PRELIMINARY SUBJECT
TO REVIEW

CULTURAL RESOURCES

AND THE EXPERIMENTAL HABITAT BUILDING FLOW

IN GLEN AND GRAND CANYONS,

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A SYNTHESIS

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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 archaeological 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 archaeological 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.

Introduction

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 treated by federal and tribal researchers attempting to understand the effects of the experimental habitat building flow upon the irreplaceable resources of the canyon. To many scientists, the cultural perspective seems more like philosophy than science. However, the melding of the traditional perspective with the western scientific method comes together within the cultural disciplines. Although scientific method was used in evaluating archaeological site integrity, sand deposition, depletion and vegetation impacts, the overall program was guided by overarching principles of preservation and protection of the resource. 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 the canyon and why these resources are so important.

Cultural resources embody the broad view of the landscape, where places and their inherent values have a significance. Whether it be the geographical locations, archaeological 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 Glen Canyon Dam program is very different from the typical western view of cultural resources. Usually, cultural resources are thought of quite narrowly, generally encompassing little more than archaeological sites and historic properties. However, cultural resources along the Colorado River corridor include not only archaeological 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.

Research was conducted on sediment deposition and depletion by the Hopi Tribe. Vegetation transects at significant locations were studied by the Southern Paiute Consortium and the Hualapai Tribe. Mitigation of potential impacts to archaeological sites was conducted by National Park Service (NPS) archaeologists and conservation specialists from the Pueblo of Zuni. Traditional archaeological studies were conducted by the NPS through inundation models, repeat photography, planimetric survey, terrace mapping, drainage cross-sections,

aerial photograph, along with 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 archaeological sites contain human burials, individuals who are still fulfilling their spiritual life journey. Sacred plants, animals, all living beings and elements, are significant. Birds, water fowl, 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 which have occurred as a result of the experimental habitat building flow. Elements from the inorganic, vegetation, aquatic, and the animal, to archaeological sites are of great importance to the indigenous people of the area. The ultimate concerns is for the protection of all cultural resources of the canyon" (Dishta, personal communication 1997).

Methods

The integrity of many of the cultural resources of the river corridor are dependant upon the sediment deposits which form the alluvial terraces. Since the completion of Glen Canyon Dam, the sediment resource has declined and alluvial terraces have eroded. A system-wide method for regenerating the river terraces and redistributing sediment is an essential component to maintaining integrity for cultural resources. The effects of these flows on the margin deposits and terraces is an especially important area of study since many of the terraces are of relatively recent origin and contain buried cultural remains. Inclusion of cultural resource studies related to sediment deposition, depletion and flow inundation were an important component of the habitat building flow research. Efforts were put forth in these research areas by the Hopi Tribe and the National Park Service, in cooperation with the Bureau of Reclamation. The effects of the flow on ethnobotanical resources were identified as a concern from both the Southern Paiute Consortium and the Hualapai Tribe. To address these concerns, studies were developed to evaluate vegetation change at certain locations of traditional importance to both tribes.

Overall objectives and hypotheses for all of the various investigations related to cultural resources can be summarized easily. The null hypothesis, simply stated, is that the experimental habitat building flow will have no effect upon cultural resources. Alternative hypotheses were stated as the flow will have a positive beneficial effect or will have a negative, adverse effect. The overarching objective can also be simply stated: preservation of all cultural resources *in situ*. Within each of the various studies conducted as part of the

cultural resource effort, specific objectives and hypotheses were developed. The reader is directed to the individual reports or the integrated cultural resource report for specific information.

The studies conducted by researchers representing the cultural discipline was exhaustive and varied. Seven separate lines of inquiry were investigated, 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 archaeologists 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.

At four of the five locations evaluated using this method, a net gain of sediment ranging from 19.2 cubic meters to 30.8 cubic meters was measured. The minor, but measurable sediment gains at these four locations contrasts to data gathered at the fifth location, where a net loss of 682.9 cubic meters was measured.

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.

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, three in Reach 5. These locations were chosen because they contained cultural resources, fell 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. Field work was conducted by a Glen Canyon Environmental Studies (GCES) surveyor and a Hopi tribal archaeologist. Pre- and post flow maps were completed at a 0.25 meter contour interval. Areas above the expected inundation level were included to provide a relative error assessment. Mapping was carried into the river to 0.75 meters below the water surface. A digital terrain model (DTM) of each site was created using Terramodel® surveying software. From the DTM, contour maps and

surface models of the sites were produced. Interpretation of changes to the surfaces and volumes of material at the sites were made from comparison between the pre- and post flow DTM's.

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 and 124.6 cubic meters of material was eroded.

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 archaeological sites. The results substantiate the concept advanced in the 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.

Aerial Imaging

Two different types of analysis utilizing aerial imagery were utilized to evaluate the experimental habitat building flow. One technique was utilized by an archaeologist and hydrologist at GLCA in conjunction with Reclamation's Remote Sensing and Geographic Information Group. The other method, utilized by Grand Canyon National Park (GRCA) archaeologists, employed aerial video documentation taken at the 45,000 cfs level to determine actual distance from the water's edge to the archaeological site. The video image was processed on cd-rom and was analyzed using the Map Image Process System (MIPS).

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%).

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 flow to within 15 centimeters of actual flow. 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.

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 archaeological sites. Work was conducted by a GLCA archaeologist utilizing 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 cs flow were produced.

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; the model predicted greater inundation than actually occurred. The linear interpolation model from existing flow data should be used prior to future experimental flows to determine where inundation might occur.

Photographic Replication

Photographic replication was employed by NPS archaeologists 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.

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. A combination of over 200 color sides, 35mm and medium format black and white photographs were archived for this portion of the study.

Pre and post flow photographs were taken at one site in Reach 1, two sites in Reach 2, two sites in Reach 4, nine sites in Reach 5, one site in Reach 6, and three sites in Reach 10. A stationary camera taking photographs on a pre-set schedule was utilized at one additional site in Reach 5.

Evaluation of the photographs suggests that similar conditions prevailed along the terrace margins at three locations within Reach 0. The cross sections of the terraces changed, and the building of the beaches was at least partially the result of terrace sediment loss. At two locations in Reach 0, there was no loss of terrace deposits, there was little loss of vegetation, and sediment was added to the beach. At the remaining Reach 0 location, the water from the flow rose above the terrace armor, causing loss of terrace deposits above the 10,000-15,000 cfs flow zone.

Photographic replication documented an immediate overall positive effect on archaeological sites located in close proximity to the river below Lees Ferry through the accumulation of sediment. Sediment accumulation was documented at 5 locations, with deposition in eddy complexes adjacent to sites noted at 2 locations. No sites were adversely affected by the flow, and the information gathered provides considerable insight into the effectiveness of controlled high flows as systemwide mitigation for archaeological sites where sediment depletion is the causal factor.

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.

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 an historic steamboat. General data recovery methods included excavation units measuring 1x1 or 1x2 meters, excavated in arbitrary 0.10 meter levels except where natural stratigraphy was apparent. Excavations were suspended when culturally sterile soil or bedrock was encountered. Shovel tests of soils at two meter intervals between excavation units and the waters edge determined the lateral extent of the buried cultural materials.

The data recovery program resulted in the complete excavation of one site in Reach 0 and testing of three other sites in Reach 4 and 5. Information concerning the nature, depth, and integrity of subsurface deposits, artifacts, and features was collected, along with radiocarbon and botanical samples. The excavated site in Reach 0 was determined to be a short term habitation areas, dated to ca. AD 500-600. The specific features excavated at the other three sites wither contained no surface cultural materials or were determined to be natural occurrences.

Pre- and post flow photography resulted in medium format (6x7cm) and 35mm photographs and color slides at three historic inscriptions inundated by the flow. Pre- and post flow underwater dives resulted in assessment and documentation of the condition of the historic steamboat, along with the establishment of monitoring points and detailed photographs.

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 since the flow had the potential to adversely affect these resources. Additional information was gained through the data recovery program which allowed expanded information on the geomorphic setting and soil formation processes at these locations. Photographic

documentation revealed no adverse impact to the historic inscriptions. The historic steamboat was positively affected by the flow due to an increase in sediment deposition around the remains.

Ethnobotany

Ethnobotanical studies were undertaken by the Southern Paiute Consortium (SPC) and the Hualapai Tribe. Methods utilized in the studies included both permanent and nonpermanent valuative 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 to ethnobotanical resources were either positive or negligible. For example, the initial scouring and burial of plants such as willow *(Salix exigi)* that reproduce vegetatively, resulted 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.

The results of the ethnobotanical research conducted were varied. The locations investigated by the SPC generally exhibited little to no negative impact, with new growth evident at most locations. These sites, primarily in the upper sections of the canyon, did not appear to be as affected by encroachment of exotics as those investigated by the Hualapai Tribe (generally in the western portions of the river corridor).

Effects documented by the Hualapai Tribe include severe erosion, removal of plants by scouring and substrate removal, deep sand deposition, and burying. In some cases there was no effect. All sites showed both erosional and depositional effects, often at different places along the same transect.

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. Many species, both shrubs and herbaceous plants, are clonal, with well-developed root systems that allow rapid regrowth when above ground parts of the plants are damaged or destroyed. Some species, such as willows and cottonwoods, sprout from sections of stems or roots deposited with sediment. Many species produce prolific amounts of seed which may be wind or water-disseminated, and which can germinate and grow rapidly on wet sand. Some non-riparian plant species, however, are less well adapted to perturbation and may not recover from the effects of 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.

The final effects of the 1996 flood as identified in the Hualapai ethnobotanical research will not be apparent until it has been possible to assess the recovery of plants and habitats affected by the flood. Although the transects below Diamond Creek, re-read immediately after the flood, showed little evidence of recovery and a high level of habitat instability, readings in October and November suggest overall recovery. Upstream transects, re-read about six weeks after the flood, had developed a certain degree of stability and the early stages of recovery for some species. Riparian communities are well adapted to periodic disturbance by flooding, characteristically recovering from disturbance rapidly. Many years of stability in a riparian habitat, without disturbance, can lead to unhealthy conditions. An overall evaluation of the effects of resources at the five study sites suggests a general trend of stabilization of the habitat and recovery of vegetation.

The Gooding willow survived the flood and was observed to be in better health afterwards than it had seen in many years.

Other Resource Monitoring

The Southern Paiute Consortium monitored the effect of the experimental flow on other resources of concern. Visual inspection and photographic documentation was completed for two sites which evidenced no change. However, the flow did impact a spring source of importance to the tribe. The impacts to the spring were determined to be positive because Colorado River water cleansed the mineral spring as it regularly did in the years prior to the construction of Glen Canyon Dam. The experimental flow did impact the beaches that provide visitor access to specific Southern Paiute cultural resources. At several monitoring sites, sand was deposited and access to the site was improved. Whether or not enough additional sand was deposited to make the beach more frequently used camp for visitors could not be determined by this study.

Conclusions

The overall findings of the cultural resources studies done in conjunction with the experimental habitat building flow strongly suggest that the flow 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 which may slow erosion of sediments containing archaeological 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 Grand Part appeared healthier than it had 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 cause 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. 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 is apparent.