Cultural Resources and the Glen Canyon Dam–Colorado River Experimental Flow of 1996

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Abstract. The Bureau of Reclamation conducted an experimental flow from Glen Canyon Dam in late March and early April of 1996. The flow reached a maximum of 45,000 cfs and was expected to provide system-wide mitigation to most cultural sites in the river corridor through the accumulation of more sediment. A positive effect was presumed, but not guaranteed. Monitoring in the years prior to the experimental flow determined that a possible negative impact could result at eight archeological sites along the river corridor between Glen Canyon Dam and Lake Mead. On-site mitigation was required at these locations to fulfill federal agency responsibilities for any impacts sustained as a result of the proposed experimental flow. In addition to the required mitigation, monitoring of archeological sites and other kinds of cultural resources, ethnobotanical resources, beaches, and sediment accumulation at the mouths of arroyos was undertaken to assess the results of the experimental flow. Terraces were studied in the Glen Canyon Reach to determine whether terrace erosion in this area occurred as a result of the experimental flow. This paper summarizes the results of the coordinated mitigation and monitoring of cultural resources and sediments in the area of potential effect of the 1996 experimental habitat building flow from Glen Canyon Dam.

Key words: archeology, Glen Canyon Dam, Colorado River, American Indian Tribes, geomorphology, ethnobotany

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The cultural resources of Glen and Grand canyons take many different forms and are viewed from many different perspectives. This paper summarizes the various ways in which cultural resources were handled by federal and tribal researchers attempting to understand the effects of the experimental habitat building flow upon the cultural resources of the canyon. To many scientists, the cultural perspective seems more like philosophy than science. However, the melding of the tradi-

tional native American perspective with the western scientific method comes together within the cultural disciplines. Although scientific method was used in evaluating sand deposition, depletion and vegetation impacts, the overall program was guided by overarching principles of preservation and protection of cultural resources. This view is shared by both the federal land managers and the tribal researchers who participated in the studies. This coming together of science and philosophy is a difficult concept for many, but it forms the basis of our perceptions of Grand Canyon and why these resources are so important.

Cultural resources embody the broad view of the landscape, where places and their inherent values have significance. Whether it be the geographical locations, archeological sites, plants and animals, air and water, or rocks and minerals, all things are viewed from both their human perspective and the ways in which humans interact with the natural world. In many ways, the cultural resource approach is the original ecosystem management approach.

The approaches taken to understand the effects of the habitat building flow on cultural resources underscores the opportunities that are presented through the range of natural resource studies and the interdisciplinary nature of cultural resource concerns. Researchers within the cultural disciplines are both users and providers of information with application to other studies.

The notion of what constitutes a "cultural resource" in the 1996 Glen Canyon–Colorado River experimental flow was very different from the typical western view of cultural resources. Usually, cultural resources are thought of quite narrowly, generally encompassing little more than archeological sites and historic properties. However, cultural resources along the Colorado River corridor include not only archeological and historical sites, but also water sources, sediment and mineral deposits, plants and animals, and locations identified as traditional cultural properties. All of these resources have the potential to be affected by Glen Canyon Dam. The ultimate goal of the cultural resource efforts related to Glen Canyon Dam operations is preservation *in situ*, with minimal impact to the integrity of the resources.

The Hopi Tribe conducted research on sediment deposition and depletion. Vegetation transects at significant locations were studied by the Southern Paiute Consortium and the Hualapai Tribe. National Park Service (NPS) archeologists and conservation specialists from the Pueblo of Zuni conducted mitigation of potential impacts to archeological sites. Traditional archeological studies were conducted by the NPS through inundation models, repeat photography, planimetric survey, terrace mapping, drainage cross-sections, aerial photography, and data recovery/excavation. All of these studies applied interdisciplinary approaches, yet all were cultural resource studies. Collectively, these studies evaluated the effects of the habitat building flow upon a wide range of potentially impacted cultural resources.

The following statement, prepared by Joseph Dishta of the Pueblo of Zuni, exemplifies the perspective provided by the Indian tribes of the area:

> "The Grand Canyon, from the indigenous peoples point of view, is a vast 'traditional cultural property' that links traditional lifeways with the present. For example, ancestral archeological sites contain human burials, individuals who are still fulfilling their spiritual life journey. Sacred plants, animals, all living beings and elements, are significant. Birds, waterfowl, and animals of the canyon are important messengers of the spirit world. Minerals, part of the living earth, are also important. Many indigenous groups relate their existence to the Canyon. A place where they emerged from its depths and still reside in today. Traditional lifeways of indigenous people are affected by every aspect of scientific and technical studies that have occurred as a result of the experimental habitat building flow. Elements from the inorganic, vegetation, aquatic, and the animal, to archeological sites are of great importance to the indigenous people of the area. The ultimate concern is for the protection of all cultural resources of the canyon" (Dishta 1997 pers. com.).

METHODS

The studies conducted by researchers representing the cultural discipline followed seven separate lines of inquiry, examining 46 separate locations. The following summarizes the various efforts and conclusions for each of the methodologies employed.

Terrace Mapping

Terrace mapping was completed at five locations in the Glen Canyon Reach (0). Surveyors from the Glen Canyon Environmental Studies (GCES) and archeologists from Glen Canyon National Recreation Area (GLCA) performed the work. Data were collected on planimetric survey areas, cumulative cut and fill volumes, and net sediment gain or loss at the terrace margins. Pre-flow, post-flow, and isopach topographic maps were produced, with cut and fill data based upon 0.25 meter contour intervals (Burchett et al. 1996).

At four of the five sites mapped, the experimental flow had a beneficial effect upon the river terraces, evidenced by the increase in the amount of sediment at the base of the terraces. However, at one location, the experimental flow had an adverse effect, evidenced by the loss of sediment at the terrace margin, even though the beach at the base of the terrace was replenished. Review of the maps and measured volumes suggest that, at this terrace, the experimental habitat building flow increased the beach at the bottom of the terrace at the expense of the terrace deposit itself (Burchett et al. 1996).

Sand Deposition and Retention (Drainage Cross Sections)

Examination of the effectiveness of the experimental flow to elevate sediment into the mouths of ephemeral arroyos that drain the margin deposits along the Colorado River was undertaken by the Hopi Tribe. Four study locations were chosen, one in Reach 0, and three in Reach 5. These locations were chosen because they contained cultural resources, well within the area of potential effect from the experimental flow, and had arroyos or drainages that would be overtopped at the level of the 45,000 cfs flow. A Glen Canyon Environmental Studies surveyor and a Hopi tribal archeologist conducted fieldwork. Pre- and post flow maps were completed at a 0.25 meter contour interval (Yeatts 1996).

At three of the four study locations, sediments were deposited in the mouths of the arroyos. The fourth site received no deposition and did not experience erosion. One of the Reach 5 locations, consisting of two arroyos, had the highest variability in response. Some areas of the site eroded as much as 0.5 meters, while other portions of the site received nearly 0.8 meters of deposition. A band of sediment was deposited at the 45,000 cfs level. Overall, 202.4 cubic meters of material was deposited in this site while 124.6 cubic meters of material was eroded (Yeatts 1996).

This study illustrated that planned high flows can elevate sediments into the mouths of ephemeral arroyos, which have been implicated as a factor in the erosion of archeological sites. The results substantiate the concept advanced in the Glen Canyon Dam Environmental Impact Statement (GCDEIS) that high flows can be used as a management tool for system-wide stabilization of cultural resources. One of the most critical aspects of the study that needs to be addressed through long-term monitoring is the duration of time that the deposits remain in the arroyos. Ultimately, if these deposits are not retained long enough to slow down the rate of erosion in the arroyo systems, then the goal for these deposits of stabilizing cultural resources sites will not be realized (Yeatts 1996).

Aerial Imaging

Two different types of analysis utilizing aerial imagery were utilized to evaluate the experimental habitat building flow. An archeologist and hydrologist at Glen Canyon in conjunction with Bureau of Reclamation's Remote Sensing and Geographic Information Group utilized one technique. The other method, utilized by Grand Canyon archeologists, employed aerial video documentation taken at the 45,000 cfs level to determine actual distance from the water's edge to the archeological site. The video image was processed on CD-ROM and was analyzed using the Map Image Process System (MIPS) (Burchett et al. 1996).

Five locations within Reach 0 were evaluated using aerial photography. Evaluation of the area pre-flow and post flow suggests that three of the five sites exhibited gains in sediment, while two sites exhibited minor loss (7% and 10%) (Burchett et al. 1996).

Videography and MIPS analysis was conducted at 18 sites within reaches 1, 2, 4, 5, 6 and 10. Of the 18 sites evaluated, only three sites were impacted by the experimental flow. Two other sites, both historic inscriptions located in reach 2, were underwater during the flow. Reclamation prediction models of flow elevation at one site predicted actual flow to within 15 centimeters. Flow predictions at the other site indicated that the feature was 1.8 meters underwater at 45,000 cfs. Although both sites were affected directly by the flow, no negative impacts were identified (Burchett et al. 1996).

Inundation Model

The accuracy of a predictive 45,000 cfs inundation model supplied by Reclamation was evaluated at six sites in Reach 0. Locations were selected because they were within the area of potential effect and consisted of alluvial terraces with archeological sites. Work was conducted by a Glen Canyon archeologist utilizing Bureau of Reclamation data. The predictive 45,000 cfs water line was a linear interpolation developed from existing flow data available prior to the experimental flow. Photographic images with the interpolated 45,000 cfs flow were produced (Burchett et al. 1996; Fig 1).

The 45,000 cfs inundation model was very accurate at three of the six terraces under study. The model was less accurate at the other three terraces, predicting greater inundation than what actually occurred. The

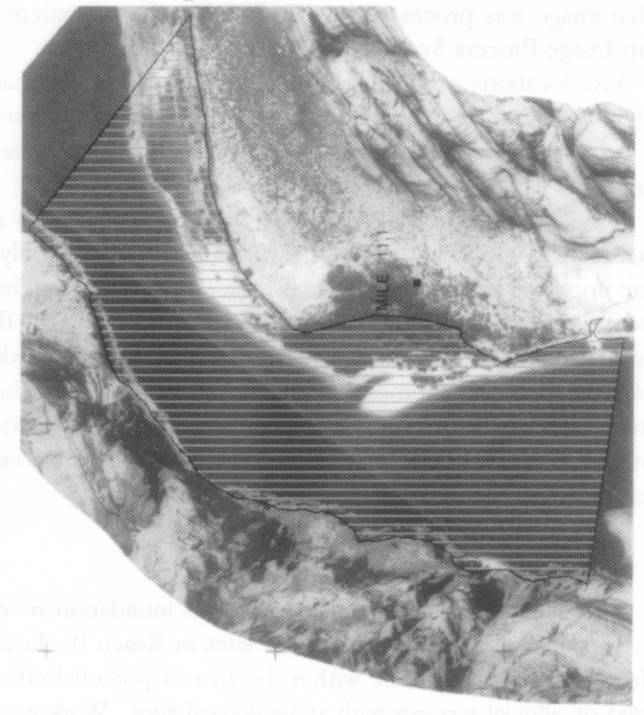

Figure 1. Linear interpolation of the 45,000 cfs water line that was developed from existing flow data.

linear interpolation model from existing flow data should be used prior to future experimental flows to determine where inundation might occur (Burchett et al. 1996).

Photographic Replication

Photographic replication was employed by NPS archeologists at 24 locations within the river corridor, producing over 200 images. Six locations within Reach 0 were visually evaluated using pre- and post-flow photographs. All but one site appeared to have lost terrace material from the experimental flow (Burchett et al. 1996).

Photographic replication was conducted at 18 sites below Lees Ferry as part of an enhanced monitoring program related directly to the effects of the experimental habitat building flow. Sites were chosen based upon proximity to the river and potential for sediment change as a result of the flow. All analyses were conducted as a time 1 (pre-flood) verses time 2 (post-flood) comparison (Burchett et al. 1996).

Photographic replication documented an immediate overall positive effect on archeological sites located in close proximity to the river below Lees Ferry through the accumulation of sediment. A combination of pre-flow mitigation efforts and replicate photography was undertaken at Palisades. Considerable effort was expended prior to the flow in the construction of erosion control features within arroyos cutting through archeological deposits. Pre- and post flow photographs document the amount of sediment accumulation in these locations and provide good indications that site stabilization efforts, coupled with sediment depositing events may preserve sites *in situ* (Burchett et al. 1996).

Sediment accumulation was documented at five locations, with deposition in eddy complexes adjacent to sites noted at two locations. No sites were adversely affected by the flow, and the information gathered provides considerable insight into the effectiveness of controlled high flows as system-wide mitigation for archeological sites where sediment depletion is the causal factor (Burchett et al. 1996).

Mitigation

Eight sites (four historic and four prehistoric) had the potential for inundation, erosion and/or damage from bank slumpage or direct surface erosion. These sites were chosen for mitigation based upon their relative location within the area of potential effect and the possibility for catastrophic loss, requiring data recovery prior to the experimental flow. The experimental flow was found to have no effect or no adverse effect

on seven of the sites. The flow was found to have a beneficial effect on one historic site located in Reach 0 (Andrews et al. 1996).

Three forms of mitigation were conducted consisting of data recovery, medium format photography, and pre-and post-flow underwater dives to determine the extent of impact to the structural integrity of the Charles Spencer steamboat. Photographs and detailed measurements of sediment at various points around the vessel were taken pre and post flow to determine the effect of the flow. Sediment accumulation was documented, indicating a positive effect from the flow (Andrews et al. 1996).

Recovery measures at the four prehistoric sites resulted in mitigation of any adverse impacts due to the experimental flow. Data recovery was the appropriate mitigation strategy because the flow had the potential to adversely affect these resources. Additional information was gained through the data recovery program that allowed expanded information on the geomorphic setting and soil formation processes at these locations. Photographic documentation revealed no adverse impact to the historic inscriptions (Andrews et al. 1996).

Ethnobotany

The Southern Paiute Consortium (SPC) and the Hualapai Tribe undertook ethnobotanical studies. Methods utilized in the studies included both permanent and nonpermanent evaluative techniques. Nonpermanent measures included qualitative assessments of the level of impact due to erosion, flooding, and the presence or absence of river-based streams. Permanent measures included photography, belt transects, line intercept transects, and selected plot monitoring. In general, the impacts were either positive or negligible. For example, the initial scouring and burial of plants, such as willow (*Salix exigi*) that reproduce vegetatively, results in an increase in the abundance of those plants. Nevertheless, the long-term impacts of the increase of introduced species, such as Bermuda grass (*Cynodon dactylon*), are unknown. Also, the effects of the availability of water to plants within the old high water zone are not immediately apparent. Thus, each of these monitoring sites will be visited again in 1997 and reevaluated (Austin and Osife 1996, Phillips and Jackson 1996).

Riparian communities are well adapted to periodic disturbance by flooding. Renewal of eroded sediments along shorelines, scouring out of stagnant return channels, scarification and water-borne dissemination of seeds, and removal of excess dead brush are all potential positive

effects of flooding on riparian communities. Most riparian species are well adapted to periodic catastrophic habitat disturbance. The general trend related to the effects of the experimental flow on ethnobotanical resources indicates stabilization of the habitat and recovery of vegetation (Austin and Osife 1996, Phillips and Jackson 1996).

The Gooding Willow at Granite Park, of special concern to the Hualapai Tribe, survived the flood and was observed to be in better health afterwards than it had been in previous years (Austin and Osife 1996, Phillips and Jackson 1996).

CONCLUSIONS

The overall findings of the cultural resources studies done in conjunction with the 1996 Glen Canyon Dam–Colorado River experimental flow strongly suggest that this event had either no effect, no adverse effect, or a beneficial effect on cultural resources. These findings support the original contention that habitat-building flows can offer a system-wide mitigation for cultural resources. Some locations, especially in the Glen Canyon Reach, did experience loss of sediments or redeposition of sediments in a way that, in the long run, could be detrimental to cultural resources.

Specific results include:

1. At four of the five sites mapped, the flow had a beneficial effect upon the river terraces as evidenced by the increase in the amount of sediment at the base of the terrace.
2. The inundation model was very accurate at three of the six terraces under study; however, at three sites, the model predicted greater inundation than what actually occurred.
3. The flow had an immediate overall positive effect on the cultural resources proximal to the river; however, this gain may be of short duration without additional maintenance flows of equal or greater volume.
4. At three of the four study locations, sediments were elevated in the mouths of ephemeral arroyos that may slow erosion of sediments containing archeological materials.
5. The flow did impact culturally important plants, however the impacts were either positive or negligible as scouring resulted in an increase in the abundance of those plants.
6. The Gooding Willow at Granite Park appeared healthier than it had been for several years during the 1996 growing season. Stabilization efforts prior to the flood release slowed erosion and the

tree was not adversely affected. However, possible loss of stabilization materials and erosion of the underwater bank at the shoreline during high releases are potential causes for concern.

One caution that should be heeded in the planning of future experimental flows is that flows higher than 45,000 cfs will impact other cultural resources than those monitored and mitigated for this experimental flow. Additional monitoring will be necessary to determine the duration of the beneficial effects of sediment deposition on sediment deposits which protect cultural resources by slowing the erosion of the terraces on which they are located. However, if the newly deposited sediments are shown to slow erosion significantly, the system-wide benefits from the experimental flow will be well worth repeating for the perspective of cultural resource preservation.

Continued monitoring will be necessary to determine the duration of the beneficial effects of sediment deposition on beaches, which protect cultural resources by slowing the erosion of the terraces on which they are located. The relatively high steady flows which have been released from Glen Canyon Dam since the spring 1996 experimental flow have caused significant erosion to the newly built alluvial terraces. Although most cultural resources appear more stable than prior to the experimental flow, the need for additional sediment deposition remains.

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