ADOPT-A-BEACH PROGRAM
Long-Term Monitoring of Camping Beaches in Grand Canyon

Summary of Monitoring Observations for 2019

By
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December 17, 2020

Example of camp restoration resulting from the early November 2018 High Flow Experiment event.
Hot Na Na Camp, RM 16.6L
Photo on left taken July 19, 2018, on right April 1, 2019

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Abstract

For the past twenty-four years, volunteer photographers for the Adopt-A-Beach repeat photography program have been monitoring beaches along the Colorado River through Grand Canyon. Comparative examination of photos gathered through the year, often accompanied by on-the-spot observations contributed by the volunteers, reveal any changes in conditions pertaining to the desirability of the beach as a camp for rafting parties. Factors which contribute to changes that may have an effect on the camp, both positive and negative, include: fluctuating river flows, aeolian action, vegetation increase/decrease, human introduced change, rain associated erosion or other actions, natural or anthropomorphic. Beginning at River Mile 11.3, as measured downstream from the United States Geological Survey gaging station at Lees Ferry, AZ (USGS, 2013), 44 separate beaches distributed along 239 miles of river are in the study. The resulting evaluations are divided into seasonal change (November through March and April through October), and are additionally examined per their distribution in each of the four separate geomorphic reaches. The conclusions are presented as observational, monitoring data only.

Photographic data sufficient for a comparison of beach evolution from late season 2018 to early April 2019 was conducted on 32 of the 44 study beaches. As a consequence of the High Flow Experiment (HFE) conducted in November 2018, 23 (52%) of the beaches had Improved compared to their condition in late summer 2018. Four (17%) of those beaches are located in the Marble Canyon reach, 10 (44%) in the Upper Granite Gorge reach, and 9 (39%) are in the Muav Gorge reach. Six (26%) of the beaches were evaluated as Unchanged since late summer 2018, with 2 (33%) located in the Marble Canyon reach, 1 (17%) in the Upper Granite Gorge reach and 3 (50%) being in the Muav Gorge reach. Of the 3 (13%) beaches classified as Degraded for this period, all three (100%) are located in the Marble Canyon reach. Two of these beaches showed significant sand deposition, usually related to camp Improvement, but by April 2019 the riverside of these beaches consisted of shear cutbanks, making parking and access to the camps difficult. There are 3 of the 44 study beaches located in the Lower Granite Gorge reach, none of which had photos acquired late enough in 2018 to be evaluated for this seasonal study.

For the time spanning the 2019 summer boating season, early April to late October, 22 of the 44 study beaches in the program had photographs and photographer comment sheets spanning a sufficient period of time to be evaluated. None of the three beaches located in the Lower Granite Gorge reach qualified for evaluation in 2019. Of the 22 beaches, 4 (18%) were classified as Improved for the 2019 season, 1 (25%) is located in the Marble Canyon reach and the remaining 3 (75%) are all in the Muav Gorge reach. Four (18%) of the beaches remained Unchanged through the season, split between the Upper Granite Gorge and Muav Gorge reaches, with 2 (50%) in each. A total of 14 (64%) beaches were seen to have Degraded through the summer. Three (21%) from the Marble Canyon reach, 6 (43%) located in the Upper Granite Gorge and the last 5 (36%) are in the Muav Gorge reach.

Regardless of events occurring during the Summer, a beach will receive a classification based on its condition on the final date of evaluation for that season. The primary factor cited for camps classified as Degraded was beach recession due to the fluctuating flow releases from Glen Canyon Dam, a common occurrence immediately following a High Flow Experiment. Other factors attributed to Degradation included Wind Scour, Rain and Vegetation Encroachment. Human impacts, both intentional and unintentional, were the primary cause of camp Improvement.

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Keywords: repeat photography; river sandbar erosion; river sandbar restoration

Introduction and Background

In 1981, the Glen Canyon Environmental Studies (GCES), under the administration of the Bureau of Reclamation, began to study the effects of controlled flow releases from the dam on the downstream river ecosystem (U.S. Department of Interior 1987). Included in this study were effects on sediment supply and recreational resources. Studies of sediment dynamics showed that fluctuating flow releases from the dam have had a degrading effect on sand bar deposits (Hazel and others 1993, Schmidt and Graf 1990) since the closure of the dam. However, beaches can also be replenished by high flows adequate to entrain bedload sand and cause deposition to high elevation areas of beaches (Parnell and others 1997, Wiele and others 1999, Grams and others 2018). Studies of campsite resources demonstrated that the impact to sand bars due to erosion decreases the carrying capacity and camping area available for river parties and backpackers (Kearsley and Warren 1993, Kearsley and Quartaroli 1997).

The Grand Canyon Protection Act was passed by Congress in 1992 to ensure that ecological and cultural resources downstream of the dam would be monitored for changing conditions imposed by operation of the dam. The Act states that Glen Canyon Dam:

"….must be managed in such a way as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park….were established, including, but not limited to, natural and cultural resources and visitor use" (U.S. Department of Interior 1996).

In 1996, following completion of the "Operation of Glen Canyon Dam: Final Environmental Impact Statement" (EIS), a Record of Decision was signed and implemented which included provision for the use of "beach/habitat-building flows." Now referred to as High Flow Experiments (HFE), the EIS defined these events as "…scheduled high releases of a short duration designed to rebuild high elevation sandbars, deposit nutrients, restore backwater channels and provide some of the dynamics of a natural system" (U.S. Department of the Interior, 1995), with the added intent of restoring some of the dynamics that resulted from flooding in the ecosystem. Further, an HFE is defined as a flow release between 31,500 ft^3/s and 45,000ft^3/s (Glen Canyon Dam Adaptive Management Program WIKI, HFE, n.d.). Sandbars form when sediment carried by the river, either from bed load or suspended load, is deposited by the action of eddy currents in recirculation zones. This occurs primarily on the downstream end of debris fans, but also in areas along the river's channel margin (Schmidt 1990). The first HFE was conducted in late March 1996, and consisted of a 7-day steady release of 45,000 ft^3/s that was preceded and followed by steady flows of 8000 ft^3/s for 4 days each (Melis, 2011).

Grand Canyon beaches form the substrate for communities of plants, invertebrates and vertebrates, including species such as riparian birds (Carothers and Brown, 1991). These beaches are also an important resource for river parties conducting trips through Grand Canyon. Both commercial and private river trips, as well as backpackers who travel along the river side, rely on wide sandy areas for camping and recreation. Consequently, those who run the river are interested in observing the changes to camping beaches throughout the river corridor in the Grand Canyon. As a non-profit organization dedicated to protecting Grand Canyon and the Colorado River experience, guide members of Grand Canyon River Guides, aided by guidance from GCES staff, developed and implemented the Adopt-a-Beach Repeat Photography (AAB) program prior to the initial flood event in 1996 in order to assess the evolving state of the recreational resource. The use of photographic duplication over time, and analysis of the differences between photo duplicates as a means of detecting change in the Grand Canyon landscape, has been demonstrated previously (Turner and Karpiscak 1980, Webb 1996). AAB is a long term monitoring program that relies on systematic photograph replication to document and analyze changes in sand deposition and other physical attributes using a dataset of 44 camping beaches along the Colorado River corridor in Grand Canyon. A cooperative agreement with Grand Canyon Monitoring and Research Center (GCMRC), ensures that the extensive AAB photo archive and legacy data are incorporated into the GIS Campsite Atlas project to build a more complete and robust understanding of the status, trends and conditions of camping beaches in the river corridor affected by the operations of Glen Canyon Dam.

Since its inception in 1996, the Adopt-A-Beach program has utilized volunteer photographers to conduct repeat photography of these camps. With the exception of the annual baseline photos acquired during the annual GCRG Guides Training river trip, professional river guides, private party river runners and occasional backpackers make the program possible. These unpaid volunteers contribute 100% of the manpower, the entire dataset of repeat photographs, and valuable input about the condition of beaches throughout each field season and between years. Volunteer photographers for this program are unique in that many run the Colorado River more than once in one season, and are able to provide multiple date sets of repeat photographs and on-the-spot comments for their adopted study beach(es). With the end of the 2019 season, and the addition of 1358 new images, river runners have produced more than 16400 replicate photographs on more than 4100 dates with associated field sheets recording the sequential condition of beaches. More than 250 additional images, mostly used as location references, are also in the archive.

Standardized comment forms completed by the volunteers at the time the photographs are acquired, assisting in the effort to document the beach conditions (see Appendix B). The program assesses the visible photographs and first-hand, objective comments pertaining to changes to beaches, and reports on the conditions as influenced by regulated flow regimes, rainfall, wind, vegetation, human impacts or any other factors that may be present. Monitoring includes information on natural and human-induced impacts to beaches such as cutbanks formed from retreating beach fronts, wind erosion and dune formation, rain gully formation and the effects of visitation and camping (Lauck, 2009).

The presence and impact of the tamarisk beetle, *Diorhabda spp*. have been included in these comments and documented photographically at least as early as 2011. Beginning with the 2014 season, photos are acquired simultaneous to the beach photographs with the specific intent on monitoring the beetle activity. This component of the analysis was added not only for ecological monitoring reasons, but also because of related questions pertaining to the recreational experience: will the beetle remove valuable shade from camping areas, how will other vegetation respond to the impacts on the tamarisk and how might these changes affect the camp. Because monitoring records of the beetle have proven to be sporadic and imprecise, evaluation will only be presented as a possible component of vegetation as a factor of change for the foreseeable future.

The purpose of this report is to present the results of the monitoring effort for the period between late summer 2018 and late October 2019.

Research results include reporting positive “Improved” conditions, negative “Degraded” conditions or “Unchanged” conditions, when no changes were found in beaches. Examples of “Improvement” could be expansion of relatively level camp/sleeping area through sand addition or vegetation reduction, or ‘friendlier’ (less rocky) boat parking and ease of access when loading/unloading boats. A “Degraded” evaluation could be as result of loss of ‘campable area’ (defined as smooth, sandy area at less than 8 degrees of slope and of sufficient size to erect a small tent, Kearsley, 1995) at the camp for a variety of possible reasons, more rocks exposed along the front of a beach, or abrupt elevation change at the beach front which complicate the loading/unloading of boats. Attributes of the primary and secondary processes that cause change in camping beach area and quality are also included. Specific research questions that are addressed by this report are:

- What changes, if any, are found at the beaches through the boating season of 2019?
- What changes occurred in beach conditions during the winter between late 2018 and April 2019?
- How are the resulting observations distributed throughout the river corridor?
- Which processes resulting in a change of condition at a beach are most prevalent?

Methods

Study locations and beaches

Since 1996 the AAB program has studied an average of 34 of the 44 targeted beaches per year from within three of the five *critical reaches* of the river corridor (Figure 1). The practice of assessing camping beach resources within critical reaches was first developed by Kearsley and Warren (1993), and modified for the 1996 Adopt-a-Beach study by Thompson and others (1997). A critical reach is defined as a section of the river where camps are in high demand and few in number. The same reach system has been in use for all years of study, 1996-2019. All river miles used conform to the GCMRC mileage system (USGS, 2013). The reaches are as follows: 1) Marble Canyon, river miles 9-41; 2) Upper Granite Gorge, river miles 71-114; 3) and Muav Gorge, river miles 131-165.

Two additional critical reaches were added during the 2003 monitoring season. The purpose was to increase the sample set of beaches in order to more widely represent the effects of beach erosion and building throughout the whole river corridor below Glen Canyon Dam. These new reaches included Glen Canyon, from the dam to Lees Ferry (river mile 0), and Lower Granite Gorge, from Diamond Creek (river mile 226) to Gneiss Canyon (river mile 236). Unfortunately, no data has been collected for the Glen Canyon reach for a few years, but the Lower Gorge reach, which was been extended to include the 250 Mile Camp in 2009, is still being actively monitored.

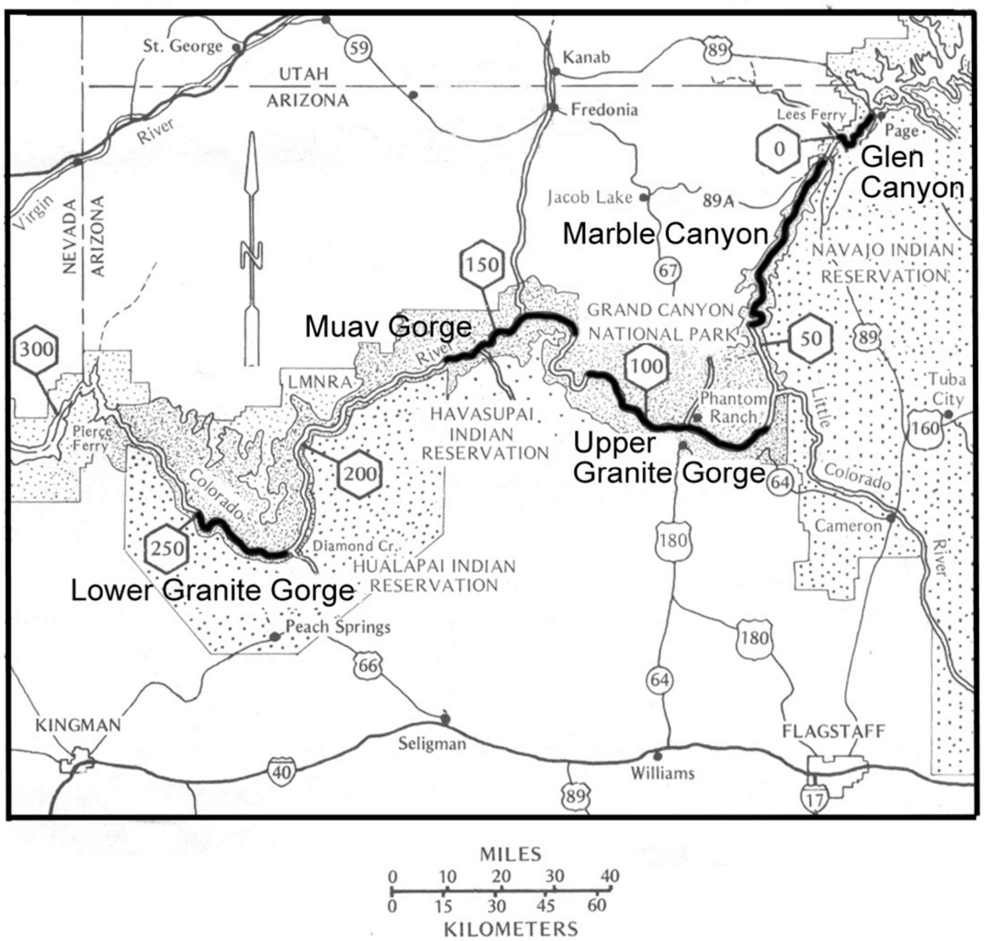


Figure 1. Locations of five critical reaches along the Colorado River in Grand Canyon National Park

Table 1 shows the study campsites (n = 46), 34 of which were originally inventoried in 1996, and includes beaches added in 2000, 2001 and 2009. Note that all analysis statistics are now based on 44 study beaches, beginning with Soap Creek at 11.3 miles downstream from Lees Ferry.

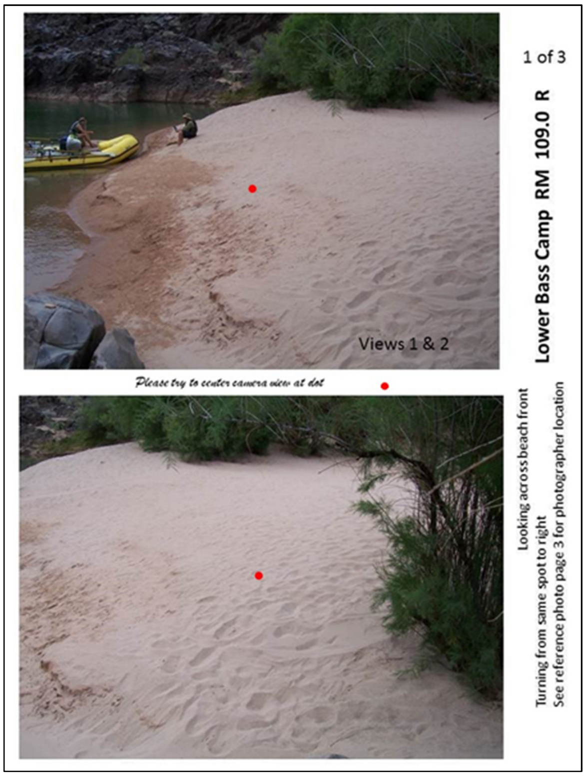
Glen Canyon		Marble Canyon		Upper Granite Gorge		Muav Gorge		Lower Granite Gorge	
Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp	Mile	Camp
-13.0	Dam Beach	11.3	Soap Creek	76.0	Nevill's	131.7	Below Bedrock	230.6	Travertine
-8.0	Lunch Beach	12.4	12.4 Mile	77.1	Hance	132.5	Stone Creek	236.1	Gneiss Canyon
		16.6	Hot Na Na	81.7	Grapevine	133.7	Talking Heads	250.0	250 Mile
		19.4	19.4 Mile	84.6	Clear Creek	134.2	Race Track		
		20.7	North Cyn	85.0	Zoroaster	134.5	Lower Tapeats		
		22.7	23 Mile	92.1	Trinity Creek	135.2	Owl Eyes		
		29.5	Shinumo Wash	96.6	Schist	137.8	Back Eddy		
		35.0	Nautiloid (Middle&Lower)	97.3	Boucher	144.0	Kanab Creek		
		37.9	Tatahatso	98.7	Crystal	146.1	Olo		
		38.6	Martha's	100.2	Lwr Tuna	148.9	Matkat Hotel		
		41.2	Buck Farm	108.3	Ross Wheeler	150.9	Upset Hotel		
				109.0	Lwr Bass	156.3	Last Chance		
				110.0	110 Mile	165.2	Tuckup		
				114.9	Upper Garnet	167.0	Upper National		
				115.1	Lower Garnet	167.2	Lower National		

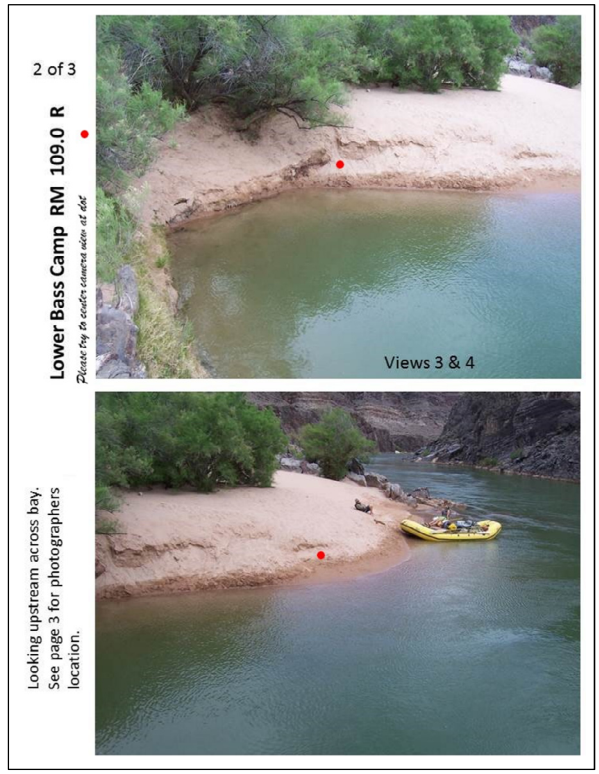
Table 1. Sample set of camping beaches inventoried that lie within the five critical reaches.

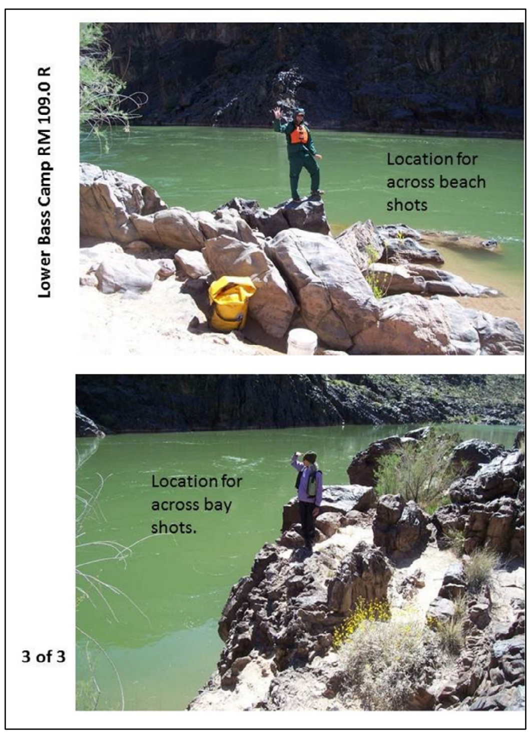
Unlike other established re-photography studies, both within and outside of the Grand Canyon, the AAB program does not adhere to a regime which includes matching photos per a specific time of day or date (Webb 1996, Webb, Boyer and Turner, 2010). The photographs obtained here are much more opportunistic and acquired whenever a volunteer happens to pass their chosen camp. However, guidelines for the volunteer are provided to help regulate the consistency required to make adequate comparisons between the images. Every beach in the inventory has established photographic locations that show an optimum view of the beachfront and as much of the actual camping area as possible. However, the portion of the camp photographed at each beach, the relative photographic locations between beaches and the number of images acquired per beach are not all the same. This means that one beach may be evaluated through slightly differing information than another one, in that not every beach photo set contains the same 'clues.' The resulting evaluations can only be compared with results for camps using the same views. Most commonly, photo sets are taken from the boat on the river, taken as a single image or overlapping series, to provide a full, upstream to downstream look at the beach. Photos taken from specifically designated locations on shore, looking across the front of the beach, usually from an elevated, oblique angle, are usually acquired as well (See Figures 2 & 3). Combined, these views provide a considerable amount of information for analysis.

Occasionally, a few beaches are photographed from the river only. Unfortunately, this often limits the visibility of the upper or rear part of the camp. Efforts are being made to expand these visits to include a shore-based view, but this is completely up to the volunteer and their time available. Also, almost half of the beaches have photo locations toward the back of the camp, looking across the upper part of the beach or toward the river. While not always practical, these views are invaluable additions to the beach dataset.

Each year, GCRG motivates guides to adopt as many beaches as possible. To encourage a relatively complete data set from year to year, GCRG encourages adoption of high-priority beaches (n = 27) first. These beaches have been adopted consistently for most of the study years. Usually, they are camps that can be used year after year by the river community, and thus are continually in high demand. Due to Park regulations or changes in the river channel, seldom used beaches, like Hance, Kanab Creek, Lower Tapeats or Gneiss are considered as lower priority but are still photographed regularly. The remaining beaches are adopted once high-priority beaches have been claimed.







Figures 2, 3 & 4. Examples of reference sheets supplied to volunteers directing photographer on where to stand and which views should be acquired.

The time-series photos taken within study locations allow assessment of relative change over the course of each season and between monitoring years. The number of adopted beaches with useable summer season long data in 2019 totaled 22. Each record in the data base represents an individual visit to a beach where each beach usually has 2-5 photos associated with it. Adopters often take extra snapshots of various impacts such as flash flooding in Hot Na Na (July 2018) and North Canyon (October 2010) and debris flows at National Canyon (July 2012). These documented events and data are available to any interested researchers through Grand

Canyon River Guides or Grand Canyon Monitoring and Research Center, http://www.gcmrc.gov/ and the images are currently available as part of the Adopt-A-Beach photo gallery at https://www.flickr.com/photos/147271391@N08/collections

Part of the Adopt-A-Beach program is to provide photos of unusual natural events in Grand Canyon to interested parties.

Analysis

When a volunteer requests a camera and a beach assignment, they are asked to photograph a completed datasheet (Appendix B), identifying the beach name and mile, plus the photo date and time, immediately prior to photographing the camp. This information is included in the captioning of the image, and helps to correctly place the photo chronologically during analysis. While this practice occurs most of the time, occasionally the datasheet is photographed later or, rarely, not at all. Photos without a distinct date/time attribute in the photography sequence are examined by water color, shadowing on the surrounding walls, or other common elements such as guest attire when available, to help correctly identify the proper sequential placement of the image(s). Embedded metadata in the image can also be used as reference to correctly code the image by date and time. Very infrequently, the date or time may be incorrectly recorded on a datasheet, then onto an image.

When comparing the photos for evaluation, numerous criteria are used to gather the empirical data. After the images are sorted by camp and have been given a date and time caption, a consistent pattern of examination was conducted for every analysis. This began with the water level determination for the first image examined in any set. This was accomplished by consulting the flow graph of one or all of the following USGS gauges: Colorado River at Lees Ferry, AZ (09380000), Colorado River Near Grand Canyon, AZ (09402500), Little Colorado River Above Mouth Near Desert View, AZ (09402300), Kanab Creek Above the Mouth Near Supai, AZ (09403850), Havasu Creek Above the Mouth Near Supai, AZ (09404115) or the Paria River @ Lees Ferry, AZ (09382000) and Colorado River Above Diamond Creek near Peach Springs, AZ (09404200). See Figures 4 – 12. These graphs also helped determine when additional sediment may be entering the mainstem for possible deposition along beaches downstream. During comparison to each subsequent image, identification of a near-shore landmark or two and its proximity to the current shoreline was employed to help determine relative water levels. The flow graphs were also revisited if required, particularly when it appeared that the river volume and possible sediment load changed due to additional input from the Paria or Little Colorado tributaries.

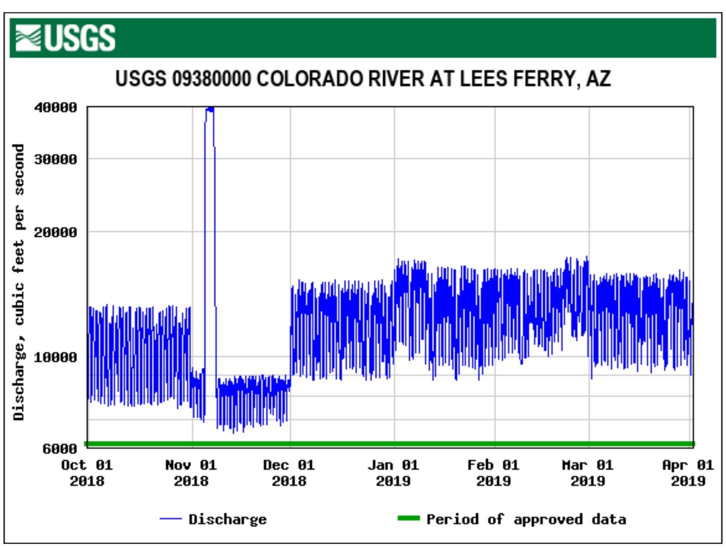


Figure 5. Flow graph for Colorado River at Lees Ferry, AZ., October 1, 2018 through November 1, 2019

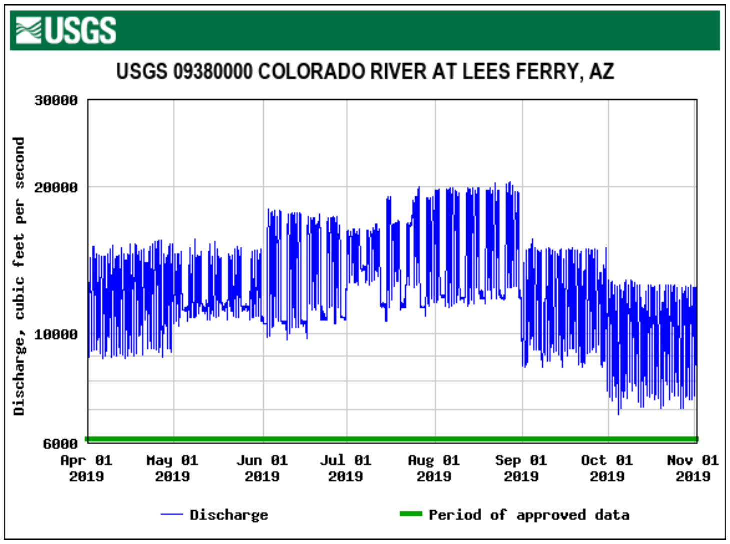


Figure 6. Flow graph for Colorado River at Lees Ferry, AZ., April 1 through November 1, 2019

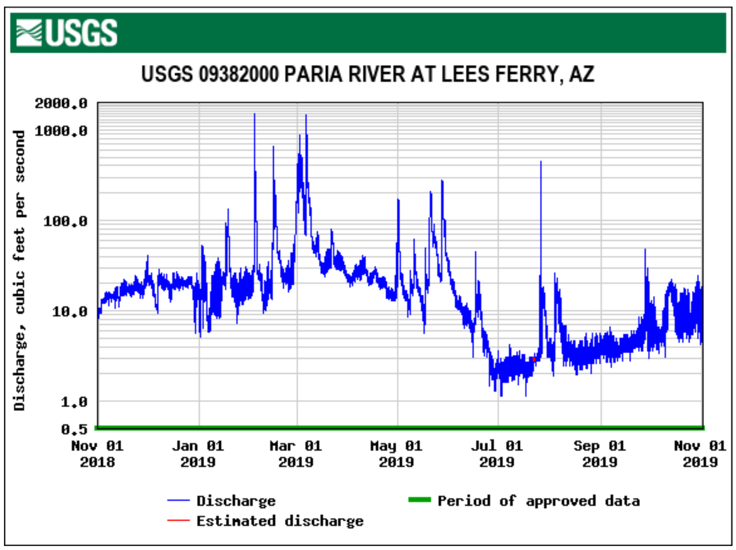


Figure 7. Flow graph for Paria River at Lees Ferry, AZ., November 1, 2018 through November 1, 2019

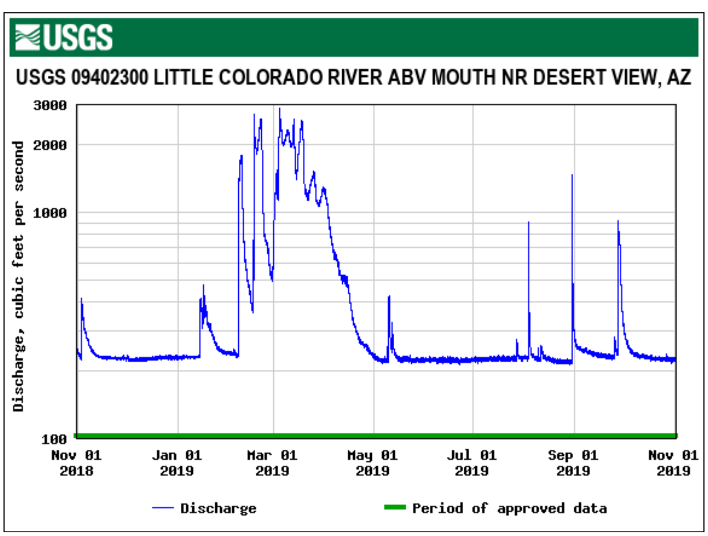


Figure 8. Flow graph for Little Colorado River above mouth near Desert View, AZ November 1, 2018 through November 1, 2019

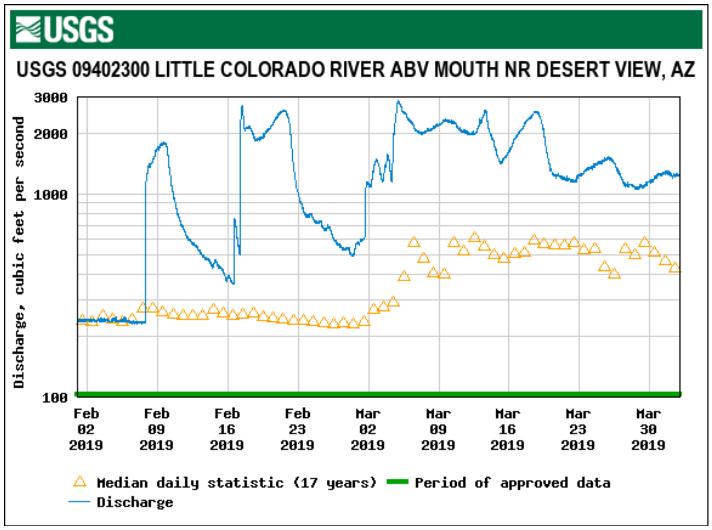


Figure 9. Flow graph for Little Colorado River above mouth near Desert View, AZ February 1, 2019 through March 30, 2019

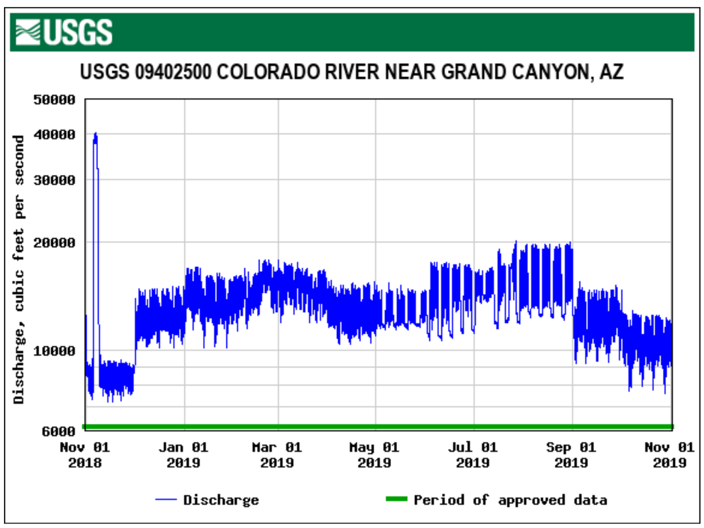


Figure 10. Flow graph for Colorado River near Grand Canyon, AZ. November 1, 2018 through November 1, 2019

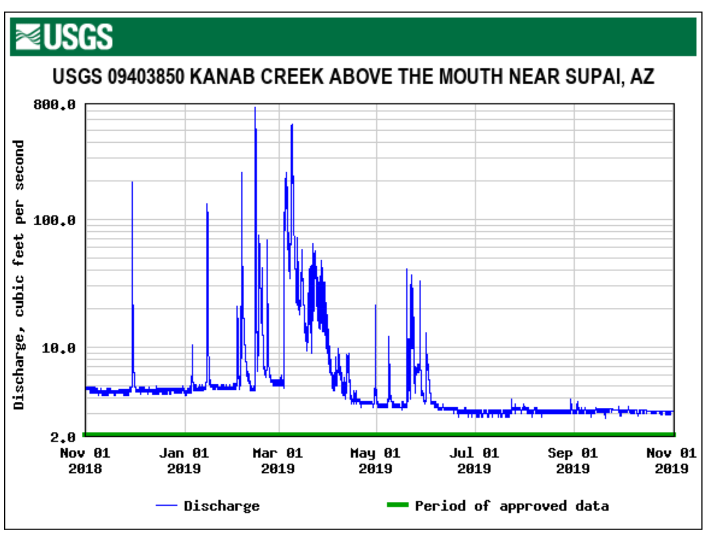


Figure 11. Flow graph for Kanab Creek above the mouth near Supai, AZ. November 1, 2018 through November 1, 2019

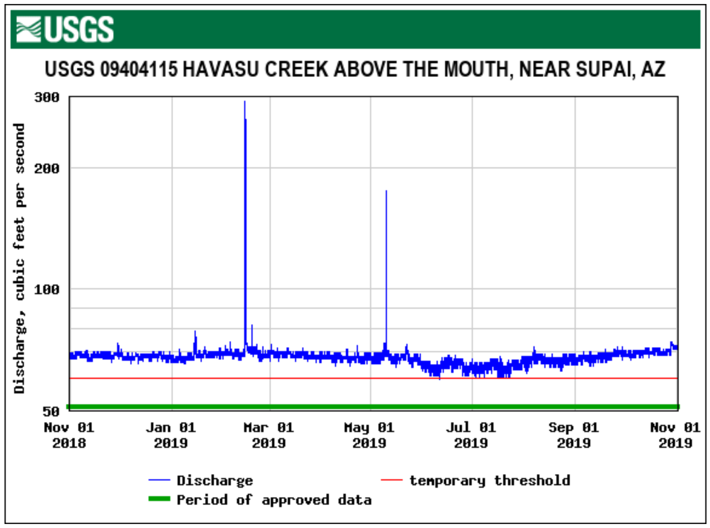


Figure 12. Flow graph for Havasu Creek above the mouth near Supai, AZ. November 1, 2018 through November 1, 2019

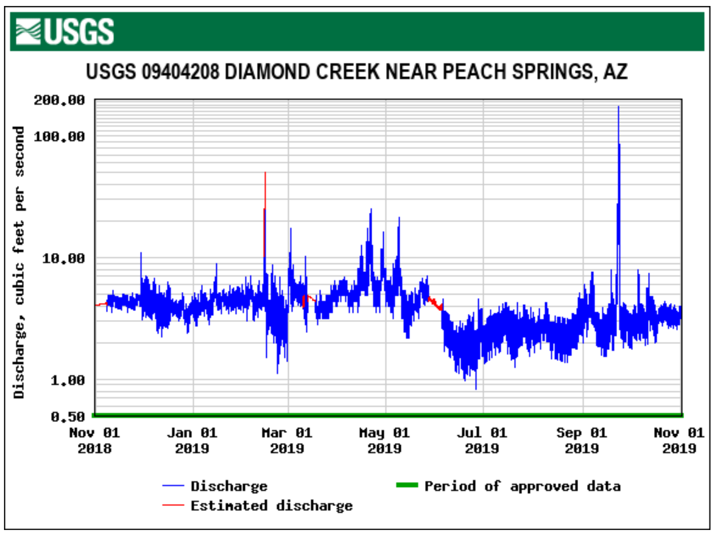


Figure 13. Flow graph for Diamond Creek near Peach Springs, AZ. November 1, 2018 through November 1, 2019

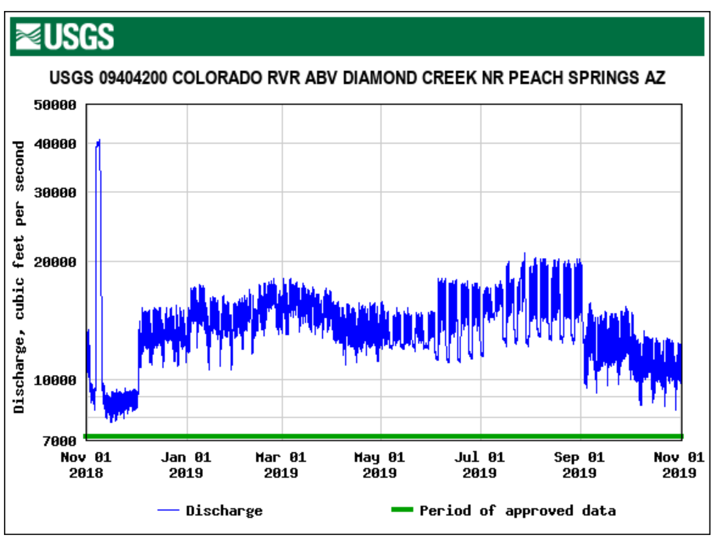


Figure 14. Flow graph for Colorado River above Diamond Creek near Peach Springs, AZ. November 1, 2018 through November 1, 2019

Prior to visual analysis, each set of datasheets for that particular beach is consulted to identify the photographers' impressions and to note any factor or event that should be evident during the analysis.

The images were viewed for evaluation using the Adobe Photoshop v7.0 and Windows 10 Photos Viewer software viewed on a Dell 24" monitor. Beginning at the front, or shoreline of the beach, the images were examined and compared. The presence/absence of rocks or debris, either hindering or enhancing boat parking, were noted. Due to the variety of river flow levels between the comparison photos, change in the 'parking' at a particular beach is often difficult to evaluate, and, when covered at higher flows, is considered only when recorded by the AAB observer. Any beach front cutbanks which would affect unloading/loading of boats at similar flow levels, or which indicated erosion of the beach by the river flow were also noted. Conversely, the absence of a cutbank or smoothing of an access slope helped determine the possible addition of sand by sediment augmentation or other river action that benefited the camping desirability of the beach.

The images being compared were then examined progressively from beach front to back to note the absence or addition of rocks or other debris which would impact the total area being used as a camp. The location and visual extent of emerging rocks can usually indicate the physical action which occurred to reveal the rocks. As an example, rocks which were covered in image "A" by sand, covered by river flow in image "B" and subsequently revealed as the water level receded, are noted as indicators of river flow erosion. Conversely, the reverse action would be noted as an indicator of sediment deposition.

The same kind of visual clues can also be used to determine aeolian impact, particularly when the exposed and/or covered rocks and shelves are higher than any possible river flow level during the time period being examined. During the November 2018 HFE, some camp areas increased as a result of boulders and bedrock being covered by sand carried onto the beach at the higher flow. Since then, some of these rocks have re-emerged as a result of wind scour, resulting in a decrease in camp area.

Determining whether a beach was uncomfortably steep for access was easily assessed if one of the photos was taken across the front, either looking up or downstream. But beaches with only head-on photos are more difficult to discern. Well-trodden paths, leading to and from obvious access points, creating easily eroded channels, are the primary clues. Human caused erosion is usually noted by the volunteer photographer and can be correlated with the images.

Beach images acquired from various viewpoints were the easiest to determine changes in vegetation. When this was not possible, such as head-on only shots, a systematic comparison from one end of the beach to the other was used. Baccharis species, arrow-weed (*Pluchea sericea*), Russian thistle (*Salsola tragus*), coyote willow (*Salix* species) and camelthorn (*Alhagi* species) were usually identifiable when noted moving into a previously open sand area, or were missing from subsequent images.

Because of varying photo locations from one beach to the next, some agents of change are more readily apparent than others. Deposition/erosion across a beach front at waterline is always more prominent in the images than perhaps vegetation incursion or loss. Aeolian activity on a beach is more apparent when the photograph is acquired from an angle slightly higher than the beach itself, and vegetation changes are more readily denoted when there are images of the beach in addition to the beach front itself. Not all beach photos include areas where human impacts would most likely be found.

While every effort is made to ensure an even, consistent analysis of the beaches, the patterns of photo acquisition on any particular beach may bias the evidence of an agent of change. Conversely, some bias towards a No Change determination may be present in other photo acquisition sets. The final determination is sometimes dependent on the patterns of photo acquisition established for a particular beach and, to a lesser extent, the effort exerted by the volunteer photographer.

Prior knowledge of the study sites by the investigator was also considered, though this did not determine the final classification used for any particular beach. Using these analysis criteria, the beaches are given classifications indicating desirability as camping beaches, stated as Improved, Degraded or Unchanged. While the designations of Unchanged, Improved and Degraded are inherently subjective, the results are reflective of the stated evaluation purpose of determining the beach as a useable camp for river trips. No photogrammetry techniques were employed and this should not be interpreted in any way that results were obtained using anything other than objective evaluation.

The data are compared and analyzed according to the research questions that are most applicable for the time period being studied.

Figures 15 & 16. Documentation of beach access Improvement through a combination of human traffic and fluctuating flows. Tatahatso Camp, RM 38.6 L, April 2, 2019 (upper) and September 13, 2019 (lower).

Results

Winter of 2018 - 2019

Per Classification

To qualify for analysis of change through the winter of 2018-2019, a beach needed be have been photographed in 2018 after mid-August and again in April 2019. Of the 44 Adopt-A-Beach study beaches, 32 are included in the through-winter evaluation. Of the thirty-two, 23 (72%) appear to have Improved, three of the beaches (9%) have Degraded since summer 2018 and 6 (19%) show no appreciable change. The predominant factor associated with this exceptionally high percentage of Improved beaches is the replenishment of sand attributed to the HFE conducted in November 2018. The subsequent erosion and shear cutbank of the replenished and elevated beach was the reason for at least one Degraded and one No Change classification as well. (See Figures 15, 16). It appears that both of these beaches had Improved with the HFE but had deteriorated from subsequent events, most likely the fluctuating flow regime through the winter.

All three (100%) of the beaches receiving a Degraded classification are located in the Marble Canyon reach and all three displayed significant cutbanks and sand recession across the front of the camp. Distribution of the six beaches with Unchanged classification include 2 (33%) in the Marble Canyon reach, 1 (17%) located in the Upper Granite Gorge and 3 (50%) found in the Muav Gorge and are fairly well distributed through the corridor from River Mile 12.4 to mile 167.2.

It is evident that the 72% of camps which Improved increased in size due to the HFE. However, the beneficial results did not always present as simply increased camp area. While a larger sand substrate was often found, ease of camp access due to improved parking and a leveling of the camp were also factors. The Improved beaches were distributed throughout the first three reaches with 4 (17%) located in Marble Canyon, 10 (44%) in the Upper Granite Gorge and 9 (39%) are found in the Muav Gorge. Unfortunately, none of the 3 beaches located in the Lower Granite Gorge reach had photos acquired late in 2018 and therefore did not qualify for analysis.

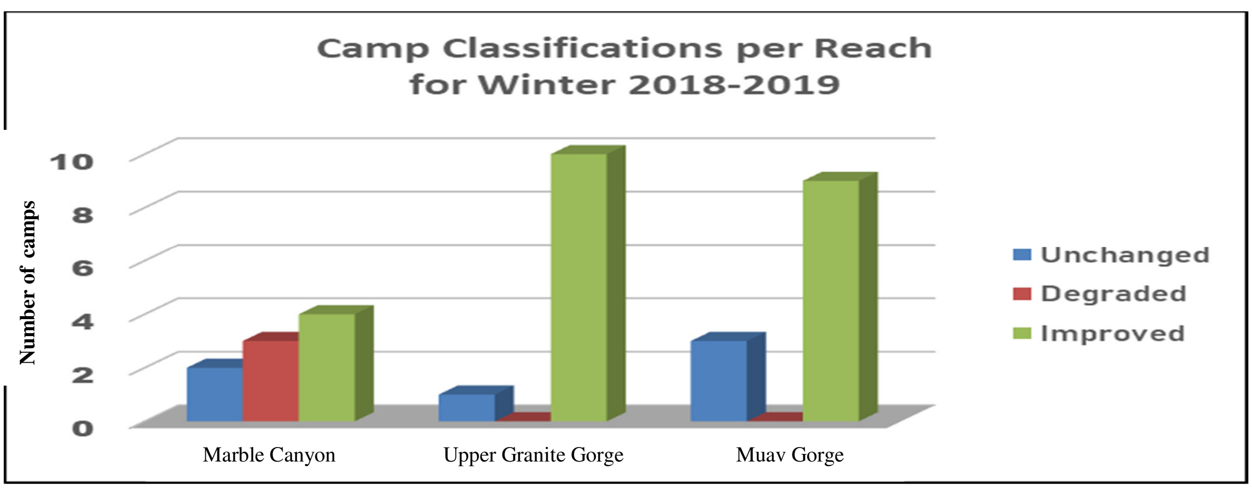


Figure 17. Graphic illustration for Winter 2018 to 2019 evaluations per Reach.

Through 2018 boating season

Per Classification

For the period covering the 2019 summer boating season, photos were used which spanned from April 1 to October 31. The minimum range of dates considered was April 20 through September 4. Daily fluctuating flows occurred steadily during the study period with the exception of the weekend steady invertebrate enhancement or “bug flows” during May through August. These are constant dam releases of approximately 10500 cubic feet second (cfs) over a 30 hour period. The weekday fluctuations in April and May averaged 9 – 15000 cfs, in June the flow range increased to 11000 – 17000cfs. July bumped up slightly to 13 – 16000 cfs for the first two weeks and continued sporadically through the month at an average fluctuation of 14 – 19000 cfs daily. Through August, flows were steady weekday daily fluctuations of 13000 – 20000cfs. During September and October, steady weekend releases were discontinued. Daily fluctuations for the month of September ranged from 9 – 14500cfs and for October, 7500 – 12500cfs.

Thirty-nine of the 44 beaches were adopted for the 2019 season with 22 having photographs and adopter comment sheets spanning a sufficient period of time to be evaluated. The seventeen beaches excluded were not photographed after August 1 and no images were available to be late enough in the season to be considered for a complete season analysis. Of the 22 beaches included in this portion of the analysis, 4 (18%) did not show significant changes, and were classified as Unchanged through the season. Fourteen of the beaches (64%) had Degraded through the summer, and 4 (18%) of the beaches evaluated was considered to have Improved by the Fall of 2019.

The most often cited cause of beach Degradation during the 2019 season was beachfront erosion by fluctuating flows, particularly noticed after the higher flows during August. This was considered the primary cause in thirteen cases and as a contributing factor in 2 additional instances. Beach recession and both increased occurrence and height of cutbanks are common and most pronounced when fluctuating flows begin cutting new deposits of sand from an HFE. The high releases reaching 20,000 cfs in August were particularly destructive. Wind erosion was the second leading factor of degradation, exposing rocks in the camp area and forming hillocks of dunes at tent sites. Rain erosion creating gullies, increased vegetation in camp and human traffic were also noted as primary factors of degradation, though at a small number of sites. Anecdotal information confirmed that, during the summer of 2019, the river corridor experienced very little of the rainfall events which commonly create beach erosion. Wind deflation, vegetation increases and trailing by people were secondary contributors when camps became less desirable.

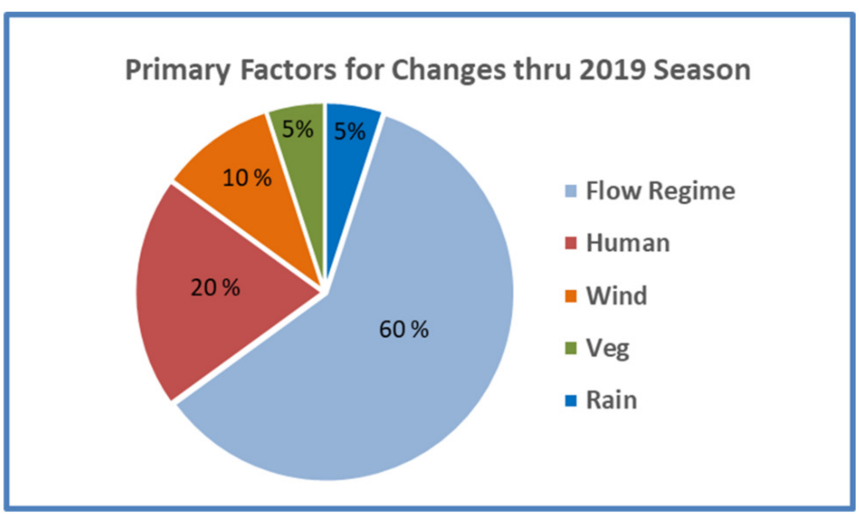


Figure 18. Graphic illustration for factor frequencies behind any change during 2019 season

Four beaches were classified as Improved through the 2019 season. In each instance, human traffic, slope failure and simple gravity brought sand downslope to cover rocks at parking spots and to soften the incline from the water into camp, making access when loading/unloading boats easier. There were also 4 beaches that showed little, if any change and were classified as No Change. One of these beaches had an increase in vegetation, one had a minor gully from erosion and a third did have sand movement, but none of these factors impacted the immediate camp area of the beach.

Figures 19 & 20. Documentation of sand deposition during November 2018 High Flow Experiment. Upper North Canyon Camp, RM 20.7 R, October 15, 2018 (upper) and April 2, 2019 (lower).

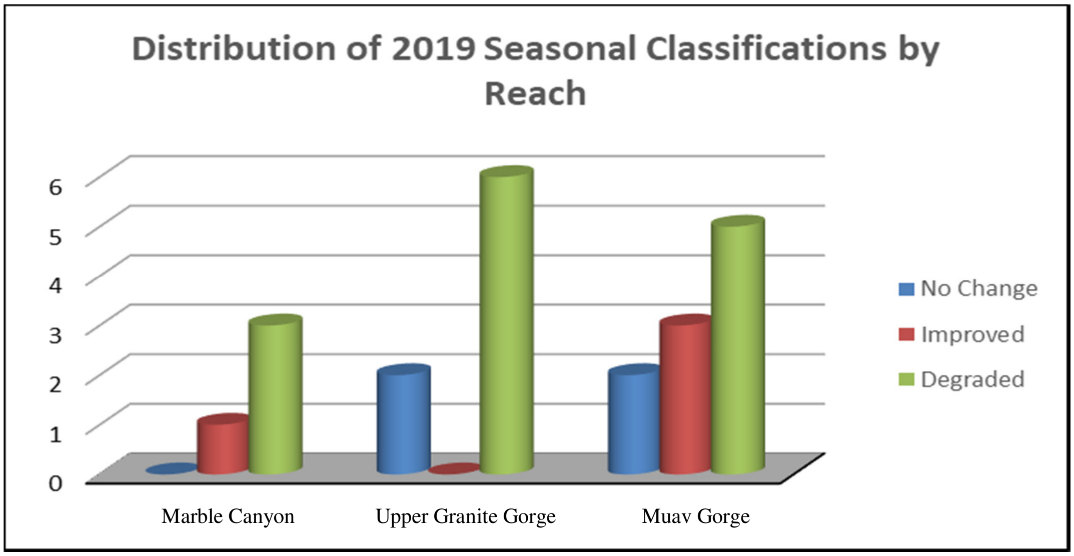


Figure 21. Graphic illustration for 2019 classifications by reach

Per Reach

Those beaches classified as Unchanged through the 2019 season were evenly split between two reaches, The Upper Granite Gorge and the Muav Gorge, with 2 (50%) in each.

There were 14 beaches classified as Degraded in the study and were distributed throughout the first three reaches. There were 3 (21%) found in Marble Canyon, 6 (43%) in the Upper Granite Gorge, and 5 (36%) distributed through the Muav Gorge. (See Figure 21).

It's unfortunate that none of the three beaches located in the Lower Granite Gorge had sufficient data for analysis as two, Travertine Falls and Gneiss showed marked Improvement as a result of the HFE and could have been informative as to the effects of fluctuating flows the further one gets from the dam. A comparison of weekday flow graphs for August 2019, from Lees Ferry and the Colorado Above Diamond Creek shows that, as the releases from Glen Canyon progress downstream, the river maintains the higher cfs release throughout the corridor but the daily low increases as the distance from the dam increases.

Conclusions

For the winter 2018-2019, 72% of the beaches showed a decided Improvement attributable to the High Flow Experiment from early November 2018. There are indications which lead the author to believe that the number of beaches benefiting from the HFE may have been higher, but the winter fluctuating flows, particularly in early January and late February, may have diminished the positive effects. Spike inflows from the Little Colorado River during February and March may have added enough sediment to the system to offset the fluctuating flow scour on beaches in the Upper Granite Gorge reach.

It's inevitable that beaches which displayed benefits from an HFE should degrade throughout a summer of fluctuating flows. This was the primary factor which resulted in an end-of-season classification of Degraded on 63% of the beaches. No matter how it may appear from one week to the next, this is a dynamic system and beaches which Improved with the addition of freshly deposited sediment must degrade. The flow regime just accelerates this action.

The summer of 2018 was one of the most destructive to beaches by rain events recorded by the Adopt-A-Beach program. The HFE in late 2018 helped in a substantial way to mitigate the effects of these erosional events and return camps to a more desirable condition. Fortunately, very few beaches were seriously impacted by rain erosion or tributary flashes in 2019. The Adopt-A-Beach Project still advocates for management of dam releases which are not detrimental to the beach environment and which support beach enhancement for recreational opportunities.

While this analysis is limited to reporting monitoring observations and presumptive factors affecting change, it does provide evidence of changes in the beaches and the effects on associated recreational camping. Both natural and manmade actions contribute to the acceptability of a beach as a desired recreational camp area.

ACKNOWLEDGEMENTS

Grand Canyon River Guides, Inc. would like to thank all of the adopters for volunteering the time to pull over and photograph their beaches and for their valuable observations and written comments. It takes time and effort to do this, and the dedication shown by guides has literally kept this program alive for twenty years. The result is the most comprehensive collection of repeat photographs of critical camping beaches in the Grand Canyon. An added benefit is the public outreach fostered by the volunteers' actions. By taking time to include guests as active participants and by answering their questions, volunteers can further explain how this resource in Grand Canyon is enhanced, degraded or maintained by the influence of man and technology.

Special thanks to Lynn Hamilton, GCRG Director, for exhaustive work in support of this project.

Special thanks also to the members of the guide staff and participants in the Grand Canyon Youth program for incorporating the Adopt-A-Beach program into their river trips.

This material is based on work supported by the U.S. Geological Survey under Grant/Cooperative Agreement No. G18AC00125 as well as a grant from the Grand Canyon Fund, a non-profit charitable grant-making program established and managed by the Grand Canyon River Outfitters Association. Without their generous assistance, this program would not be possible. And finally, our sincere thanks to those individual GCRG members who believe that the Adopt-A-Beach project worthy of their support.

DISCLAIMER

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Geological Survey. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Geological Survey.

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Appendix A

Results of Analysis in Tabular Form

Page 1 Table 2 Results of evaluations, late 2018 season to early April 2019

Camp name	Rvr mile	2018	to	2019	Reason
		No change	Degraded	Improved	
Soap Creek	11.3 R		X		Lots of recession, cutbank, exposed rocks
12.4 Mile	12.4 L	X			
Hot Na Na	16.6 L			X	Huge new sand deposition
19.4 Mile	19.4 L				No late 2018
Upper North Canyon	20.7 R			X	Great new beach
23 Mile	22.7 L				No late 2018
Shinumo Wash	29.5 L			X	Huge expansion
Nautaloid	35.0 L	X			Poor images for evaluation
Tatahatso	37.9 L		X		Huge cutbank along front. No access
Martha's	38.6 L			X	Covered veg and rocks. Filled gully
Buck Farm	41.2 R		X		Cutbank, recession. Some interior fill
Total per Reach	11	2	3	4	
Nevills	76.0 L			X	Big deposit. Rocks covered along front
Hance	77.1 L				No late 2018
Grapevine	81.7 L			X	Beach wider, higher, but STEEP
Clear Creek	84.6 R			X	Generally more sand available.
Zoroaster	85.0 L				No late 2018
Trinity Creek	92.1 R				No late 2018
Schist	96.6 R				No late 2018
Boucher	97.3 L			X	Small but significant beach gain
Crystal	98.7 R			X	Slight increase, cutbank softer
Lower Tuna	100.2 L			X	Rocks covered in camp. Gully still present
Ross Wheeler	108.3 L	X			Maybe slight improvement.
Bass	109.0 R			X	Camp area increased
110 mile	110.0 R			X	Parking, interior much better. More WOOD
Upper Garnet	114.9 R			X	Parking same but camp increased
Lower Garnet	115.1 R			X	Upper beach improved
Total per Reach	15	1	0	10	
Below Bedrock	131.7 R				No late 2018
Stone Creek	132.5 R			X	Huge deposition but very high cutbank
Talking Heads	133.7 L			X	Camp increase but cutbank, recession
Racetrack	134.2 R			X	Significant sand addition to camp
Lower Tapeats	134.5 R				No late 2018
Owl Eyes	135.2 L			X	Much bigger FLAT camp
Backeddy	137.8 L	X			Very similar
Kanab	144.0 R				No late 2018
Olo	146.1 L	X			Larger camp but difficult access
Matkat Hotel	148.9 L			X	Lots of deposition. Downstream end bigger
Upset Hotel	150.9 L			X	More sand on top of beach
Last Chance	156.3 R			X	Great sand replenishment
Tuckup	165.2 R			X	Beautiful rebuild of camp
Upper National	167.0 L			X	Interior space has grown and flattened
Lower National	167.2 L	X			Useable area has moved far upstream
Total per Reach	15	3	0	9	
Travertine Falls	230.6 L				No late 2018
Gneiss	236.1 R				No late 2018
250 Mile	250.0 R				No late 2018
Total per Reach	3	0	0	0	
Total Reporting	32 of 44	6	3	23	

Page 2 Table 3 Results of evaluations, April through October 2018 season

Camp name	Rvr mile	2019	thru	Season	Reason
		No change	Degraded	Improved	
Soap Creek	11.3 R				No late season photos. More veg noted
12.4 Mile	12.4 L				No late season photos
Hot Na Na	16.6 L				No late season photos
19.4 Mile	19.4 L				No late season photos
Upper North Canyon	20.7 R		X		Sand loss in camp from wind, fluc flow
23 Mile	22.7 L				No late season photos
Shinumo Wash	29.5 L		X		Beach much narrower. Fluc flow
Nautaloid	35.0 L				No late season photos. Sand loss at prking
Tatahatso	37.9 L			X	Easier access thru season. Human erosion
Martha's	38.6 L		X		Cutbank and recession. Fluc flow
Buck Farm	41.2 R				No late season photos. New veg
Total per Reach	11	0	3	1	
Nevills	76.0 L		X		More rocks from fluc flow. Veg increase
Hance	77.1 L				No late season photos
Grapevine	81.7 L		X		Human erosion at parking, more veg
Clear Creek	84.6 R	X			Veg growth
Zoroaster	85.0 L				No late season photos
Trinity Creek	92.1 R				No late season photos
Schist	96.6 R		X		Fluc flow recession
Boucher	97.3 L				No late season photos
Crystal	98.7 R				No late season photos
Lower Tuna	100.2 L		X		Huge recession from fluc flow
Ross Wheeler	108.3 L				No late season photos
Bass	109.0 R		X		Fluc flow recession, cutbank
110 mile	110.0 R	X			No change
Upper Garnet	114.9 R		X		Cutbank and fluc flow recession
Lower Garnet	115.1 R				Cutbank and fluc flow recession. Traffic
Total per Reach	15	2	6	0	
Below Bedrock	131.7 R	X			More sand upper beach, less at lower
Stone Creek	132.5 R		X		Considerable fluc flow recession, cutbank
Talking Heads	133.7 L		X		Much receded, less camp area. Fluc flow
Racetrack	134.2 R			X	Front slope softened by human traffic
Lower Tapeats	134.5 R		X		Fluc flow and wind loss
Owl Eyes	135.2 L				No late season photos. Same
Backeddy	137.8 L				No late season photos. Same
Kanab	144.0 R		X		Fluc flow cutbank, more veg
Olo	146.1 L		X		Lots of fluc flow erosion and wind action
Matkat Hotel	148.9 L			X	Easier access, rocks covered. Wind, people?
Upset Hotel	150.9 L			X	Traffic sends sand to cover low rocks
Last Chance	156.3 R				No late season photos. Some veg increase
Tuckup	165.2 R				No late season photos. Same
Upper National	167.0 L	X			Gully cut in rear of camp
Lower National	167.2 L				No late season photos. Camp very far away
Total per Reach	15	2	5	3	
Travertine Falls	230.6 L				No late season photos
Gneiss	236.1 R				No late season photos
250 Mile	250.0 R				No late season photos
Total per Reach	3	0	0	0	
Total Reporting	22 of 44	4	14	4	

Appendix B

Adopt-A-Beach Data Sheet
Used by Volunteers to Record Comments

Adopt a Beach Data Entry Form

Guide s Name ______________________

Camp Name ______________________

Camp Mile ____________________

Date ____________________

River Flow (circle one) Low (5-12K) Med (12-18K) High (18-25K)

Photo Numbers: ________________ (remaining)

Any Comments about Beach Change? (describe in this space)

Change in Beach Size from Previous Visit (circle one): Increase Decrease Same

Dominant Cause of Change (circle one):

Spike Daily/Monthly Flow Rain Wind People Don't Know

Supporting Observations for Dominant Cause (check any that are appropriate):

- ☐ New cutbank
- ☐ Change of slope
- ☐ Bench in eddy
- ☐ Gully
- ☐ Trib/Debris flow
- ☐ Scour from wind or people
- ☐ Mounded sand

Secondary Cause of Change (circle one):

Spike Daily/Monthly Flow Rain Wind People Don't Know

Supporting Observations for Secondary Cause (check any that are appropriate):

- ☐ New cutback
- ☐ Change of slope
- ☐ Bench in eddy
- ☐ Gully
- ☐ Trib/Debris flow
- ☐ Scour from wind or people
- ☐ Mounded sand

Do you find evidence of tamarisk beetles currently in/near this beach? YES NO

Campsite Quality Compared to Last Visit (circle one): Same Better Worse

Supporting Observations for Campsite Quality (check any that are appropriate):

- ☐ Boat parking
- ☐ Rockiness
- ☐ Vegetation encroachment
- ☐ Steepness
- ☐ Trail erosion
- ☐ Open sand area
- ☐ Human impacts- ants, pee spots, litter (circle those that apply)

Any Comments about Campsite Condition? (describe in this space)