To: Larry Stevens
From: Mike Liszewski

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GCMRC CONTINGENCY MONITORING PROGRAM, OF ANTICIPATED AND UNANTICIPATED HIGH FLOWS FROM GLEN CANYON DAM IN GLEN AND GRAND CANYONS, ARIZONA

INTRODUCTION

The 1992 Grand Canyon Protection Act and the 1995 Glen Canyon Dam Environmental Impact Statement direct the Department of Interior to manage the Colorado River ecosystem in lower Glen Canyon and all of Grand Canyon through an adaptive management program. This program is designed to balance the tradeoffs between economics and environmental issues. Water storage, hydropower production, river running and trout fishing are the primary economic concerns, while protection of native fish, wildlife (some of which are endangered species), and archeologically and culturally significant sites are the primary environmental concerns (Bureau of Reclamation 1995). The Grand Canyon Monitoring and Research Center (GCMRC) was created in 1996 to provide information to the Adaptive Management Work Group (AMWP) regarding dam impacts on the river ecosystem. The AMWG, in turn, recommends management actions to the Secretary, who considers and acts on those recommendations in relation to the recommendations of the Annual Operating Plan Work Group and the Law of the River.

The Colorado River ecosystem is a house built on sand, and maintaining its ecological integrity depends, in large part, on management of flows and alluvial sediment distribution to rejuvenate native fish habitats, cultural sites and sandbars. The climate of the Grand Canyon region is unpredictable, and wet winters, such as occurred in 1982-83, 1984 and 1997, produce large snowpacks which melt and fill the Upper Basin's reservoirs to capacity. Releases at or above Glen Canyon Dam powerplant capacity (31,500 cfs) have occurred fairly regularly since the closure of the dam in 1963 (Table 1), and planned high flows recently have been used to restore ecosystem components and processes downstream (e.g., GCMRC 1997). High flows may be used intentionally for restoration purposes during high inflow years, but high flows may also be necessary under high reservoir levels. High flows, particularly unanticipated high flows, may result in excessive sediment export, and therefore management strategies involving high flows will range from ecosystem enhancement to impact mitigation. Furthermore, planned flooding for restoration purposes is not an ecological panacea: flooding negatively affects some terrestrial species of concern, and potentially recreation, in this ecosystem (GCMRC 1997). With these caveats, high flow effects must be assessed both in short-term and in longer-term scales. The GCMRC concludes that the continued scientific study will improve understanding of the benefits and impacts of high flows for stakeholders.

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Table 1: Flows above powerplant capacity, planned high flows, and exceptionally low flows from Glen Canyon Dam, 1963 to 1997.

Year	Month	Peak Flow (cfs)
1965	May-June	65,000
1973	June	33,000
1977	Spring	Extreme low flows
1983	June-July	96,200
1984	June	50,000
1985	May	55,000
1986	June	48,000
1996	March/April	45,000
1997	August/September	30,700

The GCMRC initiated a pilot Contingency Monitoring Program in February 1997 to assess the impacts of anticipated high releases from Glen Canyon Dam on the physical, biological and cultural resources along the Colorado River. The GCMRC recommends that a Contingency Planning Committee be formulated as part of the Technical Working Group to provide recommendations to the Adaptive Management Work Group regarding contingency planning. The present document expands upon the existing inter-agency monitoring and research program to stimulate discussion amongst the Contingency Planning Group regarding monitoring of future planned and unanticipated exceptional releases (high or low) that vary from those recommended in the Secretary's Record of Decision levels (5,000 cfs to 25,000 cfs). The objectives of this program are to:

1) Determine the immediate and longer-term impacts of planned high releases ("enhancement flows") from Glen Canyon Dam on the Lake Powell and Grand Canyon ecosystems.
2) Determine the immediate and longer-term impacts of unanticipated exceptinoal releases ("mitigation flows") from Glen Canyon Dam on the Lake Powell and Grand Canyon ecosystems.
3) Develop and iteratively refine an ecosystem model to predict exceptional flow impacts on Colorado River ecosystem resources and processes.

Appendix 1 lists the resources of concern to stakeholders listed in the Glen Canyon Dam Environmental Impact Statement (Bureau of Reclamation 1995), and reiterated in the Secretary's ROD (1996) and the GCMRC documents. This provides guidance on which resources and processes should be monitored during planned and unplanned high and low flow events.

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METHODS

Objective 1: Determine the immediate and longer-term impacts of planned high releases ("restoration floods") from Glen Canyon Dam on the Lake Powell and Grand Canyon ecosystems.

Preliminary Resource Effects: As a preliminary exercise to identify stakeholder concerns with high flow effects, the GCMRC developed a flood impacts resource matrix (Appendix 1). This matrix is based on a short-duration (2-4 d) flow of 45,000 cfs, and was reviewed by leading scientists who are knowledgeable about this river ecosystem. They evaluated potential resource effects for each month between January and June, the period when high flows are most likely, and provided supporting scientific literature citations. This exercise is only applicable to a flow of a specific magnitude. As part of this objective and Objective 3, this exercise should be expanded to include all months of the year and for a variety of flows above ROD levels.

Event Documentation: One of the most important monitoring approaches in this ecosystem involves low-level aerial photography of the river corridor during a three-day constant low flow. Aerial photographic images have been obtained each year between 1990 and 1996, with constant flow aerial photography as early as 1984. The base level for the aerial photographs has been kept as low as possible to allow for as much exposure of riverside sandbars, camping beaches, aquatic vegetation and streamside vegetation as possible; however, aerial photography may not be desirable at low stages during high inflow years. Prior to August 1991, low flows had been conducted at 5,000 cfs. The steady flow level for photography was increased to 8,000 cfs in the fall of 1991 to conserve the aquatic foodbase. Constant flows provide an essential control for river stage at all study sites, and achieving a constant river level throughout the Canyon requires three days.

Aerial photography should be conducted immediately prior to, and immediately after, exceptional flow events, preferably during a low constant flow. This is standard protocol for scientific assessment of the state of the river ecosystem, and is regarded by most river scientists as an appropriate, if not essential, permanent record and monitoring approach. In high flow years, a constant flow of 20,000 cfs may be acceptable as a baselevel for photography.

Flow and Sediment: Flow and sediment interactions have been a major focus of the existing monitoring and research program, and antecedent conditions are a primary concern prior to any high flow event. The status of the in-channel and bank-stored sediment supply will dictate whether a high flow event can be considered an enhancement or a mitigation event.

Flow will be monitored at the existing USGS gages, and an additional streamflow gage in upper Marble Canyon, if it is added to the USGS gage network. Sediment transport data should be collected at each gage, as well as from the major gaged tributaries (e.g., the Paria and Little Colorado rivers) before, during and after major flow events.

The USGS cross sections from the Paria River to Badger Rapid, and near the Little Colorado River mouth, should be monitored prior to the high flow event. These measurements should be be repeated 6 month later through the monitoring program, and reported within nine months of the conclusion of the high flow event.

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Sand Bar Erosion: Sand bar erosion should be studied at all sites before and immediately following high flow events at all study sites. Prior and 6-month follow-up surveys may be part of the existing monitoring program, if flow timing is appropriate.

The relationship between high flows, bank erosion and the fate of eroded sediments has been questioned in Glen Canyon National Recreation Area (GCNRA); however, few data have been presented on these processes. GCMRC recommends that GCNRA present a scientific review of its database on this topic to help focus study design and implementation, if GCNRA is interested in monitoring this topic.

Lastly, channel morphology in GCNRA may be monitored to determine the fate of eroded sediments and to monitor bed elevation change in that reach, if warranted by the above review.

Aquatic Biological Resources

Drift and Benthos: The Glen Canyon aquatic food base was not strongly affected by the 1996 Test Flow, and recovered quickly (Blinn et al. 1997). However, there is considerable concern that preceeding and follow-up low flows may negatively affect the aquatic food base. Given the strength of the on-going monitoring program, it does not appear to be necessary to undertake additional benthic studies immediately following a single, short duration, 45,000 cfs flow event. A more efficient, system-wide approach to determining flow impacts may be to monitor drift throughout the river ecosystem before, during and after such a high flow. Mid-channel drift should be sampled 4 times daily (high, low, rising and falling hydrograph points) for three days prior to the event, every four hours during the two-day high flow, and four times daily for three days following the high flow event. Mainstream sampling should be conducted, at a minimum, just downstream from Glen Canyon Dam, at Lees Ferry and just downstream from the Paria River (these could all be sampled by one team); just upstream from the Little Colorado River confluence and at Mile 65 upstream from Lava Chuar Rapid (by another team); and at Mile 225 near Diamond Creek by another team. Whether or not the Paria and Little Colorado rivers are flowing above baseflow levels, they should also be sampled on the same schedule by the appropriate teams. This sampling strategy would entail processing a total of 8 sites x 4 samples/d x 8 days, or 256 samples for algae, zooplankton, macroinvertebrates and detritus. Daily bed-load samples should also be collected, as well as observations on drifting CPOM. Data would consist of ash-free dry mass of each category, and the analyses should be structured to assess reach-based losses in the upper Canyon, and total loss at Diamond Creek. Experimental scour studies may also prove useful for assessing flood impacts.

Dissolved organic carbon concentration in the mainstream may change as a result of this test flow. A monitoring program at Glen Canyon Dam, Lees Ferry, the Paria River, above and downstream from the Little Colorado River, and at Diamond Creek will be coupled with the organic drift analysis project.

Native Fish: Native fish were not shown to be substantially affected by the 1996 Test Flow, and GCMRC recommends no analysis be undertaken for native fish for flows conducted between January and late April. Studies of flows during the humpback chub spawning period should investigate the loss of drifting larval fish to the mainstream at the Little Colorado River. On-going monitoring trips should be timed to take as much advantage of the high flow as possible.

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Flannelmouth suckers in the Glen Canyon reach may be monitored if sufficient pre-event data are available. This analysis should focus on the FMS activity in the lower Paria River, and on movement of individual fish in relation to the hydrograph. Such a study should seek to determine whether FMS movement is stimulated by the mainstream hydrograph.

Native Fish Habitats: Backwaters were not substantially rejuvenated by the 1996 Test Flow, and it is unlikely that substantial change in backwater distribution will result from a shorter-duration event. However, helicopter monitoring following the event will be collected to verify the condition of mainstream backwaters. Assessment of aerial photographs should be used to determine the impacts to the area of individual backwaters through the various geomorphic reaches.

Trout: The Lees Ferry trout fishery will be sampled with electro-shocking before and after the high flow event, and the data related to longer-term monitoring results. Depending on the timing of the planned flow, analysis of trout redds may be justified, provided sufficient pre-event data have been collected. Density and, if possible, particle-size should be monitored.

Terrestrial Biological Resources

Riparian Vegetation: The 1996 Test Flow resulted in little change of the sandbar vegetation under study by NAU. Therefore, changes in bar vegetation under a shorter duration 45,000 cfs flow are unlikely, and the normal vegetation monitoring should be sufficient to document these changes.

Endangered Kanab Ambersnail: This endangered species is known to exist in Grand Canyon only at Vaseys Paradise (Mile 31.5R). Its population and habitat are presently monitored on a bi-monthly basis during the growing season. The 1996 USFWS Biological Opinion prohibits the Bureau of Reclamation from conducting another 45,000 cfs flow because of the threat of take on this population. Moving snails to higher portions of the habitat prior to the 1996 Test Flow did not result in any detectable negative consequences on the Vaseys Paradise population (Stevens et al. 1997, unpublished). Therefore, if the USFWS permits another BHBF, physically moving the snails may be an important mitigation activity. Alternatively, the Arizona Game and Fish Department is in the process of developing a captive population at the Phoenix Zoo, and snails found in the flood zone could be collected and used to establish that captive breeding population. The timing of the BHBF may provide opportunity for the pre-event and 6-month follow-up habitat and population surveys. In addition, an immediate post-event monitoring effort should also be conducted.

Southwestern Willow Flycatcher: The 1996 Test Flow had little to no impact on historic nest stands or trees used by southwestern willow flycatchers. However, rather substantial reduction occurred of the riverside marshes associated with those nest stands and used by SWWF as foraging habitat. Asssessment of habitat changes associated with planned flooding may be warranted, under advisement of the U.S. Fish and Wildlife Service.

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Cultural Resources

NPS Cultural Resources:

Hualapai Cultural Resources:

Southern Paiute Culutural Resources:

Socioeconomic Resources

Power marketing changes associated with a BHBF should be reported to the AMMG, and monitoring these impacts and changes are the responsibility of Western Area Power Administration.

Safety

The National Park Service has claimed that river running safety is not an issue during high flows in Grand Canyon; however, depending on the time of year in which the high flow occurs, GCMRC may engage in safety analyses to better understand this issue.

SCHEDULE

The logistics associated with a planned flood require approximately 90 days; however, spike flow triggering criteria (Appendix 2) may provide far less time for planning. The GCMRC needs to have the support of the National Park Service in developing an annual helicopter and logistics plan, rather than the presently cumbersome trip-by-trip process if this contingency plan is to be effective. Unanticipated high flows may necessitate river trips and helicopter aerial photography runs with less than two weeks notice.

BUDGET

Aerial Photography and Analyses
Streamgage Analyses
Mainstream Cross-sections Sandbar Erosion
Dissolved Carbon Concentration
Drift and benthos
Native Fish
Native Fish Habitat
Trout
Kanab Ambersnail
Southwestern Willow Flycatcher
Hualapai Resources
Southern Paiute Cultural
Economic Analyses

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Objective 2: Determine the immediate and longer-term impacts of unanticipated exceptional releases ("dam mitigation flows") from Glen Canyon Dam on the Lake Powell and Grand Canyon ecosystems.

Preliminary Resource Impacts: Unanticipated, exceptional flows, such as the high flows that occurred in 1983-1986, or the low flows that occurred in 1977, are presently managed against, and should only occur extremely rarely; however, GCMRC recommends that a contingency plan be developed in the unlikely event that such flows occur. The preliminary resource matrix identifying stakeholder concerns with high flow impacts (Appendix 1) should be expanded to consider each month of the year and a range of flows at 1000 cfs increments up to 5,000 cfs, and at 10,000 cfs increments above the ROD level (25,000 cfs), and including the possibility of a catastrophic failure of Glen Canyon Dam. At minimum, this exercise will help identify information gaps regarding flow impacts on river resources, and at most may assist in the management of unforeseen flow emergencies.

Event Documentation: If time permits, the minimum documentation of an unanticipated high flow event should include low-level aerial still or videography photography of the river corridor prior to, during and after the flow peak. Photography should include the mouth areas of major tributaries for the purpose of understanding pool area effects of high flows.

Flow and Sediment: Flow and sediment interactions have been a major focus of the existing monitoring and research program, and antecedent conditions are a primary concern prior to any high flow event. The status of the in-channel and bank-stored sediment supply will dictate whether a high flow event can be considered an enhancement or a mitigation event. On-going monitoring should continue to provide information; however, truly large, unanticipated flows may eliminate streamflow gages. This has repeatedly occurred in the gaged in-canyon tributaries. Therefore, an assessment of flow stage and sediment transport should be conducted as soon as possible after the unanticipated flow. Exceptional low flows may also require monitoring.

Flow will be monitored at the existing USGS gages, and an additional streamflow gage in upper Marble Canyon, if it is added to the USGS gage network. Sediment transport data should be collected at each gage, as well as from the major gaged tributaries (e.g., the Paria and Little Colorado rivers) before (if possible), during and after the flow event.

The USGS cross sections from the Paria River to Badger Rapid, and near the Little Colorado River mouth, should be remeasured prior to (if possible), and after, the high flow event. These measurements should be be repeated 6 month later through the monitoring program, and reported within nine months of the conclusion of the high flow event.

Sand Bar Erosion: Sand bar erosion should be studied at all sites before (if possible) and immediately following high flow events at all study sites. Prior and 6-month follow-up surveys may be part of the existing monitoring program, if timing is appropriate.

Aquatic Biological Resources

Drift and Benthos: On-going monitoring provides sufficient data on the status of the aquatic foodbase. Mid-channel drift should be sampled 4 times daily (high, low, rising and falling hydrograph points) for three days prior to a high flow event (if possible), at regular intervals during the event, and four times daily for three days following the event. If time and funding permits, mainstream sampling should be conducted just downstream from Glen Canyon Dam, at Lees Ferry and just downstream from the Paria River (these could all be sampled by one team); just upstream from the Little Colorado River confluence and at Mile 65 upstream from Lava Chuar Rapid (by another team); and at Mile 225 near Diamond Creek by another team. Whether or not the Paria and Little Colorado rivers are flowing above baseflow levels, they should also be sampled on the same schedule by the appropriate teams. However, if conditions do not permit access to these stations, drift should be monitored at least at the U.S. Geological Survey streamflow gages.

Dissolved oxygen and organic carbon concentrations in the mainstream may change during and after an unanticipated high or low flow. If time permits, a monitoring program at Glen Canyon Dam, Lees Ferry, the Paria River, above and downstream from the Little Colorado River, and at Diamond Creek may be coupled with the organic drift analysis.

Native Fish: Native fish may be substantially affected by unanticipated high flows and, depending on the magnitude of the unanticipated flow event, GCMRC may recommend analysis of impacts on native fish. On-going monitoring trips should be timed to take as much advantage of the unanticipated high flow event as possible.

Native Fish Habitats: Backwaters may be substantially rejuvenated by flows in excess of 45,000 cfs, and monitoring of those habitats may be warranted. Aerial photography may be used to determine habitat area, and land surveys may be used to document the extent of scour and rejuvenation.

Trout: The Lees Ferry trout fishery should be sampled with electro-shocking before (if possible) and as soon after the unanticipated high or low event. Those data should be related to longer-term monitoring results. Analysis of trout redds also may be justified.

Terrestrial Biological Resources

Riparian Vegetation: Changes in wetland and riparian sand bar vegetation may result from flows in excess of 45,000 cfs. Therefore, aerial and on-the-ground monitoring are warranted for flows in excess of approximately 50,000 cfs. These data should be related to on-going monitoring data.

Endangered Kanab Ambersnail: This endangered snail population may be substantially affected by flows in excess of 45,000 cfs. The Kanab Ambersnail Contingency Plan (Appendix 3), proposed by the Kanab Ambersnail Work Group, should be implemented at the earliest possible time. This contingency plan calls for snail and habitat salvage prior to the high flow. If time does not permit, monitoring of the snail population and habitat should be conducted as soon as possible after the unanticipated high flow event, and the data related to on-going monitoring of this population.

Southwestern Willow Flycatcher: Unanticipated high flows in excess of 45,000 cfs may affect historic nest stands or trees used by southwestern willow flycatchers, as well as the associated fluvial marshes in which they feed. The GCMRC recommends that the AMWG Technical Work Group develop a contingency plan for the southwestern willow flycatcher in case of an unanticipated high flow event.

Cultural Resources

NPS Cultural Resources:

Hualapai Cultural Resources:

Southern Paiute Culutural Resources

Socioeconomic Resources

Power marketing information associated with unanticipated flow events should be compiled and reported to the AMMG. Monitoring these impacts and changes are the responsibility of Western Area Power Administration.

Safety

The National Park Service has claimed that river running safety is not an issue during low or high flows in Grand Canyon. Because safety is everybody's business, the GCMRC recommends that the National Park Service provide the AMWG with a safety plan that can be used to advise river runners and backcountry users of unanticipated high and low flow events.

SCHEDULE

The need for impact assessment and public accountability during unanticipated flow events requires increased flexibility of logisitics planning on the part of the AMWG and particularly by National Park Service. The GCMRC recommends that the TWG develop a Contingency Planning Committee to consider these issues and the logistics (e.g., helicopter access, river trip permitting, and funding to cover logistical needs).

BUDGET

Developing a logistics budget for unanticipated events should be the responsibility of the proposed Contingency Planning Committee. The following are some areas that may require monitoring and therefore logistics budgeting attention:

Aerial Photography and Analyses
Streamgage Analyses
Mainstream Cross-sections
Sandbar Erosion
Dissolved Carbon Concentration
Drift and benthos
Native Fish

Native Fish Habitat
Trout
Kanab Ambersnail
Southwestern Willow Flycatcher
Hualapai Resources
Southern Paiute Cultural
Economic Analyses

Objective 3: Develop and iteratively refine an ecosystem model to predict exceptional flow impacts on Colorado River ecosystem resources and processes.

The impacts of exceptional flows should become more predictable as more data become available. Aft to guarantee its utility in understanding exceptional flow impacts on the Colorado River ecosystem, as well as in relation to emergency planning measures by the stakeholders.

REFERENCES CITED

GCMRC. 1997. Glen Canyon Dam beach/habitat building flow: attachments and executive summaries. Grand Canyon Monitoring and Research Center, Flagstaff.

APPENDIX 1: Resource Matrix Analysis of a 2-4 day 45,000 cfs Flow on Colorado River Ecosystem Resources and Processes.

APPENDIX 2: Exerpts from the November 1997 TWG Meeting, Phoenix, AZ Regarding Spills and Beach Habitat Building Flows

"**Risk-of-Spill Flood Trigger Task Group:** (Wayne Cook and Tom Moody) The group evaluated alterna in downstream resource management, historic characteristics of powerplant bypasses, how GCD spill risks are modeled, alternative BHBF decision criteria, and recommendations for BHBF triggering criteria and additional studies.

Tom Moody reported that the ad hoc group investigated criteria and a process for bypass releases from GCD in response to spring inflow forecasts. They created a hydrologic box which gives the opportunity to plan a 45,000 cfs/hr. that will protect and mitigate sediment transport. They evaluated risks and came up with an average box consisting of hydropower on one side and downstream resources on the other. The "hydrologic box" process will be triggered when there is a decision to go over a certain discharge/release.

Spike Flow Triggering Criteria was reviewed (overhead transparency). Every January the forecast is >140% of normal. If subsequent forecasts cause monthly releases to exceed 25,000 cfs/hr. average daily release, we have two triggering mechanisms: 1) January 1st is over percentage of normal forecast (13 MAF). If the forecast from NWS is 13 MAF or greater, we use the first box. 2) if subsequent forecasts show over 25 MAF/year, then you go over 25,000 cfs/hr it is outside of the normal operating criteria and the ROD. January-July is unregulated. The long term chances of this trigger being activated are: 1:6 for low hydrology years; 1:3 for high hydrology years; 1:10 for current conditions. The AOP will need to reflect this in order to stay within the agreement box. Two additional issues (Attachment 7) that go beyond the ROD were identified:

1. Broader fluctuation limits on a daily basis and above the ROD release cap of 25,000 cfs. This is anticipated to benefit sediment and hydropower resources.

2. Increase bypass flows to discharges greater than 45,000 cfs.

Recommendation: Ad hoc group findings to be presented at next AMWG meeting. A request will be made of AMWG to formally charge TWG and GCMRC to investigate the scientific and institutional ramifications of greater fluctuations and bypass releases above 45,000 cfs. Tom Moody's flood release issue paper to be included in 30-day mailing to AMWG.

Contingency Planning Process for Potential High Flows, 1998: Randy Peterson reviewed the strategies analyzed (Attachment 8) under the Proposed, Moderate and Aggressive Operations, assuming that Lake Powell was at maximum storage level on January 1, and starting at 21,500 cfs/hr releases. Present strategy is to leave storage room in Lake Powell by starting to release water in January to provide space in the spring for power plant capacity and releases. They used the aggressive strategy then the present strategy (for historical spill years too). The Present strategy produces 5 spills. Under the Proposed strategy, if there is 13 MAF or greater, a BHBF (spike flow) is initiated immediately. One criteria was to hold 20,000 cfs/hr. until the forecast drives it bigger. If the forecast tells you to go over, do a spike, and then let the forecast happen; the sediment has been moved and the system is prepared to take whatever powerplant releases are necessary. The Proposed strategy produces 6 spills. They experimented with 4-6 spills in the proposed criteria and ended up with 10 out of the 30+ BHBF years. In 4 of the years, a BHBF would have occurred but an actual spill did not. The sediment is set up, 6+ MAF released, then a spill would not have occurred. The Aggressive strategy works for 3:7 or 3:10 cases--they came up with four spills (it is the same historically). 1973 was a dry anomaly. El Nino or La Nina back-to-back anomalies were significant in 1970-1974. In 1983-1984 we would have had a BHBF and a spill afterwards anyway; only 100,000 acre feet is released during a BHBF. The only way to handle a big year of 32 MAF is to start at 21.5 MAF in capacity in Lake Powell, go to 21.3 MAF capacity and then go to 2.8 MAF releases. In a perfect operation you can handle 15 MAF (but whenever have that kind of forecast). 1995 started out less than average above 13 MAF, 2.7 MAF increase in June-July. A BHBF would not have been done early, but when the volume went above 25 MAF, a BHBF would be done. Three out of ten occurrences would have been set up by forecasts to 13 MAF or higher and subject to the resource questions, a BHBF should have occurred. Dave Garrett stated that last year's January forecasts indicated we should be releasing more water than we did. With the current El Nino potential and political climate, is saying 20,000 cfs/hr. in January flows acceptable? Wayne Cook stated that it depends on if maintaining or protecting sediment in the system and you're confident of a high runoff. To prepare for a high runoff, a BHBF leaves sand on the margins and reduces sediment transport rate out of the system. This would be a mitigating spike flow. Historically BHBF's were done on forecasts if they were modified by the NWS then Randy Peterson does his operations on forecasts. Wayne thinks it could be done if other indications are considered rather than politics. Bruce Moore asked how the assumption of ½ MAF water storage space fits in with the flashboards. Wayne Cook stated that if you need to spill and the extensions were there, you can decide on a resource question: we can release 90,000 cfs/hr. or to get a sediment boost we can release 32,000 for 5 months. We need to re-think the process of flashboard use; we are attempting to reduce spills to 1:3, 1:5, 1:6.

An overhead transparency was presented "Glen Canyon Unregulated Forecast Errors." This shows the magnitude of the forecast, but in July there can be an error in the forecast of 1 MAF.

Wayne Cook distributed revised Table 1 (Attachment 8a) (replaces Table 1 in the Report of the Spike Flow Subgroup information) which is a summary of analyses from 1966 to 1997 showing months in which actual spills occurred, categorized by aggressive and current operating practices, and proposed BHBF triggering criteria. It is a graphing of variability and forecast to attempt to understand how much a forecast has to change before we get into spill releases and dam safety purposes. He discussed historical flows and what effects differing flow regimes could have had on the dam flows, spike flows and storage.

Recommendation: This report and proposals be forwarded to the AMWG, including Randy's histogram of when BHBFs would have occurred starting the year at 20 MAF on January 1, recommendations that the powerplant be opened wide immediately, and preceded by a BHBF in January, and that March was more typical with a purposeful BHBF in anticipation of the high year."

APPENDIX 3: Kanab Ambersnail Contingency Plan