concerns in the Colorado River ecosystem.

Traditional Cultural Properties

Protect, and maintain physical access to and use of traditional cultural properties and other cultural resources, where such access and use may be impacted by dam operations.

Resource Indicators

Number of archaeological sites expected to be impacted that cannot be successfully mitigated.
Number of TCPs expected to be impacted that cannot be successfully mitigated.

Draft Report

Beach Habitat Building Flow Resource Criteria Analysis for January-July 1999: Analysis Methods and Materials for BHBF Recommendation

Prepared by: Barbara Ralston, General biologist, GCMRC

Submitted to: Technical Work Group
December 7, 1998

Beach Habitat Building Flow
Resource Criteria Analysis for January-July

Summary

This analysis is divided into a summary that provides an overview of the action/no action hydrologic releases, a summary for 10 significant resources, and a comparative table for action/no action for water year 1999 Flow Scenario 2 (Table 1) relative to management objectives. The summary highlights effects of no action/action of resources of concern. The table provides managers a way to compare the effects of no action with alternative actions in relationship to management objectives.

Table 1 provides a comparison of the effects of no action versus the alternative of conducting a BHBF in January-July following water year 1999 Flow Scenario 2. The intent of this analysis is to illustrate the methods and materials that are available to consider a BHBF for the months of January to July, should a hydrologic trigger be met. This is a analysis, not an action recommendation. The documents used to develop this analysis include the resources matrix, the resource narrative that pertains to biological resources and the state of the resources report (SCORE Report). The objectives that are driving this analysis are listed in Table 1 and are derived from management objectives. The purpose of the analysis is to point out areas that may need further consideration before a recommendation can be made.

General Overview

The effect of no action under water year 1999 Flow Scenario 2 would be high steady releases above 25K cfs for a month followed by daily high fluctuating releases. A no action decision would have the effect of increasing sediment transport downstream, increasing erosion of beaches and inundating and altering marsh habitats. Most eddy return channels that serve as backwater habitats would be inundated under both scenarios, although some reformed channels would be available. A BHBF would temporarily increase backwater number, but subsequent flow volumes (> 15,000 cfs) would likely inundate these habitats.

Resources of greatest concern are either affected equally though time (e.g. sediment, archeology sites), or the effects change over time (e.g., native fish, whitewater rafting). Often with these time dependent resources, later timed BHBF events have greater effects associated with recovery and immediate effects. For example, a BHBF in May could effect the interactions between young fish and a nursery habitat (aquatic food base, habitat), and non-native fish. While a BHBF in March would also affect nursery habitat (via reworking), but would be less likely to disrupt the use of these habitats by young fish later in the year. The overall effects of a BHBF versus no action are positive for sediment conservation, camping beaches, and the delayed erosion of archeological resources. Early timed BHBF would have small negative effects for native fish, the aquatic food base, avifauna, and riparian vegetation. Immediate effects and recovery

time of these resources increase after April. Increased negative impacts for whitewater rafting occurs after April.

Resources that scored in the -1 to -2 range of the resource matrix included aquatic and terrestrial habitat, aquatic food base, life history stages of native and non-native fish, breeding birds and waterbirds, the Kanab ambersnail, and recreation. The following is a brief summary of the possible effects of a BHBF on the resource areas and specific resources with attention paid to those resources that were ranked at -1 or lower.

Sediment Resources

Sandbars and beaches - The effect of a BHBF on sandbars and beaches is dependent on channel and eddy storage and sediment input, and when a BHBF last occurred. A maintenance flow occurred in October 1997. Sediment storage increased from February to April of 1997 as well as in the summer of 1998. Volume gains were larger below the LCR than above in 1997. More recent analysis for channel storage in the Marble Canyon Reach suggest that sediment input from the Paria in 1998 have replenished this reach. Channel bed thickness increased and average of .4 m system-wide in 1997.

The steady high flows in between April and June of 1997 were erosional with respect to sandbars (Kaplinski et al 1997.). However, sandbar created during the 1996 BHBF are still larger than they were prior to the 1996 BHBF event. In most cases sandbars would be rebuilt with erosion occurring overtime.

Backwaters - backwater numbers that exist at 8,000 cfs stage have increased since April 1996 (Stevens & Hoffnagle, unpublished). However these data do not indicate utility of these backwaters, nor the location of these backwaters relative to fish distribution. Overtime, deposition of sediment into the return channel and erosion of higher elevation reattachment bars will fill-in these habitats. The BHBF had the effect of filling in some return channels thus reducing backwater numbers. A BHBF would temporarily increase backwater number, but subsequent flow volumes (> 15,000 cfs) would likely inundate these habitats, making them unavailable as "backwaters". The benthic community associated with return channel environments might also be disrupted temporarily. The months of May-July may be critical times for backwaters to be stable and productive for young fish (native and non-native). A BHBF in May could effect the interactions between young fish and a nursery habitat. Alternatively, unstable environments (i.e., backwaters) may favor native fish.

Terrestrial Resources

Kanab ambersnail - a single population in Grand Canyon at Vaseys Paradise continues to persist. Growth of primary habitat occurs in April – October. Most individuals mature and reproduce in mid-summer. A BHBF in January – March results in take of habitat and egg masses, while a later BHBF results in take of reproductively active snails and habitat. Regardless of the timing, the action affects annual reproductive output (see Narrative). An earlier BHBF may reduce provide opportunities for habitat recovery than a later timed

event. Habitat in 1997 within the impact zone was estimated to be 11-16% of total primary habitat.

Southwestern Willow Flycatcher - the matrix suggests that SWWF would not be impacted by a BHBF in January - May. A BHBF in June- July may affect food resources of adults and hatchlings.

Breeding Birds & Waterbirds- other birds that inhabit the river corridor may be impacted by a BHBF if these birds nest in low-lying areas (e.g., marshes or the ground within the inundation zone). Recent survey data from avifauna census is needed for this evaluation. A BHBF in May - July could result in the loss of a year's recruitment in the riparian bird community.

Riparian habitat - near shore habitat (marshes) will be affected by either being buried by sediment, or scoured to some extent. The rate at which recovery/response occurs is influenced by the subsequent flows (i.e., high steady flows may hasten recovery of vegetation in the marshes and along the shoreline). April and early May are primary growing seasons for vegetation so that a BHBF after mid-April may delay recovery by these plants and encourage non-native plants to become established.

Tamarix germination - Seed production by Tamarisk occurs from April through July is of concern. Subsequent flow management may lessen the impact of this resource concern.

Aquatic Resource

Humpback Chub - the larval stage of the humpback chub is of concern during May and June. Concern is over larvae being pulled/swept into the mainstem from the LCR. Pooling at the tributary during a BHBF may result in larvae moving into the slow water and them being subsequently swept into the mainstem with little chance of survival (see narrative). Impacts to HBC larvae that get into the mainstem from the LCR are dependent when spawning occurs in the LCR. Spawning by HBC was reported to be late in 1998 due to the high flows coming out of the LCR. Spawning may be occur as late as May or as early as March for any given year.

Flannelmouth Sucker - the larval stage of the FMS is of concern during May and June. Habitats utilized by larvae and juvenile suckers (backwaters, shoreline) may be impacted by BHBF and become unavailable for use, or the benthic community utilized by the FMS in the sand/silt may also become unavailable at time when growth and survivorship is a primary concern. Alternatively, high steady flows associated with no action would result in backwaters being inundated and unavailable, as well as possibly not reworked/reformed. In both cases these habitats are unavailable to juveniles. Some backwaters reworking during the BHBF may create temporary habitats for juvenile FMS during the summer months if reattachment bar elevations are high enough to sustain subsequent flows.

Trout - Fry come off redds from January through May. The number of fry reach maxima in electrofishing samples during the spring and fall, reflecting extended spawning periods. Fingerlings are present throughout most of the year. High flows did not show a significant loss of fingerlings in the Lees Ferry population (McKinney et al 1996b see narrative). Small fish (fry and fingerlings) show affinity for low velocity near-shore habitats. High scouring flows may transport small fry downstream, but this has not been documented. Fingerlings and adult seek cover from high velocity flows. Little or no downstream displacement of fish was apparent due to the experimental spate of 1996.

Aquatic Food Base - The BHBF had an significant immediate negative affect on the filamentous green algae: reducing biomass to 15% of the total representation, but one month later had increase to 65% of the ash free dry mass. The difference between a recovery from a January -April vs. a later event is not known. Recovery time for both phytobenthos and macroinvertebrates occurred within one months time for some monitoring sites in 1996. Variables affecting recovery time were light availability (i.e., clear water with no tributary inputs), and discharge patterns: steady vs fluctuating flows (McKinney et al 1996a, 1997; Shannon et al 1996). Steady flows following a BHBF may enhance recovery of this resource.

Macroinvertebrates that use the algal community as a substrate follow a similar pattern of productivity. There is a lag time associates with this interaction. 1995-96 data indicate that macroinvertebrate biomass was lowest in February and showed an increase through September (Ayers and McKinney 1996a, McKinney et al 1996; Shannon et al 1996). A BHBF in May/June would likely show a decrease in biomass and recovery by September.

Cultural Resources

Archeological sites - Archeological sites within the inundation zone are determined to be either not impacted or can be mitigated for.

Traditional Cultural Properties - Properties associated with marshes and near shore may be impacted but would likely recover in a pattern similar to those described for riparian vegetation.

Table 1. Summary of comparison of No Action and BHBF Action for a "January-June Analysis" for Water Year 1999 Flow Scenario 2.

Objectives (based on management objectives)	Resource	No Action	Proposed Action (Scenario 2 for Water Year 1999)
	Hydrologic Scenario	Steady releases of at least 25K to 31K cfs for one month (Jan/June) followed by daily averaged fluctuating releases of 20-25K cfs through July.	Same as no action but with BHBF for 2-4 days at 45K cfs release followed by daily average fluctuating releases of 20-25K.
Increase height and area of existing sandbars	**Sediment**	Continued erosion of sandbars with some accumulation of sand in river channel and eddies. High steady flows increase erosion rates.	Conservation of sediment through sand deposition, especially if eddies storage capacity is full. Sand deposition on sandbars/beaches (3 feet or more), followed by erosion overtime. High steady flows increase erosion rates.
Reform/rework backwaters for native fishes **Displace non-native fish**	**Aquatic resources**	Aquatic food base continues development. Drift loads downstream remain within observed patterns for flow following ROD. Backwater habitats fluctuate in temperature and are likely unavailable due to inundation. Spawning patterns of trout undisturbed. Native -Non Native interactions continue. Stabilized return channels not inundated may favor non-natives.	Potential reduction in food base with increased drift downstream. Recovery of food base becomes delayed after May and consequently impact to fish is greater Some disruption of trout fry through displacement (Mar-May). Some backwaters temporarily reformed, or filled-in due to discharge/force dynamics. Potential downstream drift of juvenile or larval native fish, or increased habitat via pooling of tributary mouths (May-July)—Needs to be monitored. Native-Non-native interactions temporarily interrupted, but rapidly return to no action conditions.

Table 1 Cont.

Provide water to Old-High Water Zone Vegetation. **Maintain open sandbars for camping**	**Vegetation and Habitat**	Continued woody vegetation development to the 25K cfs shoreline. Marsh areas inundated and some development of emergent marsh vegetation. Replacement of marsh vegetation with transitional riparian plants (e.g., cattails, willows), gradual loss of marsh habitat. Vegetation utilized by riparian bird community. SWWF nesting areas unaffected. Potential transport and establishment of Tamarisk seedlings. KAS habitat inundated to 25K stage possibly to 31K with associated incidental take of snails	Some emergent marsh and woody riparian vegetation lost due to burial. Recovery to no action levels within six months **(Jan-April)** or 1 year **(April-July)**. Some wildlife habitat lost with 6 month recovery time. Ground nesting sites may be inundated (April-July). Recruitment of some riparian song birds may be affected, but the extent and species are not known **(April-June)**. Nesting sites of SWWF unaffected. Potential transport and establishment of Tamarisk seedlings **(May-July)**.
Not cause significant adverse effects on aquatic food base, trout fishery, endangered species, economics, cultural resources	**Endangered Species and Other Special Status Species**	Endangered species not significantly affected at flows to 25 K cfs. Habitat for native fish remains unchanged. Non-native/native fish interactions remain at current levels given current state of knowledge. Raptors food base not significantly affected. KAS habitat inundated to 25K stage possibly to 31K with associated incidental take of snails.	Possible habitat improvement for native fish or non-native fish (unstable backwater habitats). KAS habitat scoured to 45K cfs stage with incidental take of $\leq$10% of population. Recovery of KAS habitat 1-2 years to 24K cfs stage based on 1996 results. Raptors food base not significantly affected. Potential downstream drift of juvenile or larval native fish **(May-July)** or increased habitat via pooling of tributary mouths--Needs to be monitored.
Protect cultural resources from erosion	**Cultural Resources**	Continued erosion of high terraces containing archeological sites by wind, rain and backward erosion from river channel.	Deposition of sand temporarily reduces erosion rates. Restoration of natural processes generally beneficial.
Preserve and restore camping beaches	**Recreation**	Anglers, day rafters and white-water rafters experience high fluctuating daily flows. Continued reduction of camping beaches. Beach numbers and sizes are still greater than pre-1996 flood event	Recreation activities disrupted for 2-4 days. Downstream safety and available camping areas reduced during BHBF, Safety a greater concern **April- July**. Number and size of beached increased subsequently.
	Hydropower	Operations constrained to high steady flows and moderate fluctuating flow that average 20-25K cfs daily.	More energy is generated during the BHBF, when generating a full capacity, but overall less energy is generated due to the water by-passing the turbines.