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DRAFT CONTINGENCY PLANNING OPTIONS FOR UNANTICIPATED GLEN CANYON DAM HIGH FLOWS

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INTRODUCTION

Unplanned flows from Glen Canyon Dam, such as the 1983 peak flow and constant high flows from 1984-1986, may exert significant impacts on river resources downstream in Glen and Grand canyons (National Research Council 1987). Past studies have identified impacts to the limnological structure of Lake Powell (i.e., chemical and thermal structure, and sediment deposits), as well as downstream impacts to: physical resources (especially those related to sediment transport and geomorphology, including the structure of rapids); biological resources, including benthos, native and non-native (i.e., trout) fisheries, riparian vegetation, and terrestrial fauna and their habitats, including endangered species; cultural resources (i.e., archeological sites); recreational safety and economics; hydroelectric power generation; and dam structure and safety. A major characteristic of the post-dam hydrograph in Grand Canyon is that high flows are more prolonged than those that occurred in the pre-dam period. The duration of high flows strongly influences sediment export from the river corridor, and is major concern for sediment management.

To reduce the likelihood of unplanned high flows the BOR (1995) and Record of Decision (1996) increased buffer storage in Lake Powell, and identified sediment storage and availability of that sediment for redeposition during habitat beach building flows. This management strategy is designed to minimize beach erosion, minimize impacts on biological and cultural resources. Under Interim Flows, a ceiling of 20,000 cfs was established on releases. Under the ROD, the flow ceiling was increased to 25,000 cfs, a level which excited public concern. The impacts of steady 25,000 cfs flows have not been evaluated. However, the extreme variability of Rocky Mountain snowpack limits accuracy of runoff prediction. Due to continued snowpack accumulation in the upper Colorado River basin, the BOR decided on 7 February 1997 that flows from Glen Canyon Dam would have to be increased immediately (on 11 February 1997) to 25,000 cfs to protect the integrity of the lower Colorado River basin structures. Discussions with our science staff indicated that an appropriate strategy would include GCMRC evaluation of the river ecosystem during a constant discharge of 8,000 cfs before prolonged flows (4-5 months) of 25,000 cfs begin. The analyses of resource conditions proposed in this document will serve as a database against which to evaluate subsequent high flow impacts, but also to relate resource conditions to the changes resulting from the 1996 BOR test flow. Impacts to river resources may not be avoidable during

unplanned high flows or spills; however, adequate assessment of high flow impacts requires acquisition of monitoring data immediately prior to initiation of high flows during this 8,000 cfs constant flow.

This draft contingency plan was developed to present options for acquisition of essential resource data prior to prolonged high flows from Glen Canyon Dam in late winter, spring and possibly summer of 1997. This plan is designed to answer the question of whether prolonged constant 25,000 cfs flows will result in significant erosion or alteration of sediment deposits, benthos, backwaters, marshes, and cultural sites as compared to 20,000 cfs flows.

Data from some on-going monitoring activities can be used as a baseline for unanticipated high flow events. Use of these data will minimize the costs of impact analyses. However, some resources that are particularly sensitive to flows may require emergency field excursions prior to and after the event during constant 8,000 cfs flows. Rapid analysis and report preparation should be stipulated in all contracts for a prompt reporting of impacts. This draft plan is specifically designed to evaluate the state of resource attributes at a constant 8,000 cfs flow during the period of 15-17 February 1997. A second assessment will be made during a comparable 8,000 cfs flow at the termination of the flows $>24,000$ cfs. The focus of this study plan will be to relate constant high flows to resource conditions.

As this assessment plan is being implemented, a GCMRC interdisciplinary team will develop a second contingency plan for potential flows above powerplant capacity (33,200 cfs). The second contingency plan may not need to be implemented, but will provide guidance if needed.

MONITORING OPTIONS

OPTION 1. NO ACTION. USE PRESENTLY EXISTING AND ON-GOING MONITORING PROGRAMS TO EVALUATE HIGH FLOW IMPACTS.

PROS:: This option would involve no additional FY97 expenditures or experimental flow regimes, and would relate potential high flow impacts to the seasonal or annual resource assessments which are being monitored under the present 1997 Grand Canyon monitoring program.

CONS: This option will provide sufficient data for some resources. For example, erosion of arroyo channel deposits that protect archeological sites can be monitored at any flows below 25,000 cfs. Also, riparian vegetation is largely dormant, and high flow impacts will not be detectable until the middle of the 1997 growing season. However, other resources, such as sand bars/campsites, benthos, backwaters and endangered Kanab ambersnail habitat, have probably changed considerably over the course of $\sim$20,000 cfs flows during the 1996-97 winter. Those resources are likely to respond dramatically to unanticipated high flows. The existing, infrequent monitoring program will not be able to distinguish high flow impacts from the previous winter's flow impacts. Legal disputes over the impacts of high flows on these resources may arise, increasing the need for having a good understanding of the pre-event condition. If this option is used, a high flow impacts report may still be warranted.

OPTION 2. MODIFY THE EXISTING INFORMATION COLLECTION PROGRAM WITH CONTINGENCY MONITORING (THE PREFERRED OPTION): **USE THE EXISTING FY97 PROGRAM TO THE EXTENT POSSIBLE, AND AUGMENT THAT PROGRAM FOR RESOURCES OR SPECIES CONCERN WHICH MAY BE EXCEPTIONALLY RESPONSIVE TO HIGH FLOWS.**

PROS: This option provides a strategy to relate high flow impacts to resource conditions which have been monitored during the past six years. It would also allow collection of information on specific resources which may have changed substantially, or which are not being presently monitored (i.e., recreational safety).

CONS: This option will entail additional expenditure of monitoring funds, and two experimental 3-day test flows of 8,000 cfs. This option will allow for a fairly detailed assessment of resources in the upper Grand Canyon, but will only use remote techniques to define impacts in the lower Grand Canyon, and will not allow assessment of indirect or weak flood impacts to some resources (e.g. southwestern willow flycatcher habitat). Time constraints (3 days) limit the ability to stage a more comprehensive assessment.

OPTION 3. CONDUCT AN EXHAUSTIVE INFORMATION COLLECTION PROGRAM: **PLAN AND CONDUCT A THOROUGH BASELINE CONDITION ANALYSIS COMPARABLE TO THAT PRIOR TO THE 1996 BOR 45,000 cfs TEST FLOW.**

PROS: This option would provide a rigorous assessment of high flow impacts on the ecosystem.

CONS: Insufficient time and funding exist to accomplish this option. It would be expensive and logistically intractable with less than 6 days notice.

SPECIFIC RESOURCES AND PROCESSES CONSIDERED IN CONTINGENCY PLAN

Limnology

The thermal and chemical structure of Lake Powell may be affected by high flows, but probably only gradually. The seasonal monitoring program undertaken in previous years may relates high flows to historical limnological structure. The Lake Powell monitoring program was reduced in scope in 1997. It is recommended that the 1997 program be upgraded to match the historic limnological monitoring. The upgraded program should be continued through 1997.

Flow

Unit values of flow (15 minute intervals) should continue to be collected at the dam (by the BOR) and at the four downstream gauges on the mainstem prior to, during, and after the high flow event by the USGS. If flows exceed 50,000 cfs, daily cameras may be suggested as a means of carefully document stages at which gauge accuracy is questioned. Flow data are required by all monitoring researchers. Streamflow data on the gauged tributaries (Paria R., Little Colorado R., Havasu Cr., Diamond Cr.) should also continue to be collected. These data will be collected using normal monitoring procedures.

Mainstream Geomorphology

The structure of rapids may be influenced by flows near or above powerplant capacity (33,200 cfs). Aerial photography at equivalent flows before and after the high flow event should demonstrate the

impacts of change at rapids. Interviews with commercial river guides can also provide useful corroborative information.

If debris fan alterations significantly change the navigational difficulty of one or more large rapids, a debris fan geomorphologist should be sent to study the site; however, large changes in rapids are not anticipated below powerplant flows. No action for this topic is presently anticipated under flows of $<33,200$ cfs.

Sediment Transport

Bed-stored sediment supplies and movement may be monitored. Monitoring should be conducted pending communication with USGS researchers. Monitoring should be conducted before and after the high flows between the Paria River confluence and Badger Rapid, and below the Little Colorado River. Monitoring is not dependent on a low flow for assessment.

Mainstream sediment transport rating curves may be substantially improved at the Lees Ferry (post-dam), Above Little Colorado River and Above Diamond Creek mainstream gauges under high flows. The USGS should contribute to determining whether such an undertaking is necessary and feasible, and what staff should be involved.

Sandbar Erosion

Aerial photographs are considered one of the most valuable databases for evaluation of the river corridor in Grand Canyon. Black and white 1:4800 scale photographs may be used for reach-based analyses of sand bar change. Black and white photographs are preferred if photos are to be taken during the winter and shoulder seasons, when shadows obscure many sandbars. Coupled morning and afternoon photo runs may help resolve some deep shadow problems.

Measurement of the 33 sandbars being monitored on an annual basis would provide critical information on sandbar responses to a high flow event. However, monitoring time is limited and those bars upstream from Phantom Ranch are a higher priority than those downstream, because of limited sediment availability in upstream reaches.

Coupled land and bathymetric surveys of those bars during a 3-4 day period requires that 2-3 bars be surveyed/d. This can be accomplished with two crews each consisting of 4 surveyors and 1 boatman. Crews should be transported via 22' motor snout boats because low flows increase the navigational difficulty of several rapids. A separate Hydrographics boat is required to perform bathymetric surveys as land surveys are being conducted. Low flows provide the best integration of land and channel floor survey data.

Backwater Habitats

Backwater distribution can be derived from aerial photograph analysis using MIPS. Alteration of backwater morphology can be derived on the 33 sandbars on which erosion monitoring studies are planned. Backwater benthos analyses are discussed below.

Aquatic Biological Resources

Reduction or loss of the benthic food base for fish has become a significant concern to trophy trout fishermen and guides in the Glen Canyon National Recreation Area upstream from Lees Ferry. The Glen Canyon benthos is being monitored at three sites by the Arizona Game and Fish Department and Northern Arizona University. The benthos downstream from Lees Ferry supports both native and non-native fisheries, and has been monitored by NAU (Blinn and Shannon). Downriver pool and riffle benthos should be monitored prior to the high flow event, at least at their five study sites upstream from the Upper Granite Gorge.

Backwater habitats are created and altered by high flows, and may provide critical habitat for young native fish. Six backwaters are being monitored by AGF (44L, 58L, 60.5L, 63.3L, 117L and 161R). These sites need to be monitored during the 8,000 cfs constant flow, requiring one boat. Parnell et al. (NAU Geology) are monitoring 3 additional backwaters (-6.5, 55.5R and 194L) in relation to flood flows. All three NAU backwaters and some of the AGFD sites are sandbar erosion sites. Depending on the time limitations, area-based benthic standing mass of macrophytes and invertebrates, water quality and bathymetric data should be collected at those sites.

Wetland and Riparian Vegetation

Wetland and riparian vegetation is being monitored on an annual basis by NAU (Ayers and Kearsley) and NPS (Spence and Bryan). Wetland and some riparian vegetation are usually dormant in winter and may have no living above-ground parts. Therefore, discerning high flow impacts on vegetation cover is impossible until the growing season begins. Because of these reasons, comparison of the post-flow data with historic data will provide the most defensible interpretation of winter high flow impacts in this system. Post-flow data can be collected as part of the annual monitoring program. Although interpretation of vegetation cover changes may be restricted to comparison of post-high flows photography in 1997 with that in September 1996, seed bank can be monitored. This will entail replicated collections of soil samples from each of the five study sites upstream from Phantom Ranch. Good stage to discharge relationships have been established at all of the vegetation monitoring sites.

Terrestrial Fauna

The U.S. Fish and Wildlife Service Phoenix Field Office should be contacted to coordinate analysis of impacts to endangered species. Endangered Kanab ambersnail (KAS) exists in low-lying wetland vegetation at Vaseys Paradise (Mile 31.5). If sufficient time (2-3 d) is available prior to upramping, an FWS recommendation to conduct a KAS habitat and or population survey should be anticipated. The FWS requests an on-site evaluation of flood impacts for all flows exceeding the Preferred Alternative (25,000 cfs). This may involve staff in a 3-d hike or transport by river to the study site.

Endangered southwestern willow flycatchers (SWWF) are Neotropical migrant birds which do not arrive in Grand Canyon until April. No nest sites in upper Grand Canyon lie at less than the 45,000 cfs stage. Therefore, no direct impacts of spring high flows (<45,000 cfs) are anticipated on the SWWF population; however, marshes associated with nest site stands may be affected by high flows. Those impacts can be assessed from aerial photographs and oblique site photographs.

Monitoring flood impacts to other terrestrial fauna has been restricted to avifauna, and avifaunal study plots should be revisited during the breeding season, according to the established 1997 monitoring program. However, other terrestrial vertebrates and invertebrate populations may be extensively affected by high flows. Impact analysis will be less successful during winter because of dormancy and indirect habitat impacts.

Cultural Resources

Archeological and historic sites (i.e., the Spencer Steamboat) lying near the post-1991 normal maximum discharges may be affected by flows above powerplant capacity. These resources persisted through the 1983 flow (maximum ca. 96,200 cfs), and are unlikely to be negatively impacted by flows substantially less than that post-dam record flow. However, following the return to normal flows in 1997, and pending coordination with managing agencies, Native American tribes and scientists, qualified archeologists should be directed to evaluate high flow impacts and in accord with the established 1997 monitoring program.

Recreation

Recreational safety may be an issue at flows above powerplant capacity. The majority of river running use in Grand Canyon occurs between April and October. Winter private trips are the only river running group likely to be affected if winter flows exceed 33,200 cfs. Impacts to this user group may require monitoring by the NPS. If the high flow extends into the river running season, and flows exceed powerplant capacity, significant safety and recreational economic impacts may result. Therefore scientifically credible analysis of rapid safety and modification of the private and commercial trip orientation program at Lees Ferry may be warranted.

Changes in campsite area may be monitored using aerial photography, coupled with a ground-based assessment following the high flow event. This monitoring should follow the methods of Kearsley et al. (1994), which emphasize campsite area changes in critical (narrow) and non-critical (wide) geomorphic reaches of the river.

If the high flows extend into the commercial boating season (April-October), the 'Adopt a Beach' Program being conducted by the Grand Canyon River Guides can provide useful corroborative information.

Economics

It may be of value to develop a report on economic impacts of the high flow event. The report should be prepared by a committee, including Western, to evaluate the cost to the public by this event. If a large flow event occurs (>45,000 cfs), a detailed analysis of hydropower, recreational and fishing economics may be warranted.

MATRIX OF RESOURCES, ACTIVITIES, PARTICIPANTS AND LOGISTICS

RESOURCE ISSUE	ACTIVITY	STAFF	DATES, LOGISTICS AND EQUIPMENT
1. Public Relations	Press releases, public discussions	Barry Wirth, BOR	12-14 Feb., 17-21 Feb., post-Q_{high}; meet with the Lees Ferry fishing guides, commercial outfitters and GCRG
2. Lake Powell Limnology	Continue seasonal monitoring of LP limnology	Vernieu, Huefftle, Corn	Seasonal sampling; integrate data into historic data
3. Flow	Monitor discharge from Dam and mainstream gauges	USGS, BOR	Unit values in 1997
4. Geomorphology			
a. Aerial Photography	Pre-Q_{high} and post-Q_{high} aerial photography	Horizons, BOR, Quararoli	16-18 Feb. and post-Q_{high} fixed wing for photo acquisition and BOR helicopter videography; collect B&W 1:4800 images, with possible double coverage in Marble Cyn. and Muav Gorge
b. Sandbars and debris fans	GIS reach-based assessment of bars, debris fan analyses	Schmidt and Melis	Use of aerial photographs
5. Sediment Resources			
a. USGS Cross Sections	Bathymetric survey (Hydro or tag line)	J.Graf	2 trips (ca. 13-21 Feb., and post-Q_{high}), 4-5 d/site
b. Sandbars	Coupled land and bathymetric surveys	Parnell/Kaplinski/Hazel	2 crews of 4 + hydro crew; 3 motor snouts 2 trips (15-21 Feb. and post-Q_{high})
(c. Sediment Transport	Monitor sediment transport at mainstream gauges	USGS	Sample at Lees Ferry gauge and other gauges pending recommendations of the USGS)
6. Aquatic Biology			
a. Benthos	Monitor macrophytes & invertebrates standing crop chlorophyll-a at 3 sites above Lees Ferry (AGFD), and at LF, 2-mile, South Cyn, Nankoweap, LCR, Tanner and Phantom (NAU)	Ayers, Blinn/Shannon	AGFD 6 backwaters, 15-22 Feb (AGFD), 14-21 Feb. (NAU); post-Q_{high} trips; time data coll'n with seasonal monitoring, but this will involve separate report preparation; upriver logistics involve AGFD craft; downriver logistics = 2 motor snout trip
b. GCNRA Macrophyte Beds	Map during pre- and post-8k cfs flows	AGFD (Ayers, McKinney)	Monitor prior to and after the high flows
c. Drift	Continue monitoring at Lees Ferry, increase NAU downstream drift monitoring?	Blinn/Shannon	Part of above trips
d. Recovery	Recovery of varial zone benthos	Blinn/Shannon	Bi-weekly monitoring of benthos after high flows

e. Backwaters			
1) Video	MIPS video mapping of 15-17 Feb., post Q_{high} flow	Ralston (ATA) and AGFD	Lab work in Flagstaff
2) Field work	Monitor 6 AGFD sites; monitor -6.5R, 55.5R	NAU (Parnell, Springer, Stevens) AGFD (Persons and Hoffnagle);	Monitor before and after Q_{high}; Monitor GW hydrol. at 55.5R under constant 25k cfs
e. Fisheries			
1) Electrofishing	Glen Canyon elecrofishing run	AGFD	3 nights during 15-17 Feb. 8k cfs constant flow; another 3 night trip post-Q_{high}
2) Downriver fisheries	Monitor the mainstream in Grand Canyon	AGFD (Persons, Hoffnagle), Hualapai Tribe?	No action here, use existing monitoring program
3) Flannelmouth Sucker	Monitor Paria mouth (electrofish); monitor movement and collect eggs	UA (McIvor) and AGFD	Egg coll'n at -4 Mile during 8k cfs constant; Sample Paria Mouth under high flows.
4) LCR mouth pool area	Monitor pool area at LCR mouth (fixed camera?)	AGFD, ATA (Brod), NAU? (Manone)	Establish camera on 15-21 sandbar trip; download monthly
7. Terrestrial Biology			
a. Wetland/Riparian Vegetation	Prepare a Q_{high} report using existing annual monitoring data, collect soil samples	NAU (Ayers, Kearsley), Hualapai Tribe (Christensen), GLNRA (Spence), GRCA (Bryan)	Place two staff on sandbar trips, develop report from soil seed bank samples, existing annual monitoring program and post-Q_{high} flow analyses
b. Kanab Ambersnail	Evaluate habitat area by stage elevation	ATA (Stevens) and AGFD (Kubly)	Site visit from sandbar monitoring or backwaters trip
c. Avifauna	Prepare a Q_{high} report using existing annual	NBS (Sogge), Hualapai (Christensen) GLNRA (Spence), GRCA (Ray)	No additional field work needed, develop report from existing annual monitoring data

(The possibility of inundating as yet undiscovered SWWF nest sites in upper Lake Mead exists, and may further involve the Hualapai Tribe)

8 Cultural Resources			
a. Glen Canyon Cutbanks	Survey and monitoring of eroding cutbanks in vicinity of archeological sites	Henderson/Balsom+surveyor Manone assist?	Use existing monitoring program and and photo analyses; post-Q_{high} follow-up)
b. Archeological Site Arroyos	Land surveys of 4 sites monitored during 1996	Yeatts and Brod	Use annual monitoring trip and post-Q_{high} follow-up
c. Grand Canyon Sites	Use on-going monitoring?	Balsom (NPS)	???

9. Recreation			
a. Safety Advisement	Advise trout fishing guides, anglers, downriver users (private trips) of risk; advise NPS to place public notices at Lees Ferry and Phantom Ranch	NPS, AGFD, BOR public relations	12-14 Feb (pre-8k cfs low flow); 15-17 Feb (before upramp to 25k
b. River Running Safety	Navigational difficulties at rapids through mailed questionnaires and interviews	NPS, Myers (GC Clinic), ATA (Stevens)	Begin ASAP
c. Campsite inventory	Inventory campsite area changes using aerial photos and post-high flow site visits (coordinate with GCRG Adopt-a-Beach Program	Quartaroli (ATA)	Aerial photos and post-Q_{high} photos and surveys
10. Economics			
a. Predict Economic Impacts	Analysis of economic impacts to power production and recreation (trout fishing, daily trips, and downriver trips)	BOR, NPS	ASAP