# Monitoring the Effects of the Spring 2000 Habitat Maintenance Flow on Colorado River Ecosystem Sand Bars

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Sand Bar Studies Fact Sheet
January 2001

***The magnitude and timing of controlled floods required to distribute large amounts of sand into eddies and rebuild eroded sand bars is a critical objective of research and monitoring in the Colorado River ecosystem, downstream from Glen Canyon Dam. Aggradation of sand bars at higher elevations is dependent on the size and abundance of sand temporarily stored on the channel bottom and the duration and stage of the high release. New and existing deposits are valued components of the riverine ecosystem. They provide habitat for native and non-native fish, the substrate for riparian vegetation, erosion-protection for archeological sites, and are used for camping by river runners. The 1995 Glen Canyon Dam Environmental Impact Statement recommends scheduled high releases of short duration be implemented for environmental purposes (U.S. Department of Interior, 1995). Habitat maintenance flows (HMF) are within powerplant capacity (~940 m$^3$/s), whereas those above this discharge are beach/habitat-building flows (BHBF). The former were intended to maintain existing camping beaches and wildlife habitat and the latter to more extensively modify and create sand bars, and thus restore some of the dynamics that result from flooding in the ecosystem.***

## Flood Experiments in the Colorado River Ecosystem

In this study we evaluate the effects of three intentional, controlled floods that were released in 1996, 1997, and 2000. We compare the results to a natural flood that occurred in 1993. The first test of a BHBF occurred in spring 1996, with a 7-day release of 1,274 m$^3$/s. A HMF test occurred in November 1997, following large sand inputs from the Paria River in late summer 1997. The objective of the 1997 HMF was to transfer some of the tributary supplied sand to the banks and bars before it was transported downstream. This release had a 2-day duration of 868 m$^3$/s. A second HMF experiment occurred as part of the Low Summer Steady Flows (LSSF) in 2000 (Fig. 1). The LSSF was designed to test the benefits of low flows on native fishes of the Colorado River below Glen Canyon Dam. The LSSF was preceded in May by a 4-day spike of 858 m$^3$/s, partly intended to improve aquatic habitat by rebuilding and restructuring sand bars. In addition, an unregulated January 1993 flood on the Little Colorado River delivered large amounts of sand and increased the discharge of the Colorado River to a peak of approximately 950 m$^3$/s (Wiele et al., 1996). Together, these four floods of near powerplant capacity or greater provide an opportunity to measure sand bar response to flow magnitude and the timing relative to tributary sediment supply.

## High-Elevation Sand Bars Were Measured Before and After the Spring 2000 HMF

In 1990, a project monitoring sand bars in the Colorado River ecosystem was initiated by Northern Arizona University. Since then, the study sites have been monitored annually and before and after flood events. Site locations, methods, and results can be found in Hazel et al. (1999). The sites are representative of the different types of eddy sand bars and are spatially distributed throughout the Colorado River ecosystem.

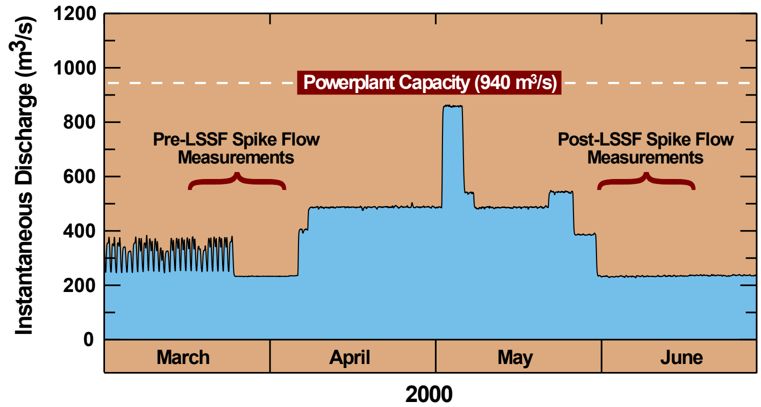


**Figure 1. Instantaneous discharge at USGS streamflow gaging station Colorado River at Lees Ferry, Arizona, March-June, 2000. The timing of measurements made before and after the spring 2000 HMF are shown.**

We calculate the area, volume and thickness of sand stored at high elevation at each bar. We define high-elevation as the area that is emergent at a flow of 566 m$^3$/s, a moderately high flow in the post dam era (Hazel et al., 1999). Areas below the stage elevation reached by this flow are regularly inundated and reworked by dam releases and typically are not available for camping or colonization by plants.

## Long-Term Trends in High Elevation Sand Bar Storage

To identify long-term trends, our approach is to develop a time series of average high-elevation change (Fig. 2). The sample population is divided into sites in Marble Canyon (upstream from the Little Colorado River) and those in Grand Canyon (downstream from the Little Colorado River). One site is located in Glen Canyon, the reach closest to the dam. Figure 2 indicates that the 1993 Little Colorado River flood and the 1996 BHBF were the only high flows to significantly replenish sand in high elevation bars. Although rapid adjustment of newly-aggraded bars to normal dam releases led to high rates of erosion following these events, the rates decreased with time. After more than a year, on average, the sand bars were still larger than they had been before either the 1993 flood or the 1996 BHBF.

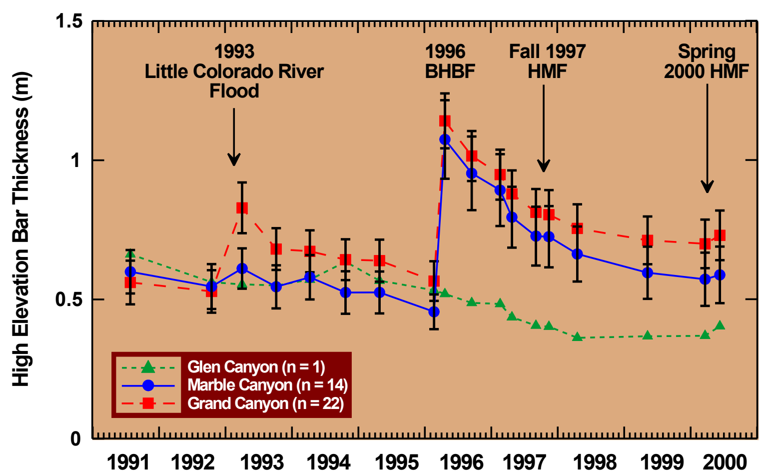


**Figure 2. Average high-elevation sand thickness changes versus time. Error bars are standard error about the mean.**

## Controlled Flood Magnitude

One reason the 1997 HMF and the 2000 HMF did not replenish high-elevation bars is that the flow magnitude was not great enough. In Figure 3, photographs illustrate this pattern of change. Higher stages increase the accomodation space available for deposition (Hazel et al., 1999). Average area and volume changes for the three controlled floods, and for the 1993 Little Colorado River flood, are shown in Figure 4. At discharges below powerplant capacity the changes are not significantly different from 0, suggesting that HMF-type flows are stage-limited. The changes downstream of the Little Colorado River in 1993 show large positive values at a discharge of 950 $m^3/s$, a flow only slightly higher than a HMF. Note that the area increase in 1993 is greater than that of the 1996 BHBF, whereas the volume increase is about half of the 1996 value. The 1993 flood created large deposits because of a greatly increased sand supply. The 1996 BHBF resulted in larger volume deposits, even though the sand supply was lower. While these results suggest that high discharges are more efficient at producing larger volume deposits if sand is available, the 1993 data show that lower discharges are capable of replenishing sand bars during tributary flooding.

## Controlled Flood Timing

Timing deliberate floods to coincide with or closely follow tributary sand inputs, typically in late summer for Marble Canyon tributaries, may provide more effective results than when following periods of prolonged high discharge (U.S. Department of Interior, 1995). The 1993 flood and 1997 HMF were associated with large tributary inputs of sand. The 1996 BHBF and the 2000 HMF occurred in the spring, when suspended sand measurements suggest that tributary sand inputs have been mostly exported from the system (Topping et al., 2000). As a result, during the 1993 flood, sand concentrations in Grand Canyon ranged from 3 to 6 times higher than those during the 1996 BHBF (Rote et al., 1997). During the HMF tests in 1997 and 2000, sand concentrations in Marble Canyon were about the same (D. Topping, USGS, pers com., 2001), and only slightly lower than those of the 1996 BHBF (Topping et al., 2000). Unfortunately, the 1997 HMF occurred more than a month after cessation of Paria River flooding, otherwise the sand supply would have been considerably greater (Hazel et al., 2000). There was little

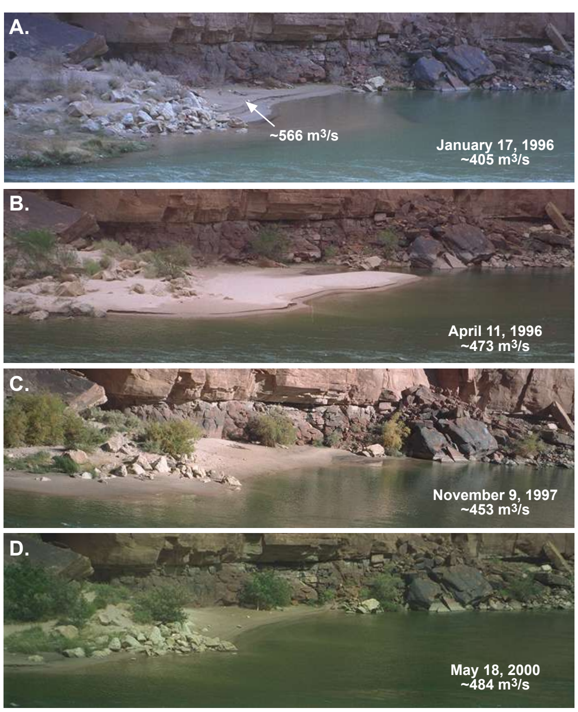


**Figure 3. Selected photographs from the study site located at river mile 16.4 in Marble Canyon. A. Pre-1996 BHBF. B. Post-1996 BHBF. C. Post-1997 HMF. D. Post-2000 MHF. Flow in main channel is from left to right.**

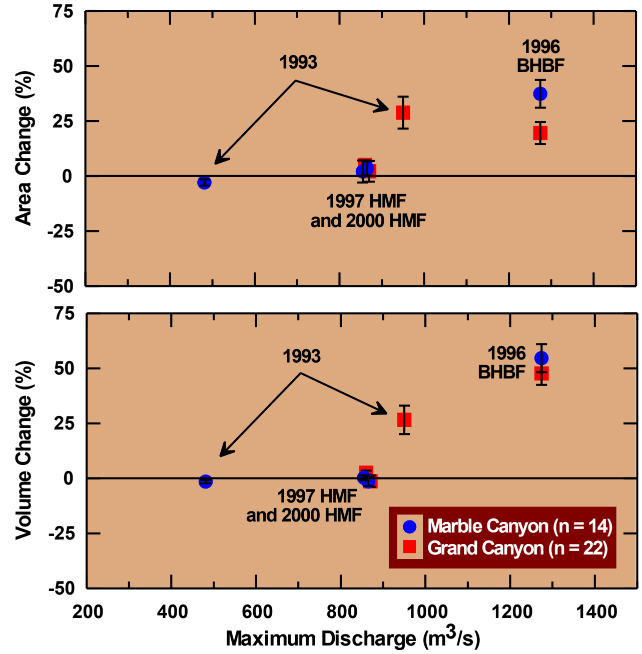


**Figure 4. Average high-elevation area and volume changes plotted as a function of the maximum daily mean discharge. The change between two successive surveys was scaled by the maximum area or volume observed at each site. Error bars are standard error about the mean.**

difference in bar response between the HMF tests in 1997 and 2000 (Fig. 4). In contrast, the 1993 flood built large bars, showing that if sand concentrations are high enough, net deposition will result from HMF-type flows.

Our data demonstrate that sedimentation in eddies is at least as sensitive to flow magnitude as sand supply, because of the major role of accomodation space in determining depositional volume and rate. The effect of lower sand supply can be offset by higher stages. The duration of high flows is considered less important because suspended-sand concentration decreased rapidly during each of the controlled releases (Topping et al., 2000), and deposition rates were highest during the first day or two (Wiele et al., 1999). Flows greater than powerplant capacity may be the only means by which eroded bars can be maintained or rebuilt, especially if HMF releases cannot be scheduled closely with newly input, tributary-supplied sand.

## Selected References

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Funded by Grand Canyon Monitoring and Research Center

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