COLORADO RIVER MANAGEMENT PLAN
ANNUAL REPORT
FOR FISCAL YEAR 2011

Project Number 133023

For Official Use Only

Contributions by:

Linda Jalbert, Wilderness Coordinator/Resource Planner
Lori Makarick, Vegetation Program Manager
Melissa McMaster, Plant Biologist
Vanya Pryputniewicz, Outdoor Recreation Planner
Eric Frye, Recreation Technician
Shelley Szeghi, Archeological Technician
Deanna Greco, Physical Sciences Program Manager
Kassandra Theobald, Restoration Biologist
Janice Stroud-Settles, Wildlife Biologist
Jennifer Dierker, Archeologist

Table of Contents

Executive Summary 5

Introduction 8

Purpose and Need 8

Mitigation Program 9

- Background 9
- Objectives 10
- Results and Observations 10
- Lower Gorge, February 23 – March 1, 2011 10
- Lees Ferry to Diamond Creek, November 1 – 18, 2011 11
- Problems Encountered and Solutions 11
- Recommendations for Future 12

Monitoring Program 13

- Background 13

Natural Resources Campsite Monitoring, September 3-19, 2011 14

- Background 14
- Figure 1. Schedule of sampling sites in a series of seven panels 2007-2010 14
- Objectives 14
- Problems Encountered and Solutions 16
- Recommendations for Future 16

Avifauna Monitoring, May 16-31 2011 17

- Background 17
- Objectives 17
- Results and Observations 17
- Figure 2. Wren detections from May CRMP avian point count surveys, 2007-2011. 18
- Problems Encountered 18
- Recommendations for the Future 18

Visitor Experience Monitoring 19

- Background 19

Objectives: 20
Results and Observations 20
Recommendations for the Future 22
Cultural Resources Assessment in the Lower Gorge 23
Background 23
Objectives 23
Results and Observations 23
Problems Encountered 24
Recommendations for the Future 24
Water Quality Pilot Study 25
Background 25
Objectives 25
Results and Observations 25
Problems Encountered 26
Recommendations for the Future 26
Summary of Partnerships and Cooperation 27
Overall Recommendations 27
Appendix A – February Lower Gorge Mitigation Trip Report 28
Appendix B – Lower Gorge Geomorphic Assessment 36
Appendix C - November Mitigation Trip Report 40
Appendix D – Natural Resources Campsite Monitoring Trip Report 46
Appendix E - Avifauna Monitoring Trip Report 53
Appendix F – Lower Gorge Cultural Resources Assessment Trip Report 60

Executive Summary

The 2006 Colorado River Management Plan (CRMP) and associated Record of Decision (ROD) prescribed a multi-resource monitoring and mitigation program to focus on areas affected by river recreation where the integrity of natural and cultural resources may be at risk and where visitor experience may be negatively affected. The ROD also prescribed a site-specific restoration program to address campsite impacts, trails, and campsite maintenance and mitigations.

The CRMP Mitigation Program was initiated in November 2006. Projects were identified, planned, and implemented by an Interdisciplinary Team that includes River Rangers, Backcountry Rangers, Resource Management Specialists, Trails Specialists, and others. Most of the fieldwork is conducted in partnership with the Grand Canyon River Outfitters Association (GCROA), and some projects have been completed in cooperation with the Hualapai Tribe and the Grand Canyon Private Boater's Association (GCPBA).

Shortly after the ROD was signed, the National Park Service (NPS), in coordination with Northern Arizona University (NAU), developed a monitoring plan to examine long-term trends in changes to campsites resulting from recreational use. The campsite monitoring program was designed to document changes to vegetation, avifauna, and general impacts from visitation during low- and high-use periods. The monitoring program was implemented in April 2007 and continued through September 2010.

In 2011, NPS teams completed four CRMP monitoring and mitigation river trips. Details of each trip are outlined in the appendices of this report. Visitor experience monitoring was conducted at five locations during representative times of the river use season, and data were collected from administrative trips and web-based surveys. The objectives, projects, and outcomes of each project are summarized below.

Lower Gorge Monitoring and Mitigation (February-March 2011)

Conducted in cooperation with the GCPBA, the team visited campsites in the Lower Gorge (river miles 226 to 277). Primary activities included assessing campsites, retaking established photo points, and completing campsite improvement projects at four locations. Four cultural sites were monitored. Seven campsites between river miles 260 and the Grand Canyon boundary at mile 277 were evaluated for resource damage due to pirate campsite development by river users in the years since the waters of Lake Mead have receded. A geomorphic assessment of the Lower Gorge was conducted by the Physical Sciences program manager.

Lees Ferry to Diamond Creek Monitoring and Mitigation (November 2011)

In partnership with the GCROA, guides from Tour West joined the NPS interdisciplinary team to conduct site rehabilitation and maintenance projects at campsites and attraction sites. The partnership aspect of this program is its greatest asset. Project areas included Soap Creek, Hance Rapid, Tapeats Creek, and Deer Creek. Phase III of the Soap Creek restoration project consisted of continued experimentation with ollas (passive irrigation system) and live plantings to address impacts in the old high water zone. Work at the other sites consisted of campsite clean-up, social trail eradication and delineation, and maintenance of primary access trails. The cyclic program also includes monitoring past projects using photo points and assessments, completed at nine sites this trip. The team also conducted site assessments at 16 campsites. These assessments serve as the primary tool for determining whether any site treatments are needed and formulating a monitoring schedule for the site.

Integrated Campsite Monitoring (September 2011)

The objective of integrated campsite monitoring is to determine long-term trends and changes to campsite conditions. Based on the program review conducted in January 2011, data collected during the first four years of CRMP implementation are being evaluated under a Cooperative Ecosystem Studies Unit (CESU) agreement with the Lab of Landscape Ecology and Conservation Ecology at NAU. The interdisciplinary team visited all 75 campsites included in the monitoring design described in the *Vegetation and Avifauna Monitoring Plan* (2007) to confirm that the sites still meet the criteria for a river campsite and that vegetation transects were installed in appropriate locations to capture visitor use and potential impacts. Vegetation and recreation project leaders reevaluated campsite selection, methods, and variables. Park partners, working under a separate CESU agreement entitled *Monitoring Tamarisk Leaf Beetle (Diorhabda carinulata) and Vegetation / Avian Response in Grand Canyon National Park*, joined the trip to remove the microclimate data loggers, implement beetle sampling, and document tamarisk defoliation. Beetle monitoring results are not included in this report.

Avian Monitoring (May 2011)

The primary objective of this trip was to conduct point counts at all campsites and control sites prescribed in the monitoring plan and to conduct Southwestern Willow Flycatcher (SWFL) surveys along the river corridor in areas identified as suitable habitat, as required by the CRMP's Biological Opinion.

One hundred fourteen point counts were conducted from Lees Ferry to Diamond Creek, resulting in the detection of 45 species and a total of 859 birds. SWFL surveys were conducted at five historical sites and two new sites between Lees Ferry and Phantom Ranch and at three historical and seven new sites between Phantom and Pearce Ferry. Two SWFL were detected. Of the 15 sites assessed for SWFL habitat, zero sites were classified as suitable habitat and nine as potential breeding habitat.

Visitor Experience Monitoring

The Visitor Experience Monitoring Program included attraction site monitoring at Nankoweap, Little Colorado River, Phantom Boat Beach, and Deer Creek. Monitoring was scheduled in early May to collect data on trips and people at one time during the shoulder season–high use season transition period. NPS and volunteer staff logged river trip observations to document campsite occupancy and attraction site use. Visitor use data collection occurred in the Lower Gorge near Quartermaster for the first time in several years. Staff recorded information on a variety of river activities including pontoon tours, jet boat traffic, and Hualapai River Runner one-day whitewater trips. In addition, data on the number of helicopter tours in the area were documented; these data were shared with overflights planners.

Water Quality Pilot Project (September 2011)

A pilot water quality sampling plan was conducted at attraction sites along the river corridor during the September CRMP monitoring trip. This was done to determine if testing procedures are a viable method for use in the Grand Canyon backcountry and if there a relative risk of bacterial contamination and/or potential degradation of water quality at attraction sites along the river corridor.

Challenges to the testing methodology in the field included finding an adequate dark area, difficulty in determining results when using a 4W UV lamp (versus a 6 W UV lamp which could not be used because it requires an electrical outlet), maintaining samples from multiple sites at the correct temperature, and scheduling collection and analysis of samples on a multidisciplinary river trip.

All of the samples collected at eight attraction sites tested positive for colliform. However, because of the difficulty in reading the florescence indicator for E. coli using the 4W UV lamp, the pilot study results for E. coli were determined inconclusive for all sites. While taking into account the uncertainty of the readings, Saddle Canyon, Elves Chasm, and Deer Creek were most likely positive for E. coli. If there is indeed presence of E. coli, it can be interpreted that the water source has been contaminated by human intestinal bacteria.

Overall, the water quality testing pilot confirmed that this methodology can work in the field. By addressing a few of the sampling challenges, it is feasible to use this method to test water quality at attraction sites along the river corridor and as part of the CRMP monitoring process.

Introduction

This report documents the accomplishments associated with the CRMP monitoring and mitigation program. In 2011, the NPS teams completed four river trips: CRMP campsite and trails mitigation trips (February and November), integrated campsite monitoring (September), and avifauna monitoring (May). Archeological site monitoring was conducted during the February mitigation trip, and water quality monitoring was conducted during the September monitoring trip. Visitor experience monitoring occurred at five attraction sites, and data were also collected using web-based questionnaires and river trip diaries. This report provides an overview of the programs and recommendations for future actions. Details of the work accomplished are documented in the individual trip reports included in the Appendices.

Purpose and Need

The purpose of this report is to provide an overview of the CRMP monitoring and mitigation activities in 2011.

The updated CRMP was implemented in 2007 following a 2006 Record of Decision. Major changes to recreation and resource management include the establishment of a launch-based system of distributing use (to ensure capacity standards were met), a decrease in maximum group size (from 44 to 32), and an increase in use during the spring, fall, and winter months (due primarily to an increase in non-commercial launch opportunities).

The CRMP management objectives emphasize managing river recreation to minimize impacts to resources while providing a quality visitor experience. To ensure these objectives are met the NPS must determine, through a research-based monitoring and mitigation program, what impacts are occurring, how these impacts alter resource condition, and how adverse impacts can be effectively mitigated. The objectives of the CRMP monitoring and mitigation program include:

- Determine status and condition trends of selected resources
- Establish reference points and provide data to compare resource condition
- Understand and identify meaningful resource condition change associated with visitor use
- Understand effects of use patterns on visitor experience quality
- Provide early warning of deteriorating resource conditions that trigger mitigation (management action toward restoration)
- In response to monitoring results, identify appropriate changes to management practices
- Assess efficacy of management actions and restoration methods
- Develop an effective approach to impacted-site mitigation and restoration

Mitigation Program

Background

Visitation and management activities can impact park resources in beneficial and adverse ways. The CRMP Mitigation Program requires that park staff mitigate the adverse effects of visitation and management activities along the Colorado River corridor. Mitigation activities include delineating trails to decrease social trailing, obliterating trails that cause damage to natural resources or archaeological sites, actively planting vegetation in highly degraded campsites, and limiting sand erosion in campsites, archaeological sites, and along trails. Grand Canyon National Park (GRCA) staff, in conjunction with many other invested stakeholders, performs restoration activities to mitigate the effects of concentrated human impacts in the backcountry and to maintain natural processes throughout the Colorado River watershed. Under the current CRMP, a core planning team comprised of resource management specialists, planners, maintenance personnel, and river rangers develops procedures for site assessment, restoration implementation, and follow-up monitoring schedules and priorities. Staff from each discipline works on mitigation planning and participates in two mitigation river trips each year, typically in February and November. The work and assessments prescribed by the core team are implemented by the interdisciplinary CRMP Mitigation Team, which is led by the Outdoor Recreation Planner. This team includes a Restoration Biologist, Trails Supervisor, Archaeologist, and a River Ranger. However, due to budget and staffing shortfalls, as well as other program priorities, it has been increasingly difficult to secure the commitment of cultural resource and trail crew specialists to participate on the CRMP mitigation trips. Between 2009 and 2011, the work and assessments were also supported through the Cooperative River Conservation Program, which partners guides from a host river outfitter with park staff to complete conservation work. In 2011, mitigation work was also supported through the Grand Canyon GCPBA and the Youth Conservation Corps.

The assessment and reassessment process through the CRMP Mitigation Program should not be confused with the CRMP Monitoring Program. The CRMP Monitoring Program collects data on long-term impacts to vegetation, wildlife, and visitor experience at campsites and attraction sites caused by visitation. The CRMP Mitigation Program addresses more short-term impacts to campsites and attraction sites resulting from a variety of causes. As more data are collected and analyzed through the CRMP Monitoring Program, these long-term trends can help provide insight in the direction of mitigation issues in the CRMP Mitigation Program. However, the assessment and reassessment process outlined in the mitigation program is the most practical way to maintain a long-lasting body of knowledge that focuses on specific impacts at a local scale.

Under the CRMP, restoration is first prescribed through an assessment system and is then completed according to priority ranking and available resources. Baseline assessments for all river campsites along the river corridor are ongoing. As of 2011, the team has completed assessments on 115 out of 234 campsites. Attraction sites, research sites, rapid scouts, and other heavily impacted areas also fall under the assessment system. Once a site is assessed, it enters into a cyclical schedule for further assessment based on the severity of impacts at the site, which are determined by the CRMP Mitigation Team. This team also determines which sites will undergo restoration and maintenance at any given time. In order to develop priorities for a site, the team uses a monitoring data form in conjunction with aerial maps and photographs. This form records the findings of the initial site assessment, prescribes in detail the recommended actions, labor hours, and materials needed to accomplish the action, and monitors the effectiveness of mitigation and restoration actions. The team then uses a mitigation data form to document the work completed at each site, along with aerial maps to delineate where work has been completed. The team also uses long-term photo points to visually monitor work that has been completed.

Once a site has been assessed, prioritized, and restored, it falls into the cyclical reassessment phase. If the team determines during the reassessments that work is needed again, the site goes back into the queue for restoration or maintenance work.

Through reassessments, mapping, and long-term photo points, the team can determine if the methods are effective. If a method is not proving effective, the team has the flexibility to try something new. New methods for restoration are being explored with each restoration effort. Each site is different, and each requires creativity and consensus to formulate a mitigation plan that will work for that particular site.

After all the forms have been filled out (assessments, mitigation data sheets, reassessments, and photo points), they are stored in the Vegetation Office with the Restoration Biologist in hard copy form. They are also summarized after each trip in an Excel table, which is also maintained by the Restoration Biologist. These records are accessible by anyone at any time, with prior notice to the Restoration Biologist. By the end of 2012, these records will be stored in a network-accessible database, and the hard copy forms will be archived in the park's museum collection.

Objectives

General

- Expand stakeholder involvement with river corridor restoration under the CRMP by actively seeking volunteer participation on park trips.
- Expand outreach and education efforts by conducting lectures and orientations for park staff and stakeholder groups, publishing articles in river journals, and distributing site bulletins to the public.

Lees Ferry to Diamond Creek (Zone 1)

- Continue to complete written assessments and plans for recommended actions to establish baseline data for all 234 campsites that lie within the area of effect for CRMP implementation.
- Continue to perform mitigation actions according to the priorities established through the CRMP mitigation assessment process.
- Continue reassessments at previous restoration sites and maintain documentation as prescribed in mitigation assessment forms.

Lower Gorge (Zones 2 and 3)

- Remove invasives and expand existing campsites as allowed to accommodate visitor use.

Results and Observations

Two river trips were conducted in 2011 to assess and mitigate damage to campsites: a lower gorge trip from February 23-March 1, and a Lees Ferry to Diamond Creek trip from November 1-18. During the lower gorge river trip, geomorphic and cultural assessments were also performed. The cultural resources assessment is summarized in the monitoring program section of this report.

Lower Gorge, February 23 – March 1, 2011 (See Appendix A for details)

This trip was conducted in cooperation with GCPBA and other volunteers. The primary purposes of the trip were to address resource damage, make improvements at four campsites below Diamond Creek, and create opportunities for dialogue and feedback between river users and NPS staff.

An estimated 300 person hours were applied to campsite assessments and substantial improvement projects at four locations: Travertine Falls, 250 Mile, Dry Canyon, and 273.5 Mile. Improvements consisted of the following: vegetation was pruned to realign and delineate trails and to increase kitchen and toilet areas. Dangerous stobs from others' pruning attempts were removed. Tent spots and terraces were leveled and enlarged. Stairways were reconstructed. In addition, Bridge City Camp and Spencer

Canyon were reassessed, and long-term photo points were taken at all above sites. A campsite at river mile 271.2 was evaluated and dropped from the program because of its deteriorated condition. Also, on several occasions, productive discussion about resource issues, stewardship, and management practices occurred between river users and park staff.

A cursory evaluation was made of the geomorphic processes occurring in the lower gorge (See Appendix B for details). These processes include erosion of the riverside lake terraces that are emerging as the lake has receded over the past 10 years, high sediment yield and deposition in the Pearce Ferry area resulting from this erosion, braided channels of very course materials in some tributaries, and headcutting at the end of other tributaries that are disconnected from the river. As a result of this evaluation, the following recommendations were made: 1) Develop informational materials for the general public, concessionaires, and the boating community and park personnel; 2) Develop a protocol for long-term monitoring techniques; 3) Request a Geoscientist in the Parks (GIP) position to assist with geomorphic analysis and monitoring.

Lees Ferry to Diamond Creek, November 1 – 18, 2011 (See Appendix C for details)

This trip was conducted in cooperation with Tour West under the Cooperative Resource Conservation Program (CRCP). The main purposes of the trip were to eradicate social trails primarily from the post-dam riparian zones to the pre-dam high water zones of campsites and attraction sites, to delineate trails and campsite perimeters in order to decrease vegetation damage, and to combat erosion that threaten the stability of trails, camping areas, or mooring areas. Work was primarily done at Soap Creek, Hance Rapid, Tapeats Creek, and deer Creek. Several one- to two-hour projects were completed at Upper 185 Mile, Lower 185 Mile, 202 Mile, and Granite Park, as well as assessments for project planning and photopoint monitoring. Additional objectives included the evaluation and removal of climbing slings, planning for future interdivisional work projects at South, Nankoweap, Tanner, Cardenas, Unkar, Hance, and Granite, and generating enthusiasm for future collaboration with NPS resource work through the CRCP agreement and volunteerism.

Most of the objectives were accomplished on this trip. The Soap creek pilot project has been extremely successful in establishing data for active restoration projects such as specific methods, plant species, and frequency and duration of active maintenance (i.e., filling of berms and ollas) requirements. It continues to serve as an excellent training and outreach location for NPS staff and commercial guides to highlight river resource management efforts and foster stewardship within the boating community. Past projects were monitored at nine sites using photo points and assessments. Pre-work assessments and mitigation assessments occurred at 16 and 11 campsites respectively. Native seeds were collected for future projects at Upper Saddle and Lava Chuar, and toilet maintenance was done at Tanner, Tapeats, and Deer Creek. Climbing equipment was evaluated, removed, and/or replaced at Sheer Wall, Deer Creek Falls, the lower gorge of Deer Creek, and Olo Canyon.

Mitigation monitoring and photo points at several popular campsites showed the need for further mitigation efforts, primarily closing of social trails and campsites in the old high water zone at Soap, South, all campsites comprising the Nankoweap complex, Tanner, Cardenas, Unkar Delta, and Hance Rapid. Ideally, most of these sites would be addressed prior to the onset of the 2012 high use period, as vegetation and archaeological resources are currently threatened, and conditions will likely deteriorate over time.

Problems Encountered and Solutions

Lower Gorge Trip: A site located at river mile 271.2 was dropped from the project list because the conditions encountered provoked reevaluation of the efficacy of investing any effort at this location. This site exhibited resource damage from recreational use for camping and was included in the itinerary to be improved for use as a small to medium sized camp. However, the presence of swift current, steep cut

banks at the landing area, and evidence of instability due to erosion in the main camp area led to the conclusion that this site should remain unimproved.

The Pearce Ferry takeout was an anticipated problem. The trip leader and shuttle drivers had previously arranged to be met by rangers from Lake Mead at the takeout in order to provide vehicles and winches necessary to extricate the truck and boat trailer in the event that either became mired in the silt sandbar that forms at the end of the ramp. After an hour of trying to use the ramp with the assistance of the Lake Mead winch and vehicles, the group moved the boat to an area adjacent to the launch ramp and was able to extricate the boat from the water at that location.

Lees Ferry to Diamond Creek Trip: In spite of communication with all other trips encountered en route, upon arrival at Hance for a scheduled project layover, another group was already camped there. As a result, much of the planned project time for Hance was lost. However, a Prescott College trip pulled in to scout just as the CRMP trip was unloading, affording the opportunity to do an impromptu resource management lecture and conduct a question and answer session with the students. A limited amount of the originally scheduled work was completed, and important reevaluation of the scope of the site prescription was completed.

Another situation developed due to a preexisting medical condition of one of our trip participants. Both Ranger Lisa Hendy and trip leader Dave Loeffler are to be commended for keen situational awareness and tactful, professional handling of a potentially serious medical emergency arising on the lower half. The individual was evacuated via helicopter from Phantom Ranch during the exchange.

Recommendations for Future

Lower Gorge Trip: Aside from the recently established campsite monitoring program and some wildlife and soundscape studies, little research has been done in the Lower Gorge. The following are some of the efforts underway to improve our monitoring of the area below Diamond Creek:

- Conduct visitor use monitoring in the Lower Gorge.
- Distribute trip diaries to the educational permit holders using the Lower Gorge to help gather campsite occupancy and user discretionary time data.
- A post-trip visitor feedback form is available online to trip leaders following their trip.
- The vegetation program will include the Lower Gorge in tamarisk beetle surveys.
- Refinement of protocols and methods for the vegetation and avifauna monitoring program under CRMP can be extended into the Lower Gorge.

Lees Ferry to Diamond Creek Trip: In the past, the CRMP project leaders have attempted to enlist the support of the Lees Ferry staff to ensure that an outreach letter and copies of the itinerary are made available to private trips launching around the date of a CRMP trip, as well as carrying extra itineraries along for trip leaders we encounter on river. Perhaps it would be more effective to provide the outreach material to trip leaders by mail or email ahead of their trip as well, to help ensure positive interactions between visitors and administrative trips.

Several of the high priority sites for the next mitigation trip are adjacent to known archaeological sites. Due to a lack of funding and available personnel, this trip lacked representation from the Cultural Resources program. The CRMP mitigation project lead will provide a work plan to the CRMP program manager and seek input and direction from the CRMP interdisciplinary team members (and their program managers, if necessary) prior to scheduling the work.

Monitoring Program

Background

The CRMP Record of Decision (2006) called for a resources monitoring program that focuses on areas affected by river recreation where visitor experience may be negatively affected and where the integrity of natural and cultural resources may be at risk. The primary components of the CRMP monitoring program include an integrated campsite monitoring program to establish baseline conditions and to monitor long-term trends in campsite condition, an archeological site monitoring program to document and monitor archeological resources that may be affected by visitation along the Colorado River corridor, and a visitor experience monitoring program to assess how current management of daily trip launches, group size, trip length and other river trip attributes affect the quality of the visitor experience. Campsite monitoring trips are typically conducted twice each year to monitor conditions in April following a low-use period, and in September, following the high-use period. Avifauna point counts were conducted along the river in May. Archeological site monitoring was conducted in the Lower Gorge on the February mitigation trip. Visitor experience monitoring was conducted primarily in the late spring shoulder and summer season (April through September).

Natural Resources Campsite Monitoring, September 3-19, 2011 (See Appendix D for details)

Background

The integrated monitoring program measures recreation-use effects by documenting standard human impact variables and measuring and monitoring vegetation and avifauna in the river corridor's new and old high water zones. Using aerial photographic maps, the team also documents changes to the campsite boundary and campable area polygons. A collection of campsite maps and a database documenting all previous campsite inventories, termed a Campsite Atlas of Maps, was developed for all campsites from Lees Ferry to Diamond Creek in coordination with the Grand Canyon Monitoring and Research Center (GCMRC) beginning in 2007. The *Vegetation and Avifauna Monitoring Plan* (2007) describes a sampling framework (including panels) to ensure that a variety of campsite sizes, locations, and levels of use are represented (Figure 1). Panel 1 sites (sites in column 1) are sampled repeatedly every trip to increase statistical power to detect trends (Figure 1). Panels 2-7 (sites in columns 2-7) are sampled for three consecutive surveys, and then are not visited for the next three surveys in a rotating manner (Figure 1).

Figure 1. Schedule of sampling sites in a series of seven panels 2007-2010

		1	2	3	4	5	6	7	
2007	Spring*	15	10				10	10	45
	Fall	14	9	8				9	39
2008	Spring	14	9	8	8				39
	Fall	14		8	8	9			39
2009	Spring	14			8	9	9		40
	Fall	14				9	9	9	41
2010	Spring	14	9				9	9	41
	Fall	14	9	8				9	40

**Following the first field session campsites were dropped from survey sample.*

Objectives

The overall objectives for the CRMP campsite monitoring program are to determine trends of conditions at representative campsites by examining changes to vegetation and avifauna in new and old high water zone areas, and to determine impacts from river runner use. The combined methodology is intended to provide an overall long-term look at changes to campsite condition resulting from human use. Repeated mapping of campsites documents changes to campsites including campable area, trailing, vegetation growth, and other factors. While the focus of the campsite monitoring is to detect changes from recreational use, we are also concurrently documenting changes to campable area, slope, and vegetation resulting primarily from the effects of Glen Canyon Dam operations.

In 2011, following a program review, it was decided to suspend campsite monitoring data collection in order to focus on analysis of data collected during the previous four years. The April 2011 trip was canceled, and the September trip focused on evaluation methods and site selection criteria.

An agreement with NAU was sought and funded, and data were prepared for analysis. Program managers and their staff worked toward refining protocols and identifying and documenting possible deficiencies in the methods and the overall program. The purpose of the September trip was to reevaluate site selection, methods, and protocols of the CRMP monitoring program. Additional objectives were to incorporate a pilot water quality component with the program and, as time allowed, to update campable area polygons and conduct "float by" beach photography to document changes in beach profiles due to flow regimes. Also, staff from NAU and U of A joined the September trip to conduct Tamarisk Beetle monitoring.

The specific objectives for campsite transect evaluation are as follows:

- Determine if the transect location was appropriate and accurately captured the vegetation structure at the 35K or 90K water line.
- Install new transects if current ones do not accurately capture camping area.
- Install additional transects at the 90K line if not already installed.
- Accurately assess if an area is/was still used as a campsite and met the requirements of a campsite (adequate kitchen, sleeping, and toilet areas).
- Assess campsites where mitigation has occurred and determine if mitigation actions influence the vegetation monitoring transects.
- Assess campsites that had previously been dropped from the monitoring panel to see if they meet requirements for camping and could potentially be reinstated in the panel.

Results and Observations

The vegetation crew evaluated all transects at every campsite on the CRMP monitoring panel. Upon evaluation, transects at the 35,000 cfs water line were moved to better capture the vegetation structure and composition at 11 campsites, transects at the 90,000 cfs water line were added at two campsites, eight campsites no longer met the campable criteria and were dropped from the panel, and four campsites were assessed for potential reintroduction back into the panels. During the trip, 62 transects were assessed at 40 campsites, and rapid campsite assessments and mapping were performed on 68 campsites. Also, 94 campsite area polygons were updated, and "float-by" beach photography documenting changes in beach profiles due to flow regimes was done for 200 campsites.

The recreation team evaluated the protocols and methods for campsite assessments using a new assessment form. Changes were made to dramatically reduce the potential for inter-observer variability, simplify the methods for assessing indicators, and eliminate indicators from the assessments that did not make a substantial contribution to informing management decisions.

Outstanding tasks related to finalizing a new protocol for campsite assessments are 1) establishing search times according to indicator or beach size; 2) developing a protocol for the mapping component; 3) frequency of monitoring; and 4) establishing training and educational requirements for data collectors.

In addition to the campsite monitoring work, an overview and site visit was done for the Granite/Monument pilot Watershed Restoration project, tamarisk beetles were monitored, microclimate data collectors that had been used for beetle monitoring were removed, mitigation prescriptions using the CRMP mitigation assessment form were done, repeat photo points for mitigation monitoring were taken, and 21 ravenna grass were removed.

Problems Encountered and Solutions

There is continued discussion about the selection of certain campsites for monitoring. In September, 3 campsites were identified as sites that were no longer campsites. There was discussion on the value of keeping them in the rotation versus replacing them with similar campsites. After the initial data analysis is completed, the team will meet to discuss the current campsite panel and subsequent changes needed to maintain a balance between high, moderate, and low use campsites as well as small, medium, and large campsites. The placement of vegetation transects in some of the campsites is also a concern, including the impacts from reading old high water zone transects. Some of the new high water zone transects were originally located in areas with dense tamarisk and/or arrow-weed thickets but were moved on this trip to better capture changes from visitation. Potential impacts on areas in the old water zone transects can be mitigated by lowering the number of times those transects are read. There is also continued concern with the absence of completed protocols for the recreation Rapid Site Assessments. Vanya will be developing protocols to cover data collected to this point.

Recommendations for Future

Data analysis needs to be completed before additional data collection takes place. It is expected that GRCA will receive a draft report from NAU in March. Also, additional campsite use information is required to confirm use levels at campsites in the Lees Ferry to Diamond Creek zone. This information is especially needed for the campsites in the current monitoring panel. As noted above, some of the campsites have become overgrown or unusable, thereby suggesting that these campsites be replaced for monitoring purposes.

Avifauna Monitoring, May 16-31 2011 (See Appendix E for details)

Background

The NPS and United States Geological Survey (USGS) participated in this monitoring trip, which was funded by the NPS (CRMP), Bureau of Reclamation (SWFL surveys) and U.S. Geological Survey (beetle surveys). In May 2011, the wildlife team conducted avifauna point counts at selected campsites and control sites. The primary objective of this trip was to conduct point counts at all campsites and control sites prescribed in the monitoring plan and to conduct SWFL surveys along the river corridor in areas identified as suitable habitat, as required by the CRMP's Biological Opinion. Two staff from the NAU/USGS and Tamarisk Coalition conducted tamarisk beetle monitoring at one-mile intervals (when possible) along the river corridor.

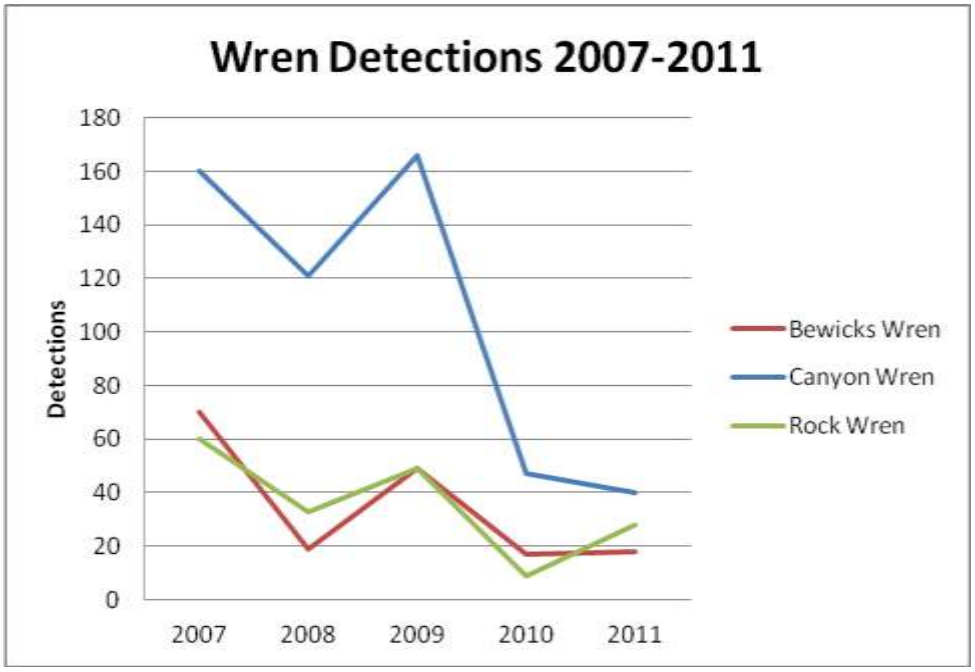
Objectives

- To conduct avifauna point counts at all campsites and control sites within panels 1,2,3, and 4 of the CRMP Monitoring Plan.
- To conduct SWFL surveys at historic sites and in areas identified as suitable habitat. To conduct SWFL habitat surveys in previously un-surveyed patches and develop a prioritized list of habitat patches for surveys on subsequent trips.
- To deploy six sound recording systems to supplement SWFL surveys. To conduct Tamarisk Beetle surveys systematically along the Colorado River corridor from Lees Ferry to Pearce Ferry.
- To deploy HOBO samplers systematically along the Colorado River corridor in conjunction with tamarisk beetle survey sites.

Results and Observations

For CRMP monitoring, the wildlife team conducted a total of 114 point counts from Lees Ferry to Diamond Creek, resulting in the detection of 45 species and a total of 859 birds. Forty-eight point counts were conducted in new high water zone camp areas and 48 counts in the corresponding control new high water zone sites. Twelve old high water zone sites were surveyed in campsite areas, and six old high water zone sites were surveyed in control sites. More birds were detected in campsites (n=464) than control sites (n=395). On average, 39 species were detected at campsites, and 38 were detected at control sites. Campsites averaged 9.5 birds/point, and control sites averaged 9.2 birds/point. Lucy's Warbler was the most common species detected (n= 198) followed by House Finch (n=82), Yellow Warbler (n=76), and Common Yellowthroat (n=52). Interestingly, detections of Canyon Wren decreased greatly from previous years. Mean detections from 2007-2009 were 149 ±24, and from 2010-2011 mean detection were only 44 ±5 were detected (Figure 2). In addition to the species detected during point counts, 18 avian species were observed.

Figure 2. Wren detections from May CRMP avian point count surveys, 2007-2011.



A total of 16 sites were surveyed for SWFL presence: five were conducted at five historical sites and two new sites between Lees Ferry and Phantom Ranch, and three historical and seven new sites between Phantom Ranch and Pearce Ferry. Completing river trips at Pearce Ferry instead of Diamond Creek allowed for three additional sites to be surveyed.

Two SWFL were detected during the trip; one at river mile 51.8L and one at 217.7L. Both were adults singing. Of the 15 sites assessed for SWFL habitat, zero sites were classified as suitable habitat and nine as potential breeding habitat. These classifications will help to prioritize survey efforts on future monitoring trips.

To capture SWFL vocalizations, we deployed six recording system units between river mile 47 and 275. The units were collected in July and recorded 1,222 hrs of audio data. No flycatchers were detected from the audio recordings.

Problems Encountered

The only major problem encountered was related to the trip itinerary. On several days too many bird surveys were scheduled. This resulted in some surveys occurring after the 10 a.m. cutoff time. The solution to this would be to extend the trip by one more day and reduce the number of surveys for each day.

Recommendations for the Future

Update or establish an agreement with the NAU lab to analyze avifauna data.

Visitor Experience Monitoring

Background

The 2006 CRMP modified several aspects of river trips (e.g. launch scheduling, trip length, group sizes) which are expected to change use patterns and impacts on visitors' experiences. A Visitor Experience Monitoring Plan (Shelby, Whittaker, Oregon State University, 2007) proposed several methods to monitor the effects of the plan on visitor experience, including: 1) annual use information report, 2) researchers documenting observations on trips, 3) post-trip surveys, 4) non-commercial post-trip contacts, 4) attraction site observations and on-site interviews, 5) administrative trip diaries, and 6) search and rescue analysis. During 2011, attraction site observations, administrative trip diaries, and non-commercial post-trip contacts were conducted.

Attraction Site Observations: Visitor experience monitoring focuses on how encounters with other trips affect river runners' experiences by measuring use levels at attraction sites. Staff was present at sites at representative times during the visitor use season to measure the number of trips and people at one time and to assess if campsite competition occurs near the attraction sites. Observers collected detailed information on the each trip including number of people on each trip, arrival and departure time, the previous night's campsite, and the planned campsite for the night.

Attraction site observations were conducted at five highly visited locations along the Colorado River corridor. Monitoring from Lees Ferry to Diamond Creek occurred at Nankoweap, the confluence of the Little Colorado River, Phantom Ranch, and Deer Creek. Monitoring in the Lower Gorge occurred at Quartermaster Canyon, where the focus was gathering information on the number and frequency of pontoon boat tours and helicopter tours operated by Grand Canyon West and the Hualapai tribe.

Attraction site observations for Quartermaster Canyon in the Lower Gorge are quite different from those above Diamond Creek because of the wide variety of activities at this site. Activities include multi-day river trips from above Diamond Creek continuing through the Lower Gorge to Pearce Ferry; jet boats traveling upriver to collect passengers, then traveling downriver to transport them to Pearce Ferry; multi-day trips traveling from Diamond Creek to Pearce Ferry; one-day trips operated by Hualapai River Runners traveling from Diamond Creek to Quartermaster Canyon where they fly out by helicopter; Hualapai-operated 20-minute pontoon boat tours of the Quartermaster area for which passengers arrive and leave by helicopter, and helicopter flights passing over the area.

Observation dates were as follows:
Nankoweap –June 5-9 and September 16-21
Little Colorado River-May 4-7 and June 18-24
Phantom Ranch- May 2-8
Deer Creek-May 3-9
Quartermaster- May 24-25, June 28-30, July14-16, August 4-6 and September 27-29

Administrative Trip Diary Data: Administrative river trip participants collected information on all observed trips such as trip type, number of boats, and number of people. They also documented where trips had stopped and what activities trip participants were engaged in at each location (for example, scout, hike, camp, lunch, project work, etc). These data were incorporated with campsite use data collected during the attraction site monitoring. These combined sources of data provided information on campsite occupancy levels for use in the analysis of the CRMP Integrated Resource Monitoring data.

Non-Commercial Post Trip Contacts: Email contacts were made with non-commercial trip leaders inviting them to participate in a post-trip questionnaire utilizing an internet program. Data was collected from late July 2010 to July 2011. The questionnaire gathered information on layovers and campsite

occupancy, health and safety incidents, soundscape disturbances, and other experiential data. These data were incorporated with observed campsite occupancy from administrative trip logs and reported campsite use data from attraction site monitoring to define actual campsite occupancy levels for use in the analysis of the CRMP Integrated Resource Monitoring data.

Objectives

- Gather data at attraction sites during the transition week from spring shoulder season to the high use season (late April to May) to assess the effects of transitioning from a lower use season with 2-4 daily launches and maximum 21-day trips to the high use 5-6 daily launches with a maximum 16-day trip length.
- Collect basic use data in the Lower Gorge for the variety of river activities, including whitewater trips, pontoon tours, and jet boat shuttles.
- Determine frequency of use by different types of trips at Colorado River campsites from Lees Ferry to Diamond Creek.

Results and Observations

Attraction Site Monitoring: Attraction site observations were documented for combined total of 50 days in 2011. The spring shoulder to high-use transition period monitoring was a combined total of 18 days. A summary of results from these observations is shown in Table 1.

Table 1. Attraction Site Observations for Lees Ferry to Diamond Creek, 2011

Site	Nankoweap	Little Colorado River	Phantom	Deer Creek
Monitoring days	11	11	7	7
Total trips recorded	45	58	31	30
Total people recorded	635	1282	364	610
# Trips did not stop at site	14	0	0	0
Private trips recorded	11	14	15	9
Commercial trips recorded	31	44	15	21
Administrative trips recorded	3	0	1	0
Average visit	1:54	2:16	2:36	2:56
Longest visit	39:50	5:22	7:00	8:00
Shortest visit	1:03	0:48	0:12	0:31

The 2006 CRMP set a standard for visitor experience that **"**100 people or less at any one time are encountered at attraction sites." Data for attraction site monitoring in 2011 show that in general, observed conditions meet this standard. During all monitoring periods, the number of people exceeded 100 only one time. This occurred at the Little Colorado River on June 24, 2011, when 101 people were in the area at the same time for a period lasting 42 minutes. However, the average number of people at one time observed at any attraction site during the periods monitored was 71 people.

It was determined that during the spring shoulder to high-use season transition, monitoring at Deer Creek was conducted too early to capture visitation by trips launching in April along with shorter trips that launched the first week of May.

This was the first season that actual use data were collected in the Lower Gorge. The NPS track use data for trips launching from Lees Ferry and also for noncommercial trips launching from Diamond Creek. The NPS has requested use data for Hualapai River Runners and the pontoon tours, but has not received any response to these requests in the past several years.

The 2006 CRMP sets limits on pontoon tour operations at 480 passengers per day with a total of five boats at one time. Table 2 summarizes the data for pontoon tour operations for 2011. With the exception of two days, the daily passenger limits were exceeded by significant numbers. The Hualapai Tribe has not accepted the conditions of the CRMP based on long-standing conflicts related to the location of the park boundary. The NPS continues to work with the Hualapai Tribe address these CRMP issues.

Table 2. Pontoon Boat Tour Activity near Quartermaster (River Mile 262)

DATE	**5/25**	**5/26**	**6/28**	**6/29**	**6/30**	**7/14**	**7/15**	**7/1**	**8/4**	**9/27**	**9/28**	**9/29**
Number of Hours Observed	8	10	3	10	10	10	10	10	7.5	8.5	10	10
Number of Pontoon tours	93	108	9	79	98	69	71	54	61	113	104	141
Total People on tours	759	951	75	637	897	609	541	485	572	985	985	1404
Avg. group size (w/drivers)	7.8	8.8	8.3	8	9.2	8.8	7.6	8.9	9.4	8.6	9.4	9.9
Avg. Length (minutes)	15.2	14.9	13.6	14.9	16.3	15.4	17.2	18.1	15	16.2	17.7	18

Note: During the August monitoring period there were no pontoon tours for two days (8/5-8/6) because helicopters could not fly due to a wildfire on the rim.

The CRMP limits on Hualapai River Runner one-day trips launching from Diamond Creek is set at a 96 passengers per day with a group size limit of 40 people including guides. Passengers finish the trip at the Quartermaster area, where they take a short helicopter flight to the rim. These trips typically arrive at Quartermaster before 3:00pm. For the observation periods, a total of 1136 passengers participated in HRR day trips. While it was not always possible to determine the number of trips, the number of boats with 10-person maximum, ranged from 5 per day to 13 boats per day. Passenger limits were exceeded only one of the observation days – 104 people on July 15.

Helicopter tours are also conducted in the Quartermaster area under permit by the Hualapai Tribe. During the monitoring period, staff also collected data on flights observed in the area. These helicopter tours include landing on and picnicking on the Hualapai Reservation bordering the Colorado River corridor. The number of flights and noise produced from them has an effect on visitor experience. Flight data collected through this program were presented to planners for inclusion in the draft overflights management plan.

Administrative Trip Diary Data:
The administrative trip diary data were collected from 18 different administrative river trips, including Science and Resource Management, Grand Canyon Youth, and river trip patrols. A total of 356 database entries documented campsite use by commercial, non-commercial and administrative trips. These data were included in the dataset provided to the NAU lab conducting campsite condition monitoring data analysis along with campsite data from other sources.

Non-Commercial Post Trip Contacts:
Non-commercial permit holders were notified by email immediately following the end of their trip. The overall response rate was approximately 40%. The highest response rate was for trips launching during November and April. The entire dataset has not yet been analyzed. Campsite layover data were incorporated into the dataset for the campsite condition monitoring analysis.

Recommendations for the Future

Attraction site monitoring. Repeat shoulder/high-use season monitoring at LCR, Phantom, and Deer Creek in 2012. Schedule Deer Creek monitoring to begin May 4th or 5th and last for seven days to document effects of faster peak season launches overlapping with longer, slower trips launching in late April. Conduct monitoring in September to establish baseline data for the early fall shoulder season.

Administrative trip diaries. Continue data collection in 2012 and request participation from the GCMRC.

Campsite use data. Obtain additional campsite use data from all trip types using a variety of methods. Methods will include administrative trip diaries, online questionnaires, and surveys at the guides' training seminar.

Non-commercial post-trip contacts. Continue distributing the questionnaire for a similar time period in 2013. Seek methods for improving the response rate, including follow-up emails and possibly personal contacts.

Cultural Resources Assessment in the Lower Gorge, (See Appendix F for Details)

Background

Implementation of the CRMP required the development of a Historic Property Monitoring and Mitigation Program to outline the identification, documentation, monitoring, and treatment of archaeological resources within the project area. The project encompasses 277 miles of the Colorado River corridor and adjacent side canyons with over 674 recorded archeological sites.

This program seeks to balance resource preservation, archaeological site integrity, and visitor use along the river corridor. The program incorporates archaeological site condition documentation by conducting field monitoring visits. Thresholds determine when to recommend and implement mitigation treatments to prevent resource or integrity loss.

Throughout the project area, desert and riparian habitats sustain abundant plants and animals. Approximately 674 archaeological sites contain the remains of nearly 12,000 years of human occupation within the canyon between Lees Ferry and river mile 277. Many of these locations remain connected to Native Indian tribes living on the Colorado Plateau. The park maintains active dialogue with 11 tribes with ancestral ties to the canyon.

Cultural resources on the Lower Gorge were monitored on the February 23-March 1, 2011 mitigation river trip.

Objectives

- To monitor archaeological sites for threats and/or disturbances caused by visitation or natural forces.
- To formally evaluate and document the "Buzz Holmstrom Inscription" as an archaeological site.
- To monitor ground-disturbing activities that could potentially reveal unknown archaeological artifacts or features.
- To participate as a member of the CRMP Mitigation Trip in the improvement of campsites along the Colorado River from Diamond Creek to Pearce Ferry.

Results and Observations

Three archaeological sites were monitored for visitation and natural forces impacts: G:02:0123, the "dynamite cache;" G:02:0106, historic site; and G:02:0101, Bridge Canyon City Historic Work Center. All three sites exhibited no significant change with little evidence of visitation or disturbance. Because access to the historic site requires traversing a steep slope, in light of safety concerns and slope erosion caused by accessing the site, it was recommended that this site be monitored once every 15 years.

The "Buzz Holstrom Inscription" at Spencer Canyon was evaluated and was determined to be an archaeological site since it is over 50 years old and contains the names of historically significant persons. This site showed no signs of recent visitation or significant impacts.

Archaeological assessments of four campsites visited during the trip, Travertine Falls Camp, 250 Mile Camp, Dry Canyon Camp, and Echo Camp, found no archaeological features at the campsites. It was also determined that ground-disturbing activities conducted during mitigation work are unlikely to impact cultural resources at these sites. This is particularly true for areas downstream of Separation Canyon since the shoreline along this region contains lake deposits left by the receding waters of Lake Mead, thereby creating a vertical buffer between the historic shoreline and the higher-elevation, present-day shoreline where campsites are located.

Problems Encountered

No problems were encountered on this trip. However, one potential problem was encountered in the clean-up of fire hearths. It is frequently difficult to distinguish modern hearths from historic or prehistoric hearths, so historic or prehistoric hearths might be mistakenly eradicated. It was recommended that if a given hearth is not definitively known to be of modern origins, it should be left in place until an archaeologist evaluates and determines its antiquity.

Recommendations for the Future

Based on archaeological observations made during this trip, it is recommended that, depending on the specific nature of the project, the utility of including an archaeologist on Lower Gorge trips is reevaluated.

Water Quality Pilot Study, (See Appendix G for Details)

Background

Water quality is one of the recommended monitoring actions in the CRMP. However, due to staffing shortages and funding limitations, water quality has not been a part of the CRMP monitoring program. In response to this need, during the September, 2011 CRMP monitoring trip, a pilot water quality sampling plan was conducted at attraction sites along the river corridor.

Pathogenic micro-organisms are associated with fecal waste and can cause a variety of diseases through the ingestion of contaminated water. Since these pathogens tend to occur in very low numbers and are very small, it is very difficult to measure them directly. Instead, indicator species of fecal contamination can be used to determine if their presence has occurred. Total coliforms are a group of bacteria that are widespread in nature. All members of the total coliform group can occur in human feces, but some can also be present in animal manure, soil, and submerged wood and in other places outside the human body. Thus, the usefulness of total coliforms as an indicator of fecal contamination depends on the extent to which the bacteria species found are fecal and human in origin. Escherichia coli (E. coli) is a single species in the fecal coliform group. The Environmental Protection Agency (EPA) recommends E. coli and enterococci as indicators of health risk from water contact. E. coli is commonly found in the intestines of warm blooded animals and humans, and its presence in water is a strong indication of recent contamination. Recent advances in microbial contamination research now make it possible to perform testing in remote backcountry environments. The sampling performed during the pilot test was non-regulatory in nature and was used to determine presence/absence of bacteria which might be harmful to humans.

For the purposes of the pilot test, the EPA-approved IDEXX Colilert Presence/Absence test was used. The Colilert test is performed in a glass tube that contains a dried nutrient powder. The test indicates presence/absence of coliform and E. coli bacteria in a 10 ml water sample. When total coliforms metabolize Colilert's nutrient-indicator, it turns the sample yellow. When E. coli metabolizes the nutrient-indicator, the sample also fluoresces. Colilert can simultaneously detect these bacteria at 1 cfu/100 mL within 24 hours even with as many as 2 million heterotrophic bacteria per 100 mL present.

Objectives

Conduct a pilot water quality sampling plan at attractions sites along the river corridor. Determine if the testing procedures are a viable method for use in the Grand Canyon backcountry and if there is a relative risk of bacterial contamination and/or potential degradation of water quality at attraction sites along the river corridor.

Results and Observations

Based on anecdotal evidence and visitor use patterns, the following sites were selected for testing: Saddle Canyon, Monument Creek, Shinumo Falls, Elves Chasm, Stone Creek, Deer Creek, National Canyon, and Three Springs.

All of the sample tubes collected in the pilot study turned yellow fairly rapidly. Most turned yellow in less than half of the 24 hour protocol recommended. A rapid color change for colliform is an indicator of abundance. Thus, it is surmised that there is a large amount of colliform naturally occurring in the waters found at the sampled attraction sites.

The 4 W UV lamp was not ideal (see "Problems Encountered") for reading the florescence indicator for E. coli. Even taking into account the uncertainty of the readings, Saddle Canyon, Elves Chasm, and Deer Creek were most likely positive for E. coli. The other sites were inconclusive. Based on a limited certainty of the readings for florescence, the pilot study results for E. coli are determined inconclusive for

all sites. If there is indeed presence of E. coli, it can be interpreted that the water source has been contaminated by human intestinal bacteria.

Problems Encountered

Even through the simplification of testing procedures, several issues need to be addressed for this testing procedure to be successful in the long term.

The need for an adequate dark area and the use of the 4W UV Lamp proved to be one of the major drawbacks to using the IDEXX test kit. Ideally, a 6W UV lamp would be used for reading the sample, but these lamps are not practical in remote backcountry localities. A 4W lamp can run off of battery power, whereas, a 6W lamp is much larger and requires an electrical outlet.

During the pilot sampling body, temperature was used to incubate the samples. Incubating samples from one site was feasible. While incubating two sites simultaneously was tolerable, incubating more than two sample sites would prove to be a challenge for one individual to incubate at the same time. The more samples collected, the more of a challenge to comfortably incubate them. For the purposes of the sampling pilot, ten vials were used in the beginning and reduced to five for ease of body incubation and to accommodate more than one set from a sampling location.

While traveling by raft along the river, proper storage and protection of glass vials can be a challenge. On the river, it can be difficult to keep the vials dry and in a cool place while working in temperatures in excess of 95^{o} F. To overcome these obstacles, the vials were kept in a foam lined waterproof "Pelican" case. They were stored in the bottom hatch of the boat to keep them closer to the water and therefore, cooler.

The last major challenge to sampling on the river is the ability to rapidly and consistently read the results of the samples. Due to the multidisciplinary nature of monitoring river trips with various field-based activities simultaneously occurring, the logistics of collecting samples must be carefully scheduled into a trip itinerary. In addition, the ability to have a location for reading the results within the protocol time frames needs to be addressed once a sample is collected.

Recommendations for the Future

Overall, the water quality testing pilot confirmed that this methodology can work in the field. By addressing a few of the sampling challenges, it is feasible to use this method to test water quality at attraction sites along the river corridor and as part of the CRMP monitoring process. Monitoring indicator bacteria can determine whether there is valid evidence for concern about the watershed, specific waterbodies, and public health. The information can be used to inform and guide management decisions about potential impacts from visitor use patterns. Recommendations for a water quality protocol for the CRMP should include the following:

- Develop a schedule for regular testing/monitoring and a list of employees who are trained to perform the testing protocols.
- Construct a portable "dark room" for E. coli detection using the 4W Lamp.
- Test at least annually, but preferably twice a year, once in Spring and once in early Fall.
- Develop educational information for the Backcountry Office, River Permits Office, Backcountry and River District Rangers, the Commercial and Private Boaters, and the park website. This would include suggestions such as treating wounds and not submerging the head at water-based attraction sites.
- Based on subsequent testing, consider a reduction in numbers of visitors at these sites to reduce the opportunity for harmful bacteria to flourish in these localities.

Summary of Partnerships and Cooperation

- The CRMP projects and river trips were accomplished in cooperation with several internal and external partners. Partnership projects ranged from hands-on campsite mitigation, tamarisk beetle surveys, and trails maintenance to data collection and on-site consultations.
- GRCA Interdisciplinary Teams included staff from River District, Canyon District, Trails, Backcountry & River Permits Office, Resources Management, and Concessions.
- The Grand Canyon Private Boaters Association (GCPBA) recruited volunteers for the February 2011 Lower Gorge trip. Volunteers provided hands-on efforts and perspectives for completing campsite work.
- The Cooperative Resource Conservation Program is conducted under a cooperative agreement with the Grand Canyon River Outfitters Association. Tour West, the host outfitter, provided logistical support and labor for the November mitigation trip.
- The Tamarisk Coalition and NAU provided researchers and volunteer researchers that conducted Tamarisk Beetle monitoring on the May and September trips.

Overall Recommendations

- Finalize protocols for the vegetation, recreation, and avifauna monitoring programs.
- In coordination with NAU Lab of Landscape Ecology and Conservation Biology, complete data analysis to determine if CRMP management questions are being addressed.
- In 2012, review the findings of the statistical analysis of the 2007-2010 integrated campsite monitoring program.
- Finalize the CRMP Mitigation Plan to include site planning strategy, monitoring and assessment protocols, and incorporating methods outlined in the draft restoration handbook.
- Establish a relationship between the monitoring program and the impact mitigation program.
- Draft a five-year synthesis report incorporating all elements of CRMP monitoring and mitigation programs. This technical report will be peer reviewed and published through the NPS Natural Resources Publications Program.

Appendix A – February Lower Gorge Mitigation Trip Report

Trip Dates: February 23- March 1, 2011

Background

The 2006 CRMP committed to the implementation of long-term resource monitoring and mitigation in the Lower Gorge. In February 2010, an interdisciplinary team conducted the first comprehensive campsite assessment and monitoring trip for the area between Diamond Creek and Pearce Ferry. The group included recreation planners, vegetation specialists, river district rangers, archaeologists, trail crew, and Hualapai tribal members. The 2010 trip 1) established a baseline for campsite condition and availability, 2) identified areas of resource concern, 3) established 18 long-term photo points, and 4) completed monitoring of historic sites.

One observation made during the trip was that dramatic and rapid changes in the shoreline resulting from the retreat of Lake Mead in recent years has created conditions rendering the size and number of available campsites insufficient to meet the use limits established in the 2006 CRMP. Significant resource damage was observed in numerous locations where camping is scarce, and recreational users had attempted to establish campsites where none had been before. In a proactive effort to prevent further resource damage while continuing to accommodate established use limits, the CRMP mitigation team began planning a mitigation trip for February 2011 to improve campsite condition in the Lower Gorge.

In accordance with planning and compliance, several factors needed to be addressed prior to engaging in any mitigation effort in the Lower Gorge.

1. The NPS needed to conduct habitat assessments for the Southwest Willow Flycatcher (SWFL) in the affected areas to determine whether the park could allow continued use of these campsites. The NPS wildlife biologists were able to add Lower Gorge surveys and assessments onto existing bird trips during the spring and summer of 2010, and each of the proposed sites were found to be unsuitable habitat.
2. The programmatic agreement for River and River Accessible Site Maintenance under the 2006 CRMP needed to be updated, and the mitigation methods table refined. This was accomplished and reviewed through an interdisciplinary team over several months between June and December 2010. The Letter of Authorization was issued by OPAC on January 20, 2011.
3. In order to address the needs below Diamond Creek, the CRMP mitigation team needed to ensure that the November 2010 CRCP mitigation trip would adequately address priority sites above Diamond Creek that should not be deferred until November 2011 for treatment.
4. A decision had to be reached regarding whether to do the Lower Gorge trip with commercial river guides under our CRCP agreement with Grand Canyon River Outfitters Association (GCROA), do it with only NPS staff, or use this trip to expand resource stewardship partnerships and service opportunities with other river users. After evaluating the options, it was decided that the trip should be staffed with volunteers recruited through both the park volunteer website and the Grand Canyon Private Boaters Association (GCPBA).

Trip Objectives

1. Address resource damage and make improvements at five campsites below Diamond Creek.
2. Create opportunities for dialogue and feedback between river users and NPS staff.
3. Conduct cultural resource assessments.
4. Install and/or retake photo points for long-term monitoring at various campsites.

Results and Observations

The following is a brief description of the main project areas addressed on this trip.

Travertine Falls Camp (RM 230.6 L)

This is a popular, well-established campsite and attraction site in the Lower Gorge. Recreational users had cut back limbs and shrubs along the main access trails and main kitchen area, leaving dangerous stobs and trip hazards. This provided an ideal classroom in which to train our all volunteer crew in proper pruning techniques and other methods for directing traffic with minimum impact in popular areas.
Total person hours: 28
Pruned 40 meters of trail around kitchen and toilet areas
Long-term photo points retaken

Bridge City Camp (RM 238.7 L)

Bridge City Camp is near the location of a historic camp dating back to the dam exploration that occurred in this area in the 1940's. A campsite assessment was completed, and long-term photo points were retaken. The trip leader facilitated a round table discussion on resource values, stewardship, and management practices.

Spencer Canyon (RM 246 R)

A long-term photopoint was installed, and a historic site assessment was completed on river right.

250 Mile (RM 250 R)

This is an established campsite that marks the last area suitable for camping until Lower Quartermaster at river mile 260.7. This campsite had been improved by river guides as part of the April 2009 Guides Training Seminar (GTS) field session. In the interim, much of the camp had become overgrown, and some of the access trails had become obscured. On this visit, the main kitchen and several campsites were reclaimed from vegetation encroachment, interconnecting camp trails were trimmed out and delineated, and substantial repairs were made to the work conducted by the 2009 GTS. In the example below, the access trail had been aligned in such a way that it terminated in a thicket of shrubs. The CRMP crew realigned the access trail into a logical clearing in the main kitchen area and reconstructed the stairway to make it more durable (see figures 2-4).
Total person hours: 56
Pruned 90 linear meters of trail (kitchen, intra-camp connecting trails, toilet trail)
Pruned 75 meters around tent pads
Construction of one 7-step staircase
Delineated 20 linear meters (rock) of access trail from main camp area to drainage
Expanded and pruned 8 tent pads (61 square meters)
Retook long term photo points

Dry Canyon Camp (RM 264.6 R)

One of the sites where resource damage had been observed during the initial campsite monitoring trip in February 2010, the Dry Canyon camp was subsequently evaluated by the wildlife biologist and considered suitable for continued overnight use. The site is a comfortable day's row from 250-mile for the typical non-commercial oar group, is easy to locate due to the presence of a large boulder on river right, and offers decent mooring and access, ample shade from large willows and tamarisk, and opportunities to explore the peculiar landscape left behind as Lake Mead recedes. The site is arranged in a series of terraces that is the characteristic result of erosion, calving, and rotational slumping cycle common to the shoreline in this reach as the river carves its way through the former bottom of Lake Mead. The project consisted primarily of widening and leveling existing terraces, and pruning and improving access on the

slopes. The site will now easily accommodate a medium-sized trip at any water level. This was another venue for facilitated discussion with the group on resource issues, management policy, and partner organizations such as Grand Canyon Association.
Total person hours:140
Pruned 91 linear meters of trail (kitchen, intra camp connectors, toilet)
Pruned 140 linear meters around tent pads
Delineated and expanded 5 tent pads (166 square meters)
Constructed one 13 step log and stone access trail (14 square meters)
Installed long-term photo points

273.5 Mile Camp (RM 273.5 L)

This is a very well-established and popular campsite, able to accommodate a medium to large sized group. The campsite was created by river users over the years as the lake receded, and it bears the scars of resource damage resulting from improperly pruned vegetation (see figures 6-8, appendix F). Work focused on eliminating the many hazardous stobs left at ground and eye level and improving the kitchen and access trails.
Total person hours: 76
Pruned 332 linear meters of trail (kitchen, intra camp connectors, access and toilet)
Pruned 142 linear meters around tent pads
Leveled and improved 14 tent pads (87 square meters)
Retook long term photo points

Problems Encountered and Solutions

The conditions encountered at river mile 271.2 caused the mitigation team to change its work plan. This site had exhibited resource damage from recreational use for camping and was included in the itinerary to be improved for use as a small- to medium-sized camp. Several factors invited reevaluation of the efficacy of working on this site:

1. Strong, fast current at the proposed boat parking area, coupled with marginal mooring options.
2. Silt bank at boat landing had eroded substantially, making access more difficult.
3. Evaluation by the physical sciences program manager indicated that conditions were too dynamic and unstable in the proposed main camp area to warrant investing any labor for improvements.

After reviewing this new information, the mitigation team decided not to improve the site for the following reasons:

1. Wrangling boats to park in swift current is inherently hazardous. Campsites that require mooring in current are less attractive to recreational users.
2. Because of the rapidly eroding access bank, the team was reluctant to invest the labor to improve access when the longevity of the investment seemed so dubious.
3. The site overall seemed too vulnerable to the caprices of erosion to warrant further administrative effort.

The Pearce Ferry takeout was an anticipated problem. The trip leader and shuttle drivers had previously arranged to be met by rangers from Lake Mead at the takeout in order to provide vehicles and winches necessary to extricate the truck and boat trailer in the event that either became mired in the silt sandbar that forms at the end of the ramp. After about an hour of trying to use the ramp, the group decided to try another spot adjacent to the ramp and was at last successful in getting the boat out of the water.

Figure1. Trying to get down to concrete at the Pearce Ferry boat ramp.

River patrol and recreation planning staff will continue to monitor campsites and visitor use patterns below Diamond Creek. The possibility of equalization flows for the summer may have significant effects on the unstable slit banks characteristic of the Lower Gorge below Separation. Public education regarding the dynamic changes at play in the Lower Gorge should be aggressive and ongoing, as campsite conditions and availability can change rapidly. The campsite list for the Lower Gorge is being reviewed and updated for the NPS website, as well as distribution through the River Permits Office.

The Pearce Ferry takeout ramp will likely continue to be a challenge for users and managers. Documenting incidents such as the one reported above might help leverage support for addressing the problems at the ramp in the future.

Recommendations for the Future

Aside from the recently established campsite monitoring program and some wildlife and soundscape studies, little research has been done in the Lower Gorge. The following are some of the efforts underway to improve monitoring of the area below Diamond Creek:

- Recreation staff will implement visitor use monitoring in 2011.
- Trip logs have been distributed to the educational permit holders using the Lower Gorge to help gather campsite occupancy and user discretionary time data.
- A post-trip visitor feedback form is available online to trip leaders following their trip.
- The vegetation program is including the Lower Gorge in tamarisk beetle surveys this summer.
- Refinement of protocols and methods for the vegetation and avifauna monitoring program under CRMP is expected to be complete later this year, at which time the program can be extended into the Lower Gorge.

Additional suggestions for research and monitoring are presented in Appendix B, and additional recommendations regarding cultural resources are presented in Appendix F.

Table 1. Participant List

Role	Participant	Division
Trip Leader/Boatman	Dave Loeffler	Visitor & Resource Protection
CRMP Planner, Project Coordinator	Vanya Pryputniewicz	Science & Resource Mgmt.
Restoration Biologist	Kassy Theobald	Science & Resource Mgmt.
Physical Sciences Program Manager	Deanna Greco	Science & Resource Mgmt.
Vegetation Program, Crew Leader	Michael Wolcott	Science & Resource Mgmt.
Trails Program, Crew Leader	Dawn Doran	Science & Resource Mgmt.
Archaeology, Laborer	Shelly Szegi	Science & Resource Mgmt.
VIP Laborer	Gary Hickman	Science & Resource Mgmt.
VIP Laborer	Dave Yeamans	Science & Resource Mgmt.
VIP Laborer	Rich Turner	Science & Resource Mgmt.
VIP Laborer	Terry Vallely	Science & Resource Mgmt.
VIP Laborer	John Forsythe	Science & Resource Mgmt.
VIP Laborer	Val Malutin	Science & Resource Mgmt.
VIP Laborer	Alex McLellan	Science & Resource Mgmt.

Table 2. Itinerary

Date	Day	River Mile	River Side	Work Location	Project Details	Campsite Name
2/23/2011	1	230.6	L	Travertine Falls Camp	Drive to Diamond, Launch, transit to camp	Travertine Falls
2/24/2011	2	230.6	L	Travertine Falls Camp	Project orientation, methods training, correct pruning and clean fire rings	Bridge City
		238.7	L	Dynamite cache	Cultural assessment	
2/25/2011	3	246	R	Opposite Spencer	Photopoint and cultural assessment	250 Mile
		250	R	250-mile Camp	Project orientation, pruning, and site delineation	
2/26/2011	4	250	R	250 Mile Camp, Dry	Finish up at 250 Mile; transit to Dry Canyon	Dry Canyon
		264.6	R	Dry Canyon	Project orientation and begin campsite delineation	
2/27/2011	5	264.6	R	Dry Canyon	Continue pruning, campsite and access trail delineation	Dry Canyon
2/28/2011	6	271.2	R	Opposite Evan's Heaven	Project orientation, campsite delineation, slope stabilization, and pruning	Opposite Evan's Heaven
3/1/2011	7	273.5	L	Echo Camp	Project orientation and pruning around campsites, kitchen and access trails	Echo
3/2/2011	8	Pearce			Transit to Pearce Ferry, hike to Pearce Ferry Rapid, take out	

Representative photographs from mitigation program

Figure 2. Post-work, 250 mile. April 2009

Figure 3. 250 mile, February 2010

Figure 4. Post work, 250 mile, February 2011

Figure 5. Middle terrace area at Dry Canyon Camp, pre-work. February 2011.

Figure 6. Middle terrace area at Dry Canyon Camp, post-work. February 2011.

Figure 7. Willow saplings broken adjacent to access trail at mile 273.5.

Figure 8. Hazardous stobs left by user "pruning" at mile 273.5.

Appendix B – Lower Gorge Geomorphic Assessment

Trip Dates: February 23- March 1, 2011 (Part of mitigation trip)

Background

Lake Mead draws a majority of its water from snowmelt in the Colorado, Wyoming, and Utah Mountains. The water is released from Lake Powell then flows through the Grand Canyon and into Lake Mead. While Lake Mead's inflow depends on releases from Lake Powell, its outflow is roughly the same each year. In years with much less snow, Lake Powell releases only the minimum flow rate required by law. This inflow from Lake Powell is less than the outflow from Lake Mead. Since 2000 the water level of both reservoirs has been dropping at a fairly steady rate due to below average snowfall and increased usage. Currently, Lake Mead is at roughly 39 percent of its capacity. Changing rainfall patterns, natural climate variability, high levels of evaporation, reduced snow melt runoff, and the current demand for water and electricity all contribute to a decrease in water storage at Lake Mead. At current usage rates coupled with the prevailing climate pattern of acute droughts, it is quite likely that reservoir levels will continue to drop over the next few years.

Historically, the location of Lake Mead backwaters has varied between river miles 235 to 237 in the Grand Canyon. In this reach of the Colorado, Lake Mead's lowering water levels are causing the river to reemerge. Rapids that once were underwater are now being exposed, and river slopes are lined with steep vertical banks of lake sediments. Underneath these sediments are the basement rocks of schist and granite and further downstream the Tapeats Sandstone. While portions of the upper Grand Canyon are sediment-starved, the lower gorge is choked with years of accumulated sediment. In response, geomorphic adjustments and changes in the lower gorge are dramatic and evolving.

Rivers tend toward a stable base level when watershed processes and climate is operating within normal levels of variability. Base level changes usually occur over geologic time scales. A rapid decrease in water surface elevation caused by lowering lake levels can change a local base. This change can shorten natural fluvial responses to a shorter time scale. A base level drop reduces downstream controls on sediments stored in a reservoir. Changes in channel morphology such as width, depth, and sinuosity will continue as the river adjusts to its new slope through lateral channel migrations. These responses can lead to altered aquatic and riparian habitats.

During the February, 2011 CRMP Mitigation trip, a cursory evaluation was made of the geomorphic processes occurring in the lower gorge of the Grand Canyon. This report contains a brief discussion of the issues and recommendations:

- Develop informational materials for the general public, concessionaires, the boating community and park personnel.
- Develop a protocol for long-term monitoring techniques.
- Request a Geoscientist in the Parks (GIP) position to assist with geomorphic analysis and with some of the recommended monitoring actions.

Logistics and Personnel

This geomorphic assessment was conducted by Deanna Greco, Physical Science Program Manager, on the February Lower Gorge mitigation trip. Please refer to participant list and itinerary in Appendix A.

Results and Observations

In the last 10 years, a rapid decline in the water levels of Lake Mead has resulted in dramatic changes to the lower gorge of the Grand Canyon. As the lake lowered, the Colorado River lost connectivity with adjacent floodplains and side tributaries. Bank slopes in the lower gorge have gradually increased during the time that water levels dropped. The geomorphic response is to adjust the high banks that are the remnants of what were once lake bottom sediments. Through sloughing, slope bank failures and toe slope erosion, the slopes are making adjustments to a more stable configuration. These changes have lead to higher sediment yields within portions of the lower gorge. In several locations, the higher sediment yields are in excess of river transport capacities. This has led to large sandbar development and sediment accumulation in the Pearce Ferry area.

Many of the side tributaries in the Lower Gorge, such as Separation (river mile 240), Spencer (river mile 246) and Surprise Canyons (river mile 249) are exhibiting multi-channel features in the confluence area with the Colorado River. Braided channel patterns are found developing in very course materials in canyons with moderately steep slopes. These tributaries are susceptible to "flashy" runoff events and highly variable flow stages that occur annually and generate a very high source of sediment. The channel adjustments in these canyons are in response to base level changes in the Colorado River.

In other side tributaries such as Dry Canyon (river mile 265), the channel is experiencing a different type of channel adjustment. The lowering of Lake Mead has caused the Dry Canyon creek bed to become disconnected from the Colorado River. In response, the creek has begun to headcut (*A headcut is an abrupt step in the channel profile*) at its confluence with the Colorado River. The headcut advancement is also due to base level shifts in the Colorado River.

Figure 1: High terrace deposits of former lake bottom sediments and the formation of a new floodplain through sloughing and slope failures (Lower Gorge, GRCA).

Figure 2: Braided channel and coarse material bed load (Separation Canyon, Lower Gorge).

Recommendations for the Future

One of the most important unanswered geomorphological questions related to the effects of water level changes in Lake Mead is what will the likely courses of change be in the Lower Gorge. In light of current trends, predicting the future of the Lower Gorge is difficult when considering the cascade of geomorphic processes and downstream accumulation of sediment. As Lake Mead stays at its current levels or, as some have predicted, the levels continue to decline, watershed changes will continue to undergo various intermediate geomorphic adjustments. Given the current state of water usage, changing climate variables and altered land covers in the drainage basins, it is highly unlikely that the Colorado River and its tributaries will return to a pre-dam condition.

The simplest way to respond and mitigate the impacts lies in finding the correct balance between gaining knowledge to improve management and achieving the best outcome based on current knowledge. In other words, adaptive management strategies will need to be developed to respond to changing conditions. It is recommended that the following steps be taken to adequately focus on these concerns raised in this report:

- Develop informational materials for the general public, concessionaires, the boating community, and park personnel. The information should explain the natural process of geomorphic adjustment and the regional history of the watershed and projected trends. Due to the level of uncertainty in regards to the stability and water level management of the lower gorge, the public should be made aware of the issues and the projected outlook, and they should be given the tools to make an educated decision for themselves about their thoughts on the management of the area. Presenting a level of awareness can be accomplished through the following avenues:
    - Develop an information bulletin.
    - Provide a hazard/slope stability notification to river users.
    - Present information in a web-based format.

- Place notifications in concession contracts and visitor permits.

- Develop a protocol for long-term monitoring techniques. A list of possible activities include:
  - LiDAR – It has and can be used to monitor dynamic geomorphic processes and perform change analysis.
  - Vertical Aerial Photography - Could be undertaken once every 2-5 years, or more if desired. In addition, use of existing aerial photography from either the park library or from archives can be orthorectified and used in an ArcGIS-based project for a suitable and accurate base.
  - Oblique Aerial Photography- Use of a park airplane to carry a park employee over the lower gorge area, making a series of turns so that pictures can be taken from the window. This would require the use of a park employee for a few hours and should be done once a year.
  - Boat-by and Land-based Photography - From the River, photographs of the area would be taken using established photo monitoring techniques. This would require a park employee performing this task while on a river trip or developing a volunteer program to perform the task. This could be repeated many times throughout the year.
  - GPS based monuments - Set up GPS points and soil stakes/pins to monitor creeping and movement on the more active slopes (especially those associated with camps) in the lower gorge. This would require two or more park employees to travel to the lower gorge and install new monuments and soils pins/rebar stakes. This technique would require multiple days a few times a year of a park employee and a boat over a period of at least five years.

- Request a Geoscientist in the Parks (GIP) position to assist with geomorphic analysis and monitoring. The program has proven to be effective in assisting parks with geosciences-based needs. A list of possible activities for a GIP include:
  - Aerial photo analysis – Examine the most recent satellite imagery available and compare past aerial photography. Place the information images into a GIS format to document past changes. This can be used as a tool to monitor changes in the area.
  - Development of a photo monitoring program. A good technical reference on photo monitoring can be found at: http://www.fs.fed.us/pnw/pubs/gtr526
  - Develop a digital geologic map that focuses on surficial conditions. The current geologic map could be used as a basis to add a surficial component.

Appendix C - November Mitigation Trip Report

Trip Dates: November 1 - November 18, 2011

Trip Objectives

As a part of the CRMP Mitigation Program, the main objectives of the trip were to address the following:

- Social trails: excessive and damaging trails leading from the post-dam riparian zones of campsites and attraction sites to the pre-dam high water zones; usually typified by damaged soil crust, gully formation, broken vegetation, and compacted soils. The pre-dam high water zone contains fragile plants, easily damaged biological soil crusts, and cultural resources.
- Vegetation damage: usually caused by social trailing and trampling of grasses, shrubs, cactus, and biological soil crusts; tree, shrub and cactus damage from campsite pioneering or illegal firewood gathering; and tree and shrub damage from unauthorized and improper pruning at campsites and attraction sites.
- Erosion: combination of weather or natural conditions that threaten the stability of trails, camping areas, and mooring areas. This usually occurs when water runoff is captured within the existing trail resulting in down cutting or soil loss.

This trip was executed through the Cooperative Resource Conservation Program (CRCP). An interdisciplinary team of Grand Canyon National Park staff and guides from Tour West joined forces to conduct various rehabilitation and maintenance projects at camps and attraction sites along the Colorado River. Major work projects were conducted at Soap Creek, Hance Rapid, Tapeats Creek, and Deer Creek. Several one to two hour projects were completed at other locations, as well as assessments for project planning and photopoint monitoring.

Additional objectives included the evaluation and removal of climbing slings, planning for future interdivisional work projects at South, Nankoweap, Tanner, Cardenas, Unkar, Hance, and Granite, and generating enthusiasm for future collaboration with NPS resource work through the CRCP agreement and volunteerism.

Results and Observations

Overall, the trip went very well, and most of the objectives were accomplished. The Soap creek pilot project has been extremely successful as far as establishing data for active restoration projects such as specific methods, plant species, and frequency and duration of active maintenance (i.e., filling of berms and ollas) requirements. It continues to serve as an excellent training and outreach location for NPS staff and commercial guides to highlight river resource management efforts and foster stewardship within the boating community.

Mitigation monitoring and photo points at several popular campsites showed the need for further mitigation efforts, primarily closing of social trails and campsites in the old high water zone at Soap, South, all camps comprising the Nankoweap complex, Tanner, Cardenas, Unkar Delta, and Hance Rapid. **Ideally, most of these sites would be addressed prior to the onset of the 2012 high use period, as vegetation and archaeological resources are currently threatened and conditions will likely deteriorate over time.**

Major Mitigation Projects Accomplished

Soap Creek
108 plants planted for phase III of olla project, representing 9 species of grasses, plants and cacti
14 social trails obliterated
1 excess tent pad obliterated
163 meters of campsite perimeters and trails pruned and delineated
130 meters of rock lining delineating trails

Hance
2 social trails obliterated
50 meters of trail pruned and delineated
~1650 meters of social trails evaluated for future work

Granite
150 meters of trails pruned and delineated
3 fire rings removed
human waste removed

Tapeats/Thunder River
1 social trail obliterated
1550 meters of trail pruned and delineated
1500 meters of trail maintained (rocked)

Deer Creek
4320 meters of trail pruned and delineated
2160 meters of trail maintained (rocked)

Routine Mitigation Maintenance Projects Accomplished

Upper 185 Mile
100 meters of trail pruned and delineated
1 log check installed

Lower 185 Mile
100 meters of trail pruned and delineated

202 Mile
50 meters of trail pruned and delineated

Granite Park
200+ meters of trail pruned and delineated

Additional Accomplishments

- Climbing equipment was evaluated and removed at Sheer wall and Deer Creek Falls by Lisa Hendy, with assistance from Kassy Skeen and Dave Loeffler. Approximately 50yds upstream of the mouth of Sheer Wall, Hendy used technical lead climbing equipment to access a 10 foot long bright red section of 1" tubular webbing to remove it from a natural anchor point. In order to facilitate Hendy's subsequent descent, another 6' section of subdued color webbing was placed in

the same location, although care was taken to reduce visual impacts through both the color and the size of the webbing. At Deer Creek, Loeffler and Hendy descended the lower gorge of the canyon from the Patio down through Deer Creek Falls. A total of six anchor points were assessed, and approximately 75' of webbing, 4 rapid links, a disintegrating bolt and hanger, a carabiner and several rusted rappel rings were removed from the canyon. All of the anchors were then re-threaded with new, subdued color webbing and hardware using only the minimum amount of equipment needed to maintain standard safety margins. One of the anchors, located approximately 25' below the top of the falls in a small alcove, was deemed to be unnecessary to the completion of the canyoneering route, and a significant visual impact when viewed from the river. Several feet of prussic cord and a 4' piece of webbing were removed from this anchor. An attempt was made to remove the bolts to prevent further use of the anchor, but they had been installed using epoxy, and the wrench the team was carrying would not create enough torque to remove them without damaging the surrounding rock surface. In the future, a socket wrench with a handle extension would be recommended. Finally, a sling was evaluated at Olo canyon, hanging just above the mouth from historic bolts. The sling was not visible from the river, and not noticeable until viewed from immediately below the pour off. This sling was left in place.

- Photopoint monitoring at the following campsites: Soap Creek, South Canyon, Main Nankoweap, Lower Nankoweap(Point), Kwagunt, Cardenas, Unkar Delta, Owl Eyes, and Deer Creek.

- Pre-work assessment and project planning at the following campsites: Soap, South, Upper Saddle, Little Nankoweap, Main Nankoweap, Lower Nankoweap, Lava Canyon, Tanner backpacker camp, Cardenas, Unkar Delta, Hance, Tonto trail into Hance, Deer Creek trail and 202 Mile.

- Mitigation assessments for the following camps: Upper and Lower Garnet, Talking Heads, Lower Tapeats, Keyhole, Above Kanab, Below Kanab, Upset Hotel, 158 Mile, First Chance, and Last Chance.

- River resource issues and CRMP mitigation overview presented to Prescott College trip at Hance rapid camp by Kassy Skeen, Dave Loeffler, and Vanya Pryputniewicz

- Native seed collection for future projects at Upper Saddle and Lava Chuar

- Human waste and trash removal at various locations

- Toilet maintenance at Tanner, Tapeats, and Deer Creek.

Problems Encountered and Solutions

In spite of communication with all other trips encountered en route, upon arrival at Hance for a scheduled project layover, another group was already camped there. The NPS trip leader was able to hand signal the rest of our group to eddy out and camp at Papago, as well as get back upstream himself! The following morning, the NPS group waited for several hours for the other group to get packed up, as the project area was in the central camp. In the meantime, foul weather had moved in, and between these two unforeseen circumstances, much of the planned project time for Hance was lost. However, the Prescott College trip pulled in to scout just as the NPS group was unloading, affording the opportunity to do an impromptu resource management talk and take questions from the students, while still accomplishing some of the necessary work.

Another situation developed due to a preexisting medical condition of one of our trip participants. The 70 year old man was evacuated out at Phantom Ranch after showing signs of hemodynamic instability for

several days. The patient had a previous history of cardiac deficiency, and that was likely a contributing factor. Both Ranger Lisa Hendy and trip leader Dave Loeffler are to be commended for keen situational awareness and tactful, professional handling of a potentially serious medical emergency arising on the lower half.

Recommendations for the Future

In the past, the CRMP project leaders have attempted to enlist the support of the Lees Ferry staff to ensure that an outreach letter and copies of the itinerary are made available to private trips launching around the date of a CRMP trip, as well as carrying extra itineraries along for trip leaders we encounter on river. Perhaps it would be more effective to provide the outreach material to trip leaders by mail or email ahead of their trip as well, to help ensure positive interactions between visitors and administrative trips.

Several of the high priority sites for the next mitigation trip are adjacent to known archaeological sites. Due to a lack of funding and available personnel, this trip lacked representation from the Cultural Resources program. The CRMP mitigation project lead will provide a work plan to the CRMP program manager and seek input and direction from the CRMP interdisciplinary team members (and their program managers, if necessary) prior to scheduling the work.

For the duration of the CRMP implementation, mitigation trips in the past have been scheduled for November and February. Unfortunately, the program is unable to fund a CRMP mitigation trip for this February. The mitigation field crew is exploring other options for accomplishing some of the most urgent priority work with backpacking trips and limited river support from other administrative trips.

Table 1. Participant List

Role	Upper	Lower	Affiliation/Division
NPS Trip Leader/Boatman	Dave Loeffler	Dave Loeffler	NPS V+RP River
Tour West Trip Leader/Boatman	Bryan Yadon	Bryan Yadon	Tour West
Project Coordinator/Boatman	Vanya Pryputniewicz	Vanya Pryputniewicz	NPS S+RM Recreation
Vegetation Project Lead	Kassy Skeen	Kassy Skeen	NPS S+RM Vegetation
Trail Crew Lead/Boatman	Shayne Rasmussen	Shayne Rasmussen	NPS FMD Trails
Technical Rescue specialist/laborer	Lisa Hendy	Lisa Hendy	NPS V+RP Canyon
Vegetation Crew Lead	Michael Wolcott	Michael Wolcott	NPS S+RM
Boatman/laborer	Russ Gregory	Russ Gregory	Tour West
Boatman/laborer	Jake Skeen	Jake Skeen	Tour West
Boatman/laborer	Dave Stratton	Dave Stratton	Tour West
Boatman/laborer	Katrina	Katrina	Tour West
Boatman/laborer	Cole Barton	Cole Barton	Tour West

Boatman/laborer	Kevin	Kevin	Tour West
Boatman/laborer	Jarred	Jarred	Tour West
Laborer	Mike Coltran	Mike Coltran	NPS VIP Lee's Ferry V+RP

The following participants hiked into the trip at a few key locations. These staff members hiked in to participate as laborers, become acquainted with the CRMP Mitigation Program, and increase their understanding of resource concerns and how we communicate them both internally and externally to best benefit the preservation of quality resource conditions for the enjoyment of park users.

Laborer	Debbie Brenchley	NPS V+RP Canyon
Laborer	Jed Dryer	NPS VIP V+RP BIC
Laborer	John Vonk	NPS V+RP Canyon

Table 2. Itinerary

Date	Day	River Mile	River Side	Work Location	Project Details	Campsite Name
11/1/2011	1	11.3	R	Soap Creek	Project orientation and introduce hikers.	Soap Creek
11/2/2011	2	11.3	R	Soap Creek	Watering, social trail obliteration, last phase of ollas installation.	Soap Creek
11/3/2011	3	31.9	R	South Canyon	Beach cleanup, photo points and mitigation monitoring.	South Canyon
11/4/2011	4	47.5	R	Upper Saddle	Mitigation (mit) monitoring.	Point
		52.1	R	Little Nanko	Watering.	
		53.0	R	Nankoweap	Mit. monitoring. Photopoints Assess for pruning and touchup needs.	
		53.1	R	Point Camp	Mit. monitoring. Photopoints	
11/5/2011	5	56.5	R	Kwagunt	Mit. monitoring. Photopoints	Lava Cyn
		61.9	L	LCR	Mit. monitoring. Photopoints	
		65.1	R	Carbon	Mit. monitoring	
		65.9	R	Lava	Mit. monitoring	
11/6/2011	6	69	L	Tanner	Mit. monitoring. Photopoints Toilet maintenance	Papago
		71.6	L	Cardenas	Mit. monitoring. Photopoints	
		72.9	R	Unkar Delta	Mit. monitoring. Photopoints at Unkar loop trail	
		77.1	L	Hance	Hikers in. Mit. monitoring. Photopoints. Project scoping and orientation/discussion	
11/7/2011	7	77.1	L	Hance	Trail realignment, social trail obliteration, pruning, campsite	Hance

					construction, and beach cleanup	
11/8//2011	8	77.1	L	Hance	Wrap up project. Hikers out	Granite
		88	R	Phantom	Fill water, charge batteries	
		93.8	L	Granite	Hikers in: watershed project overview	
11/9/2011	9	93.8	L	Granite	Beach cleanup on downstream dunes	Parkins
11/10/2011	10	114.9	R	Garnet	Mit. monitoring at upper and lower campsites	Racetrack
		133.7	L	Talking Heads	Mit. monitoring and mapping	
		134.2	R	Racetrack	Mit. monitoring and mapping	
11/11/2011	11	134.3	R	Tapeats Creek	Work up creek. Stir toilet, trail work, campsite delineation, pruning	Racetrack
11/12/2011	12	135.2	L	Owl Eyes	Mit. monitoring. Photopoints	Poncho's
		136.9	R	Deer Creek	Mit. monitoring. Photopoints toilet maintenance	Kitchen
11/13/2011	13	144.6	R	Kanab	Assessment/monitoring at creek mouth	Upset
11/14/2011	14	174.7	R	Cove	Mit. monitoring	Mohawk
11/15/2011	15	183	R	Chevron	Pruning at upper and lower campsites	Whitmore
		185.8	R	185-mile	Pruning at upper and lower campsites	
11/16/2011	16	188	R	Whitmore	Work Whitmore if needed; travel	Granite Park
11/17/2011	17	225.9	L	Diamond Creek	Travel. Derig. Round robin discussion on future trips	Diamond Creek
11/18/2011	18	225.9	L	Diamond Creek	Early take-out and travel to South Rim	

Appendix D – Natural Resources Campsite Monitoring Trip Report

Trip Dates: September 3 –September 19, 2011

Background

In January of 2011, program managers for the division of Science and Resource Management convened a meeting to review the CRMP Integrated Resources Monitoring program. After hearing from each of the disciplines involved in the program, there was some doubt as to whether the current monitoring strategy was meeting the objectives of the CRMP and answering the management questions. It was agreed that the protocols and methods needed to be reviewed and the statistical analysis performed on the data collected since the implementation of the program before any further monitoring should occur. Consequently, the April 2011 CRMP monitoring trip was canceled in order to apply financial and personnel resources to the review effort.

A Cooperative Ecosystem Studies Unit (CESU) task agreement with NAU was sought and funded, and data were prepared for analysis. Program managers and their staff worked toward refining protocols and identifying and documenting possible deficiencies in the methods and the overall program.

Trip Objectives

The purpose of the September trip was to reevaluate the site selection, methods, and protocols of the CRMP monitoring program, as well as incorporate a pilot water quality component with the program. Additional objectives were to update campable area polygons on as many campsite maps as possible as time allowed and to conduct "float by" beach photography to document changes in beach profiles due to flow regimes.

The vegetation crew evaluated all transects at every campsite on the CRMP monitoring panel with the following goals:

- Determine if the transect location was appropriate and accurately captured the vegetation structure at the 35K or 90K water line.
- Install new transects if current ones do not accurately capture camping area.
- Install additional transects at the 90K line if not already installed.
- Accurately assess if an area is/was still used as a campsite and met the requirements of a campsite (adequate kitchen, sleeping, and toilet areas).
- Assess campsites where mitigation has occurred and determine if mitigation actions influence the vegetation monitoring transects.
- Assess campsites that had previously been dropped from the monitoring panel to see if they meet requirements for camping and could potentially be reinstated in the panel.

Table 1. Participant List

Role	Upper	Lower	Division
Trip Leader/Boatman	Sam Jones	Sam Jones	Intermittent Small Craft Operator (NPS)
Boatman/Rec Tech	Linda Jalbert	Linda Jalbert	S+RM Wilderness Program Manager
Boatman/Rec Tech	Vanya Pryputniewicz	Vanya Pryputniewicz	S+RM Recreation Planner
Boatman/Veg Tech	Michael Kearsley	Kelly Rowell	S+RM Vegetation Program
Boatman	Heather Aust	Heather Aust	V+RP River District Ranger
Watershed Lead	Todd Chaudhry		S+RM Watershed Program Manager
Water Quality Tech	Deanna Greco	Deanna Greco	S+RM Physical Science Program Manager
Vegetation Lead	Melissa McMaster	Melissa McMaster	S+RM Vegetation Program
Vegetation Tech	Emily Straus	Amy Prince	S+RM Vegetation Program
Vegetation Tech	Steve Till		S+RM Vegetation Program
Recreation Tech	Maddie Tighe	Maddie Tighe	S+RM Recreation Technician
Beetle Lead for Tamarisk Beetle Study	Levi Jamison	Levi Jamison	University of Arizona
Beetle Tech	Chris Holmes	Chris Holmes	Northern Arizona University
Beetle Tech	Matt Johnson		SW Biological Science Center/NAU
Recreation Tech	Peggy Kolar	Peggy Kolar	V+RP Lee's Ferry Ranger
Wildlife Tech	Janice Stroud-Settles	Janice Stroud-Settles	S+RM Wildlife Program

In addition, the following NPS staff hiked in to meet the trip at Granite Camp to participate in discussion and planning for the pilot Watershed Restoration project:

Martha Hahn, Chief, S+RM
Ellen Brennan, Cultural Resource Program Manager, S+RM
Richard Goepfrich, Trails Supervisor, FMD
Rebecca Carr, OPAC

Table 2. Trip Itinerary

Date	Day	River Mile	River Side	Work Location	Project Details	Campsite Name
9/2/2011	1	0	R	Lees Ferry	Drive and Launch. Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Soap
		5.9	R	Six Mile		
		8.8	L	8.5 Mile		
		11.3	R	Soap Creek		
9/3/2011	2	13	R	13 Mile	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Lone Cedar
		16.6	L	Hot Na Na		
		18.4	L	18 Mile Wash		
		20.2	L	20 Mile		
9/4/2011	3	30.4	L	30 Mile	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Anasazi Bridge
		30.6	R	Fence Fault		
		31.9	R	South Canyon		
		34.2	L	Little Redwall		
		35	L	Nautiloid		
		38.7	L	Martha's		
9/5/2011	4	47.2	L	Duck-n-Quack	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Lower Nankoweap
		47.5	R	Upper Saddle		
		52.1	R	Little Nankoweap		
		53.4	R	Nankoweap		
		53.5	R	Lower Nankoweap		
9/6/2011	5	56.5	R	Kwagunt	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Basalt
		58.1	L	Opp Malgosa		
		60.2	R	60 Mile		
		66	L	Palisades		
		70.1	R	Basalt		
9/7/2011	6	71.6	L	Cardenas	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Grapevine
		73.7	L	Unkar Left		
		75.7	L	Upper Nevills		
		76.1	L	Nevills		
		77.1	L	Hance		
		79.4	L	Below Sock		
		81.7	L	Grapevine		
9/8/2011	7	85	L	Zoroaster	Phantom Exchange, Transects, Beetle Sweeps, Campsite assessments. Float by's, updating polygons	Granite
		87.6	L	Cremation		
		93.2		Salt		
		93.8	L	Granite Camp		
9/9/2011	8	97.1		Upper Boucher	Watershed Pilot project overview and tour	Boucher
		97.2	L	Boucher		
9/10/2011	9	100.1	L	Lower Tuna	Transects, Beetle Sweeps	Hotauta

		103.7	R	103 Mile	every mile. Campsite assessments. Float by's, updating polygons	
9/11/2011	10	108.3	L	Ross Wheeler	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	120 Mile
		110	R	110 Mile		
		120.3	L	120 Mile		
9/12/2011	11	122.3	L	122.3 Mile	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Across Deer
		122.8	R	122 Mile Canyon		
		123.6	R	Below Forster		
		125.5	L	Fossil		
		131.7	R	Below Bedrock		
		136.6	L	Junebug		
		136.8	L	Across Deer		
9/13/2011	12	137.7	L	Football	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Second Chance
		137.8	L	Backeddy		
		139.6	R	Fishtail		
		143.9	L	Above Kanab		
		145.9	L	Above Olo		
		150.3	R	Patch		
		158.7	R	158.7 Mile		
9/14/2011	13	161.3	R	161.3 Mile	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Honga Springs
		165.2	R	Tuckup		
		167	L	Upper National		
		167.5	L	Below National		
		167.7	L	167.7 Mile Camp		
9/15/2011	14	180.1	R	Below Lava	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Fat City
		183	R	Lower Chevron		
		185.8	R	Upper 185 Mile Camp		
		185.9	R	Lower 185 Mile Camp		
		187.5	L	Whitmore Helipad		
		192.3	L	Fat City		
9/16/2011	15	196.9	L	Froggy Fault	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's, updating polygons	Fall Canyon
		207	R	Indian Canyon		
9/17/2011	16	214.5	R	214 Mile	Transects, Beetle Sweeps every mile. Campsite assessments. Float by's,	Diamond
		216.1	R	Opposite 3 Springs		

		218	L	217 Mile	updating polygons	
		220	R	Upper 220		
		220.1	R	Middle 220		
		220.2	R	Lower 220		
		221.6	R	221 Mile		
		222.2	L	222 Mile		
		223.7	L	224 Mile		
		224.9	L	224.9		
9/18/2011	17			South Rim	Derig	South Rim

Results and Observations

The following vegetation transects at the 35K water line were moved to better capture the vegetation structure and composition at the campsite. Photopoints were re-installed and transect descriptions re-written:

1. Little Redwall
2. Duck-n-Quack
3. Upper Saddle
4. Little Nankoweap
5. Upper Nevills
6. Hance
7. Salt Creek
8. Ross Wheeler
9. Junebug
10. Lower Chevron
11. Lower 185 Mile

The following campsites will be removed from the rotation as they are no longer campsites. They did not meet the campable criteria and will be dropped from the panel:

1. 30 Mile- flash floods have removed the small beach and campable area
2. Upper Boucher- overgrown and loss of sand
3. 122.3 Mile- becoming overgrown with arrowweed, a better high water camp
4. Patch- loss of sand and challenges of safely making the lower pull-in
5. 161.3 Mile- flashflood ripped out a large section, invasion of tamarisk and Russian thistle
6. Below National- further discussion should be had concerning this camp as we could keep it in the panel, but move the transect. The camp has shifted upstream to the less vegetated area.
7. 167.7 Mile- flashflood and encroaching vegetation
8. Above Kanab- no official decision made yet- definitely not a good camp as it is, perhaps we should spend time mitigating and creating a good camp alternative for Kanab Canyon.

We assessed and discussed adding transects in the old high water zone (90K) at the following camps:

1. 18 Mile- added a transect here
2. Unkar Left- thoroughly assessed camp for potential 90K transect and determined that the 90K line is too far from the actual camp and on very sensitive sand dunes so we did not install a 90K transect.

The following campsites were assessed for potential reintroduction back into the panels. They were originally dropped due to random deletion or because they were deemed unsuitable:

1. 5 Mile: It is not legal to camp here as it is within site of the bridge, a better lunch spot than camping spot. Not recommended for reintroduction into the panel.
2. 51.5 Mile: While it meets the requirements for adequate campable area, the access to the camp is quite difficult at this time. There are steep banks and falling tamarisk trees inhibiting access to the camp. At this point we will not add the camp back to the panel.
3. Mohawk: Both transects at this camp are adequate and it could easily be reinstated as a panel site if deemed appropriate.
4. Lower Whitmore: Only 1 transect in a not super popular camp with little vegetation. Could be reinstated, but another camp in the same stretch might be more appropriate.

The following transects were evaluated for potential impacts due to mitigation:

1. Kwagunt- the mitigation work done in the old high water zone was not done within the transect area.
2. Nankoweap- need to reassess, not 100% sure at the time of the reading.
3. Hance- slight mitigation that may have an impact in the 90K transect, but very minimal and should reassess after November 2011 mitigation trip.

During the initial setup of transects, crews were not consistent in running transects up or down river. On this trip, for consistency sake, we decided to have all transects run from up to downstream and are in the process of changing those transects in the database.

The recreation team evaluated the protocols and methods for campsite assessments using a new assessment form. Changes were made to dramatically reduce the potential for inter-observer variability, simplify the methods for assessing indicators where the existing method was deemed unnecessarily complex, and eliminate indicators from the assessments that did not make a substantial contribution to informing management decisions. Some examples include:

1. Eliminating indicators involving vegetation, since the effort is redundant when vegetation specialists are reading transects at each campsite.
2. Combining indicators that were deemed too similar to warrant the effort of separate counts (eg., rock and stick impacts, which both are indicators of impacts to wilderness quality).
3. Converting the social and access trail indicators into one indicator entitled new high water zone trails, as the distinction between social and access trails had been made differently by different observers and was dependent upon water levels.
4. Adjusting the type of values to assign the indicator when the complexity and time invested were not warranted, given that an increase or decrease in the value did not affect the management response (eg., human waste, litter, and evidence of fire were changed from numbering to presence/absence).

The new methods have numerous advantages, and most of the decisions that were made are likely to be incorporated into the future implementation of the CRMP Resource Monitoring and Mitigation program. Outstanding tasks related to finalizing a new protocol for campsite assessments are

1. Establishing times according to indicator or beach size.
2. Developing a protocol for the mapping component.
3. Frequency of monitoring.
4. Establishing training and educational requirements for data collectors.

Additional campsite work included updating campable area polygons at 94 river campsites and “float-by” rephotography of over 200 river campsites.

In addition to the campsite monitoring work, an overview and site visit was done for the Granite/Monument pilot Watershed Restoration project, Tamarisk beetles were monitored, microclimate data collectors that had been used for beetle monitoring were removed, mitigation prescriptions using the CRMP mitigation assessment form were done, CRMP mitigation monitoring rephotography at Upper Saddle, Tanner and Lava Canyon were taken, and 21 ravenna grass were removed.

Appendix E - Avifauna Monitoring Trip Report

Trip Dates: May 16-31, 2011

Trip Objectives

- Conduct avifauna point counts at all Camp and Control Sites within panels 1, 2, 3, and 4 of the CRMP Monitoring Plan.
- Conduct SWFL surveys at historic sites, and in areas identified as suitable habitat.
- Complete SWFL habitat surveys in previously un-surveyed patches, and develop a prioritized list of habitat patches for surveys on subsequent trips.
- Deploy 6 sound recording systems to supplement southwestern willow flycatcher surveys.
- Conduct Tamarisk Beetle surveys systematically along the Colorado River corridor from Lee's Ferry to Peirce Ferry.
- Deploy HOBO samplers systematically along the Colorado River corridor in conjunction with tamarisk Beetle survey sites.

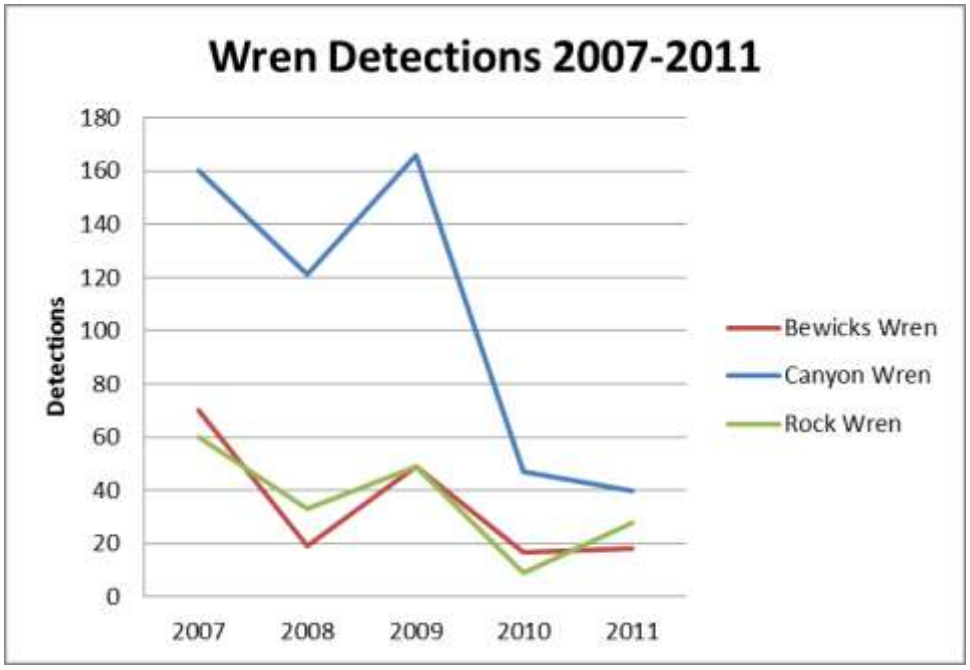
Logistics and Personnel

The National Park Service (NPS) and United States Geological Survey (USGS) participated in this monitoring trip, which was funded by the NPS (CRMP), BOR (SWFL surveys) and USGS (beetle surveys). Surveys were conducted from May 17-31, 2011. This trip utilized two motorized snout rigs driven by NPS boatmen. Point count surveys and flycatcher surveys began approximately 15 minutes before sunrise and were completed before 10:00 A.M. Tamarisk beetle surveys did not have time constraint; therefore the two boats could travel on separate schedules and complete the day's work load within the appropriate time frame. We had one individual hike out at Phantom Ranch, one individual hike in at Phantom Ranch, four depart at Diamond Creek.

Results and Observations

A total of 114 point counts were conducted from Lees Ferry to Diamond Creek, resulting in the detection of 45 species and a total of 859 birds. Forty-eight point counts were conducted in new high water zone (NHWZ) camp areas and 48 counts in the corresponding control NHWZ sites. Twelve old high water zone sites were surveyed in camp areas, and 6 OHWZ sites were surveyed in control sites. More birds were detected in camp sites (n=464) than control sites (n=395). The number of species detected at camp sites (n =39) was slightly greater than control sites (n=38). Camp sites averaged slightly more birds per site (9.5 birds/point) compared to control sites (9.2 birds/point). Lucy's Warbler was the most common species detected (n= 198) followed by House Finch (n=82), Yellow Warbler (n=76), and Common Yellowthroat (n=52). Interestingly, detections of Canyon Wren decreased greatly from previous years. Mean detections from 2007-2009 were 149 ±24, and from 2010-2011 mean detection were only 44 ±5 were detected (Figure 1).

Figure 1. Wren detections from May CRMP avian point count surveys, 2007-2011.



In addition to the species detected during point counts, 18 avian species were observed incidentally during the trip, 2 were rare sightings (cliff swallow and green heron). We had a few rare sightings during several point counts. A Bullocks oriole was seen at 6 mile camp site. A ring-billed gull was seen both at Hance camp site and the control site for 110 mile camp. A Northern rough-winged swallow was detected at Fat City camp site and the control site for Froggy Fault camp.

A total of 16 sites were surveyed for southwestern willow flycatcher presence; 5 historical sites and 2 new site between Lee's Ferry and Phantom Ranch, and 3 historical and 7 new sites between Phantom Ranch and Pearce Ferry. Completing river trips at Pearce Ferry instead of Diamond Creek allowed for 3 additional sites to be surveyed. Two southwestern willow flycatchers were detected during the trip. One adult singing was detected at river mile 51.8 L and one singing adult at 217.7 L. Habitat assessments were conducted at 15 sites from Lee's Ferry to Pearce Ferry. From these assessments, zero sites were classified as suitable habitat, and 9 additional sites were classified as potential breeding habitat. These classifications will help to prioritize survey efforts on future monitoring trips.

To capture southwestern willow flycatcher vocalizations we deployed 6 recording systems units between river mile 47 and 275. The units were collected in July and recorder 1,222 hrs of audio data. No flycatchers were detected from the audio recordings.

Problems Encountered and Solutions

The only major problem encountered was in regards to the trip itinerary. There were several days when too many bird surveys were scheduled. This resulted in some surveys occurring after the 10 am cutoff time. The solution to this would be to extend the trip by 1 more day and reduce the number of surveys for each day.

Table 1. Participant List

Role	Upper	Lower	Division
Trip Leader/Boatman	Nate Alvord	Nate Alvord	River District
Boatman	Chelly Kearney	Chelly Kearney	River District
Boatman	Caroline Alvord	Caroline Alvord	River District
Avifauna Crew Lead	Janice Stroud-Settles	Janice Stroud-Settles	S & RM
Avifauna Biologist	Jean Lawrence	Jean Lawrence	S & RM
Avifauna Technician	Brian Gatlin	Brian Gatlin	Interpretation
Avifauna Technician	Sarah Sells	Jeremy Russell	VIP
Tamarisk Beetle Monitoring	Levi Jamison	Levi Jamison	USGS
Tamarisk Beetle Monitoring	Chris Holmes	Chris Holmes	USGS

Table 2. Itinerary

Date	Day	River Mile	Work Location	Project Details: River Side, Control or Camp, Number of Sites			Campsite name
5/16/2011	1	5.9	Rig and drive to Lee's Ferry Float to Six Mile Camp	Mid-morning departure to Lees Ferry, finish the rig, and float to Six Mile.			Six Mile Camp
		5.9	6 Mile Camp	Camp	R	2	
		6.1	6 Mile Camp	Control	R	2	
		8.8	8.5 Mile	Camp	L	1	
5/17/2011	2	9.2	8.5 Mile	Control	L	1	Cave
		18.2	18 Mile Wash	Control	L	1	
		18.3	18 Mile Wash	Camp	L	1	
		19.6	20 Mile	Control	L	2	
		20.1	20 Mile	Camp	L	2	
5/18/2011	3	28.5	SWWFL+Sound		L	1	Duck N' Quack
		30.4	30 Mile Camp	Camp	L	1	
		30.5	30 Mile Camp	Control	L	1	

		32.9	Little Redwall	Control	L	1	
		34.2	Little Redwall	Camp	L	1	
		38.7	Marthas Camp	Camp	L	1	
		38.8	Marthas Camp	Control	L	1	
5/19/2011	4	47.3	SWWFL+Sound		R		60 Mile
		47.3	Duck N Quack	Control	L	1	
		47.5	Duck N Quack	Camp	L	1	
		47.5	Upper Saddle	Camp	R	4	
		48.2	Upper Saddle	Control	R	2	
		50.5	SWWFL+Sound		L	1	
		51.8	SWWFL		L	1	
		52.0	SWWFL		L	1	
		54.7	Habitat				
		56.0	SWWFL		R	1	
		58.1	Opposite Malagosa	Camp	L	1	
			Opposite Malagosa	Control	L	1	
5/20/2011	5	59.9	60 Mile	Control	R	1	Phantom Ranch/Salt
		60.1	60 Mile	Camp	R	1	
		66	Palisades	Camp	L	2	
		66	Palisades	Control	L	2	
		71.6	SWWFL		L	1	
		71.4	Upper Nevills	Control	L	2	
		71.6	Upper Nevills	Camp	L	2	
		76.9	Hance	Control	L	1	
		77.1	Hance	Camp	L	1	
5/21/2011	6	75.1	Salt	Camp	L	1	Ross Wheeler

			Salt	Camp	L	1	
		93.8	Granite	Camp	L	2	
			Granite	Control	L	2	
		97.1	Boucher	Control	R	1	
		97.2	Boucher	Camp	L	1	
5/22/2011	7	108.2	Ross Wheeler	Control	L	1	Below Bedrock
		108.3	Ross Wheeler	Camp	L	1	
		110	110 Mile	Camp	R	1	
		110.2	110 Mile	Control	R	1	Below Bedrock
		120.1	120 Mile	Control	L	2	
		120.3	120 Mile	Camp	L	2	
		122.3	121.5 Mile	Camp	L	1	
		123	121.5 Mile	Control	L	1	
5/23/2011	8	131.7	Below Bedrock	Camp	R	1	Above Kanab
		131.9	Below Bedrock	Control	R	1	
		136.4	Junebug	Control	R	1	
		136.6	Junebug	Camp	L	1	
		136.4	Across Deer Cr	Control	R	1	
		136.8	Across Deer Cr	Camp	L	1	
		137.7	Football Field	Camp	L	2	
		138.2	Football Field	Control	R	2	
5/24/2011	9	144.0	SWFL		R	1	160.5
		145.5	Above Olo	Control	L	1	
		145.8	Above Olo	Camp	L	1	
		150.3	Patch Camp	Camp	R	2	
		150.4	Patch Camp	Control	R	2	

5/26/2011	10	160.5	160.5	Camp	R	2	Below Lower Lava
		160.7	160.7	Control	R	2	
		167.5	Below National	Camp	L	2	
		168.4	Below National	Control	L	2	
		168.5	SWFL				
		171.3	Habitat				
		172.5	Habitat				
		174	Habitat				
		176.4	Habitat				
		177.7	Habitat				
		178.9	Habitat				
5/27/2011	11	180.1	Below Lower Lava	Camp	L	2	Fat City
		180.1	Below Lower Lava	Control	L	2	
		183	Lower Chevron	Camp	R	2	
		183.1	Lower Chevron	Control	R	2	
		183.5	Habitat				
		185.8	Upper 185 Mile	Camp	R	2	
		186	Upper 185 Mile	Control	R	2	
		186.8	Habitat				
		191	Habitat				
		191.3	Habitat				
5/28/2011	12	192.3	Fat City	Camp	L	2	Indian Canyon
		192.6	Fat City	Control	L	2	
		194.7	SWFL		R		
		196.4	SWFL and Sound		R		
		196.9	Froggy Fault	Camp	L	2	

		197.5	Froggy Fault	Control	L	2	
		197.6	Habitat				
		197.9	Habitat				
		198.0	Habitat				
		198.1	Habitat				
		204.7	SWFL		R		Diamond Switch
5/29/2011	13	207	Indian Canyon	Camp	L	1	Spencer
		207.1	Indian Canyon	Control	L	1	
		214	214 Mile	Camp	L	1	
		215.1	214 Mile	Control	L	1	
		217.6	SWFL				
		217.7	Below 217 Mile	Control	L	1	
		218	SWFL				
		218	Below 217 Mile	Camp	L	1	
5/30/2011	14	246	SWFL		L		Lower Quartermaster
		249.9	SWFL		L		
		252	SWFL		L		
5/31/2011	15	259.9	SWFL and Sound		R		Pearce
		274.5	SWFL and Sound		R		

Appendix F – Lower Gorge Cultural Resources Assessment Trip Report

Trip Dates: February 23- March 1, 2011 (Part of the Lower Gorge Mitigation Trip)

Trip Objectives

- To monitor archaeological sites for threats and/or disturbances caused by visitation or by natural forces.
- To monitor ground-disturbing activities that could potentially reveal unknown archaeological artifacts or features.
- To formally evaluate and document the "Buzz Holmstrom Inscription" as an archaeological site.
- To participate as a member of the CRMP Mitigation Trip in the improvement of campsites along the Colorado River from Diamond Creek to Pearce Ferry.

Logistics and Personnel

This geomorphic assessment was conducted by Deanna Shelley Szeghi, NPS Archaeologist, on the February Lower Gorge mitigation trip. Please refer to the participant list and itinerary in Appendix A.

Results and Observations

— February 23, 2011 - Travertine Falls Camp (RM 230.6 L)

The CRMP mitigation trip launched from Diamond Creek and travelled a short distance downriver to set up camp at Travertine Falls. A brief camp logistics orientation was conducted. No mitigation work was conducted on this day.

— February 24, 2011 – Travertine Falls Camp to Bridge Canyon Camp (RM 238.7)

On the morning of 2/24, an archaeological assessment of the Travertine Falls Camp was conducted. The campsite's primary access trails, kitchen area, and common area were examined for archaeological features or artifacts, none of which were determined to be present through surface survey. Prior to beginning work at the campsite, the CRMP mitigation group was given training on safety and proper pruning techniques. Work at the Travertine Falls Camp mostly involved pruning and, even if present, would not have negatively impacted sub-surface archaeological features or artifacts. The clean-up of two modern hearths from the campsite constituted the only ground disturbance. Hearth clean-up involved sifting sand contaminated with ash and charcoal through a screen. No cultural debris was encountered in either hearth; their contents were limited to lining stones, ash, and charcoal.

After completing mitigation work at the Travertine Falls Camp, the group travelled downstream and stopped at several historic archaeological sites known to attract visitors in order to monitor impacts to the sites:

- G:02:0123 - This site, visible from the river, is often referred to as the "dynamite cache" or the "powder house." Comparisons with monitoring photographs taken in 2009 showed no significant change in the condition of the Powder House. The primary disturbance to the site from visitation is evidenced by a faint social trail leading from the riverbank a short distance to the site; this impact is considered to be minor and is not anticipated to adversely affect the site itself. The primary threats to the stability of the structure come from natural forces such as insect damage, water runoff/erosion, and general erosion. Again, these are judged to be minor threats, and the site is evaluated to be in good condition. Because this site is an attraction site, it is recommended that it is monitored every five years due to the potential for increased visitation by river runners travelling from Diamond Creek to Pearce Ferry. If the site continues to be in good condition and

has not been negatively impacted by visitation after the next monitoring in 2016, it may be beneficial to revise the monitoring schedule to every 10 years.

- G:02:0106 - This historic site, also visible from the river, contains several features including retaining walls, can dumps, and a work bench. Access to this site, particularly to the work bench, has been previously noted to be very dangerous on account of the need to navigate a steep and slippery slope. Access to this site is indeed precarious, and it is recommended that, in following 1995 recommendations by L. Leap and 2008 recommendations by A. Horn and I. Hough, the 15-year monitoring schedule for this site should be strictly followed. The 15-year monitoring schedule at this site reflects the stable condition of the site, and the potential negative impact to the surrounding area from unnecessary monitoring. Feature one (the workbench) was monitored, but other site areas were avoided due to difficult access.
- G:02:0101, Bridge Canyon City Historic Work Center - Located above the modern Bridge City River Camp, this historic site served as a work camp for laborers on the proposed Bridge Canyon Dam. Site monitoring revealed little evidence of visitation or disturbance. Several social trails are present throughout the site; however, these are likely contemporaneous with the site itself and have been in continued use by visitors since the work center was closed.

The group camped at the River Camp, and aside from taking photo points, no further CRMP mitigation work was conducted at this camp.

— February 25, 2011, Bridge City Camp to 250 Mile Camp (RM 250 R)

At Spencer Canyon (RM 246), the "Buzz Holmstrom Inscription" was evaluated to determine if it should be formally recorded as an archaeological site. This inscription likely dates to the trip launched on 8/26/1938 and commemorates the run of "Charlie," the first inflatable raft to run the Colorado through the Grand Canyon. The Inscription reads as follows:

AMOS BURG
BUZZ HOLMSTROM
WILLIS JOHNSON
IN THE BEGINNING

Although the inscription is associated with no nearby artifacts, it was determined to be an archaeological site since it is over 50 years old, and it contains the names of three historically significant trip participants, thus meeting the criteria of an archaeological site as set forth by the Arizona State Museum.

After recording this archaeological site, which showed no signs of recent visitation or significant impacts by natural forces, the group travelled downstream to 250 mile camp. The ground surface of the project area at 250 mile camp was examined for archaeological artifacts and features; none were identified. CRMP mitigation work at the camp included extensive pruning and removal of vegetation in order to delineate access routes, tent pads, and the kitchen and common areas. Vegetation removal, in many cases, involved substantial ground disturbance in excess of a 12 inch depth. However, the presence of undocumented archaeological sites, features, or artifacts in the area west of Separation Canyon is considered unlikely, and therefore, ground disturbance is not considered a significant threat to cultural resources. Discussions with the Physical Sciences Program Manager revealed that, prior to its recession, Lake Mead had extended as far east as Separation Canyon (RM 239.8). Consequently, to the west of river mile 239.8 the Colorado River largely travels through old lake deposits left by the receding waters of Lake Mead. For the most part, prehistoric archaeological sites, if present, would lie under this lake deposit and are highly unlikely to be impacted by CRMP activities. It is possible that post-Lake Mead prehistoric or historic features or artifacts could be encountered within these lake deposits, but these remains may not be in situ, and their provenience would likely be unknown.

— February 26, 2011, 250 Mile Camp to Dry Canyon Camp (RM 264.6).

The CRMP mitigation group completed work at 250 mile Camp and travelled to Dry Canyon Camp. Again, the ground surface of the project area was examined for archaeological artifacts and features and none were identified, and although work involved ground disturbance in excess of a 12 inch depth, the presence of undocumented archaeological sites, features, or artifacts in this area is considered unlikely based on geomorphology of the area, discussed above. Therefore, ground disturbance was not considered a significant threat to cultural resources at this camp.

— February 27, 2011, Dry Canyon Camp (Layover)

The CRMP mitigation group continued and completed camp improvements. No archaeological concerns were encountered.

— February 28, 2011, Dry Canyon Camp to Echo Camp (RM 273.5).

The CRMP mitigation group had originally intended to work at river mile 271.2, but the suitability of this camp was reevaluated, and crew leaders decided to move on to Echo Camp. Examination revealed no cultural resources concerns at the campsite. Improvements at Echo Camp involved pruning, some vegetation removal, and removal of hazardous stobs throughout the campsite.

— March 1st 2011, Take out at Pearce Ferry

Problems Encountered and Solutions

No problems from an archaeological standpoint were encountered during the trip. NPS Personnel and members of the Grand Canyon Private Boaters Association interacted pleasantly and without incident. All trip participants were sensitive to the possibility of encountering cultural resources and understood the significance of finding and reporting such resources. Furthermore, trip participants expressed an interest in the archaeological resources of the area and contributed their knowledge of historic sites. Lastly, an acceptable amount of time was allocated to monitor and record archaeological sites.

Although no problems were encountered on this trip, one potential and significant problem was recognized. Frequently, prehistoric hearths, historic hearths, and modern hearths are difficult to distinguish from each other. While it is of course acceptable to clean up hearths that are known to be of modern origins, extreme caution is warranted during clean-up activities of hearths with unknown or unclear origins. According to the Arizona State Museum Site criteria, a hearth may be considered an archaeological site if it is:

50 years old (dates to 1961 and older) and is associated with any number of artifacts (bottle caps, tin cans, nails. etc.)

If a given hearth is not definitively known to be of modern origins, it should be left in place until an archaeologist evaluates and determines its antiquity.

Recommendations for the Future

Based on archaeological observations made during the February 2011 CRMP Mitigation River Trip, it is recommended that, depending on the specific nature of the project, the utility of including an archaeologist on Diamond Down trips is reevaluated based upon the following:

- If the CRMP trip will *not* be conducting ground-disturbing activities, or if ground-disturbing activities are *only* occurring in deposits left by Lake Mead's recession, an archaeologist may not be warranted on the trip.
- Many of the documented archaeological sites within 200m of the Colorado River centerline from Diamond Creek to Pearce Ferry are on long monitoring schedules (10 + years) and have been consistently evaluated to be in "good" condition, and therefore, do not require frequent or unscheduled monitoring.
- Many archaeological sites within 200m of the Colorado River from Diamond Creek to Pearce Ferry have been noted and observed to be negatively impacted by administrative trips (i.e., through the creation of additional social trails, destabilization of features, etc.). Impacts from administrative trips only add to those already caused by private and commercial river trips and may further deteriorate site conditions.
- Sites lying more than 200m from the Colorado River of either side of the river, even if scheduled for monitoring, may be logistically impractical to visit during a CRMP trip. Daily work-plans should be evaluated in order to determine if visitation of more distant archaeological sites due for monitoring will be able to be conducted. If an archaeologist is present on a given trip, it would be beneficial to visit several of these more distant archaeological sites in need of monitoring. One example of a way to include these more distant sites in the work plan would be to schedule lunch-stops at access points; by doing so, the day's CRMP work plan would be less impacted.
- As previous noted, Lake Mead had previously extended as far east as Separation Canyon (RM 239.8) prior to its recession. Consequently, to the west of river mile 239.8 the Colorado River largely travels through old lake deposits left by the receding waters of Lake Mead. By and large, Prehistoric archaeological sites, if present, would lie under these lake deposits and are highly unlikely to be impacted by CRMP activities. It is possible that post-Lake Mead prehistoric or historic features or artifacts could be encountered within these lake deposits, but these remains may not be *in situ*, and their provenience would likely be unknown.

Although the exact work conducted during a CRMP mitigation trip may be unexpectedly altered, the anticipated work locations (within lake deposits vs. outside of lake deposits), types of work to be conducted (vegetation removal, terrain leveling, etc.), intensity of ground disturbance (in excess of 12 inches, less than 6 inches, etc.), and flexibility of daily work-plans (i.e., whether or not more distant archaeological sites scheduled for monitoring will be able to be visited) should be used to evaluate the need for an archaeologist on a given trip.

Appendix G – Pilot Water Quality Sampling of Attraction Sites

Trip Dates: September 3 –September 19, 2011 (Part of the Campsite Monitoring Trip)

Summary

The CRMP was implemented in 2007 with the objectives of managing river recreation to minimize impacts to resources while providing a quality visitor experience. To meet these objectives, a research, monitoring and mitigation program was implemented to determine impacts from recreation, alterations to resource conditions, and effective mitigation from adverse impacts. Water quality was one of the recommended monitoring actions in the CRMP. Due to staffing shortages and funding limitations, water quality has not been a part of the CRMP monitoring program. In response to this need, during the September, 2011 CRMP monitoring trip, a pilot water quality sampling plan was conducted at attraction sites along the river corridor. This report contains a brief discussion of the monitoring pilot, sampling limitations and recommendations. A brief summary of the findings and recommendations:

- Based on the pilot water quality sampling procedures, there is evidence that bacterial contamination is occurring at attraction sites along the river corridor.
- There is a need to develop a SOP, testing schedule and make it part of the regularly scheduled CRMP monitoring trips.
- Consider adaptive management options for controlling the use levels at attraction sites and develop water quality based educational information for the Backcountry Office, River Permits Office, Backcountry and River District Rangers, the Commercial and Private Boaters and the park website.

Background

Pathogenic micro-organisms are associated with fecal waste and can cause a variety of diseases through the ingestion of contaminated water. Since these pathogens tend to occur in very low numbers and are very small, it is very difficult to measure them directly. Instead, indicator species of fecal contamination can be used to determine if their presence has occurred. These bacteria are also easy to grow and will be present if there is fecal contamination.

Members of two bacteria groups, coliforms and fecal streptococci, are used as indicators because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the probability of pathogenic (disease-causing) bacteria, viruses, and protozoans that live in human and animal digestive systems. The presence of pathogenic microorganisms poses a potential health risk and degradation in water quality to the stream system. Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms and fecal streptococci instead.

Indicator bacteria types and the most commonly tested fecal bacteria indicators are total coliforms, fecal coliforms, Escherichia coli and Enterococci. All but E. coli are composed of a number of species of bacteria that share common characteristics such as shape, habitat, or behavior. E. coli is a single species in the fecal coliform group. Total coliforms are a group of bacteria that are widespread in nature. All members of the total coliform group can occur in human feces, but some can also be present in animal manure, soil, submerged wood, and in other places outside the human body. Thus, the usefulness of total coliforms as an indicator of fecal contamination depends on the extent to which the bacteria species found are fecal and human in origin. For wild and recreational waters, total coliforms are not recommended as an indicator.

The EPA recommends E. coli and enterococci as indicators of health risk from water contact. E. coli is a type of fecal coliform bacteria commonly found in the intestines of warm blooded animals and humans. The presence of E. coli in water is a strong indication of recent contamination. In addition to the possible health risk associated with the presence of elevated levels of fecal bacteria, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand which may result in oxygen depleted water. This can have major implications for aquatic species.

The need for characterization of individual water sources and natural and human induced factors affecting them has been recognized over the years in various park planning documents (BCMP, CRMP, WRMP, etc.). A recent environmental assessment addressing mule operations identified a lack of data required to evaluate the potential impacts of these activities on water quality in Garden, Pipe and Bright Angel Creeks. In response, the Southern Colorado Plateau Monitoring Network (SCPN) set up a sampling schedule designed to examine bacterial concentrations and their diurnal and seasonal fluctuations and changes. Due to the intensity of the sampling schedule, holding times for samples and the amount of equipment necessary to perform such rigorous testing, only Garden and Pipe Creeks along the Bright Angel corridor were selected for study.

Prior to these efforts by SCNP, bacterial analysis of most tributary water sources in Grand Canyon has consisted of very few samples collected at irregular and widely spaced intervals. While the sampling pattern has provided conclusive evidence that all canyon waters are subject to fecal contamination, it provides little insight into the extent of contamination and variation with respect to time, location, human activities and natural events. Most hiker activity is not distributed uniformly along tributary creeks, but river runner activity tends to be more concentrated at attraction sites.

In the remote backcountry environment of Grand Canyon, it is not practical or always possible to test for the dozens of microbes that can cause disease. Instead, testing for the presence of the indicator bacterium E. coli can indicate recent fecal contamination. It is always present in the feces of humans and other mammals in large numbers, whether one is healthy or sick, it does not naturally grow in the environment, such as on plants, in soil or in water. It is relatively easy to detect and indicates recent fecal contamination and the possibility that disease causing microbes may also be in the water.

Until a few years ago, methods to test for microbial contamination in water required a well-equipped laboratory with electricity, incubators and sterilization equipment. Recent advances in research showed that the indicator bacterium E. coli could use specific nutrients that other bacteria cannot. Based on this discovery, new tests for E. coli were introduced that only require minimal training, very little equipment and a short amount of time to determine results. All these factors now make it possible to perform testing in remote backcountry environments. The sampling performed during the pilot test was non-regulatory in nature and used to determine presence/absence of bacteria which might be harmful to humans. The testing procedures were piloted to determine if they were a viable method for use in the Grand Canyon backcountry and if there is a relative risk of bacterial contamination and/or potential degradation of water quality at attraction sites along the river corridor.

Sampling Methods

For the purposes of the pilot test, the EPA-approved IDEXX Colilert Presence/Absence test was used. The Colilert test is performed in a glass tube that contains a dried nutrient powder. The test indicates presence/absence of coliform and E. coli bacteria in a 10 ml water sample. Colilert simultaneously detects total coliforms and E. coli in water. When total coliforms metabolize Colilert's nutrient-indicator, it turns the sample yellow. When E. coli metabolizes the nutrient-indicator, the sample also fluoresces. Colilert can simultaneously detect these bacteria at 1 cfu/100 mL within 24 hours even with as many as 2 million heterotrophic bacteria per 100 mL present.

The following procedures were followed in performing the Colilert test:

1. Use of sterile gloves to remove the chance of contamination from hands.
2. The use of a packaged sterile pipette for sample collection.
3. Careful removal of the cap of the Colilert tube so as not to contaminate it.
4. The addition of a 10 ml water sample to either 5 or 10 ml tubes.
5. Mixing by inverting the tube several times to dissolve the nutrients.
6. Incubation of the tubes at body temperature (~ 35ºC/95 ºF) to promote good bacterial growth. Tubes were placed in a small sack and/or sock, and held close to the body.
7. Examination of the tubes after incubation for up to 24 hr. Results are often evident in 10-18 hours (< 10 hours with heavy contamination, >18 hours with lesser contamination).
8. If yellow, use of a UV light to look for the presence of E. coli.

There are three possible results after performing the Colilert testing procedures:

1. If the tube is clear, no coliform bacteria are present.
2. If the tube is yellow, but there is no fluorescence under long-wave UV light, coliform bacteria other than E. coli are present. These are likely to come from the environment and do not necessarily have public health significance.
3. If the tube is yellow and fluoresces blue when a long-wave UV light shines on it, E. coli is present in the water sample, and the water poses a substantial health risk.

Additional information to be collected at the sampling sites:

- Sanitary characteristics of area surrounding water source
- GPS readings
- Approximate level of use during time of sampling
- Weather conditions
- Recommended retesting schedule
- Photo of water source

Sampling Sites

Based on anecdotal evidence and visitor use patterns, the following sites were selected for the pilot water quality sampling:

- Saddle Canyon
- Monument Creek
- Shinumo Falls
- Elves Chasm
- Stone Creek
- Deer Creek
- National Canyon
- Three Springs

The following sites were considered but not sampled:

Tapeats Creek – Storms in area and ability to access the site was limited.
Deer Creek Falls – Sampled upstream instead, but lower area definitely worth consideration.

Mat Cat – No sample taken due to weather related issues and a determination that there was a flash flood risk during time available for sampling.
Havasu Creek – known offender due to proximity below water treatment facility. It is regularly tested by the State.
Vasey's Paradise - Poison Ivy exposure and does not see get a lot of swimming/wading use by visitors.

Challenges of sampling on the river

The geography of Grand Canyon imposes its own limitations on sampling water quality. A key consideration in the design of field sampling in remote areas is the capability of equipment and transport to laboratory locations. The complexity of field analytical and sampling methods rapidly meets its limitations when there is a need for reliable energy sources and sophisticated instrumentation. To combat this complexity, a simplified method of a presence/absence test with very little equipment requirements was determined to be the most prudent approach for sampling attraction sites along the river corridor. Even through the simplification of testing procedures, several issues need to be addressed for this testing procedure to be successful in the long term.

The need for an adequate dark area and the use of the 4W UV Lamp proved to be one of the major drawbacks to using the IDEXX test kit. Ideally, a 6W UV lamp would be used for reading the sample, but these lamps are not practical in remote/backcountry localities. A 4W lamp can run off of battery power, whereas, a 6W lamp is much larger and requires an electrical outlet.

During the pilot sampling body, temperature was used to incubate the samples. Incubating samples from one site was feasible, while two sites simultaneously was tolerable, more than two sample sites would prove to be a challenge for one individual to incubate at the same time. The more samples collected the more of a challenge to comfortably incubate them. For the purposes of the sampling pilot, 10 vials were used in the beginning and reduced to 5 for ease of body incubation and to accommodate more than one set from a sampling location.

While traveling by raft along the river, proper storage and protection of glass vials can be a challenge. On the river, it can be difficult to keep the vials dry and in a cool place while working in temperatures in excess of 95^{o} F. To overcome these obstacles, the vials were kept in a foam lined waterproof "Pelican" case. They were stored in the bottom hatch of the boat to keep them closer to the water and therefore, cooler.

The last major challenge to sampling on the river is the ability to rapidly and consistently read the results of the samples. Due to the multidisciplinary nature of the river trip with various field based activities simultaneously occurring, the logistics of collecting samples must be carefully scheduled into a trip itinerary. In addition, the ability to have a location for reading the results within the protocol time frames needs to be addressed once a sample is collected.

Results and Observations

The results of the pilot water quality sampling are as follows:

- Based on the protocol for sampling established by IDEXX, a sample can be held for up to 28 hours before looking at results. In this instance, it may take longer if water is in better bacterial condition (less bacteria) for the nutrient-indicator to be consumed by the bacteria. None of the sample tubes collected in the pilot study were slow to turn yellow. Most turned yellow in less than half of the 24 hour protocol recommended.

- Based on rapid color change in the sample tubes, it is surmised that there is a large abundance of colliform naturally occurring in the waters found at the sampled attraction sites. A rapid color change for colliform is an indicator of abundance.
- The 4 W UV lamp was not ideal (covered in "Challenges" section) for reading of the florescence indicator for E Coli. Even taking into account the uncertainty of the readings, Saddle Canyon, Elves Chasm and Deer Creek were most likely positive for E Coli. The other sites, were inconclusive. Based on a limited certainty of the readings for florescence, the pilot study results for E Coli are being listed as inconclusive for all sites in Table 1.
- If there is indeed presence of E-Coli, it can be interpreted that the water source has been contaminated by human intestinal bacteria.

Table 1: List of sample sites, time of sampling, GPS locations, results and comments. *inconclusive results based on limitations of 4W UV lamp.

WQ Test Site	Date	Lat/Long	Colilert color	Colilert Florescence	Comments
Saddle Canyon	9/6/2011	36.3616419 -111.9036554	yellow	inconclusive	10 - 10ml samples; sunny and hot
Monument Creek	9/10/2011	36.0827528 -112.1860452	yellow	inconclusive	5 - 10ml samples; rained night before
Shinumo Creek	9/12/2011	36.237906 -112.349065	yellow	inconclusive	5 - 10ml samples; rainy; fish translocation work.
Elves Chasm	9/12/2011	36.1963463 -112.4507332	yellow	inconclusive	10 - 10ml samples; rainy; no visitors at site
Stone Creek	9/13/2011	36.3475655 -112.4511856	yellow	inconclusive	5 - 10ml samples
Deer Creek	9/13/2011	36.395951 -112.505513	yellow	inconclusive	5 - 10ml samples; below patio/campground
National Canyon	9/15/2011	36.254428 -112.8868284	yellow	inconclusive	5 - 10ml samples; taken at start of narrows
Three Springs	9/18/2011	35.885674 -113.308134	yellow	inconclusive	5 - 10ml samples; 3 from upper, 2 from lower pool

Recommendations for the Future

Overall, the water quality testing pilot confirmed that this methodology can work in the field. By addressing a few of the sampling challenges, it is feasible to use this method to test water quality at attraction sites along the river corridor and as part of the CRMP monitoring process. Monitoring indicator bacteria can determine whether there is valid evidence for concern about the watershed, specific waterbodies and public health. The information can be used to inform and guide management decisions about potential impacts from visitor use patterns. A central purpose of the testing is to provide for the protection of water quality while addressing visitor impacts and habitat issues. Recommendations for a water quality protocol for the CRMP should include the following:

- Develop a schedule for regular testing/monitoring and a list of employees who are trained to perform the testing protocols
- Construct a portable "dark room" for e-coli detection using the 4W Lamp.
- Test at least annually, but preferably twice a year, once in spring and once in early fall.
- Develop educational information for the Backcountry Office, River Permits Office, Backcountry and River District Rangers, the Commercial and Private Boaters and the park website.
- Recommend and encourage the river and backcountry community to treat water from all backcountry sources.
- Don't submerge head/face at water based attraction sites. It is more appropriate to use them as a place to cool off but not as a "swimming hole." Avoid situations that might lead to ingesting water from these sites.
- Doctor/cover wounds and cuts.
- Based on subsequent testing, consider the reduction in numbers of visitors at these sites to reduce the opportunity for harmful bacteria to flourish in these localities.