RIVER CAMPSITES IN GRAND CANYON NATIONAL PARK: INVENTORY AND EFFECTS OF DISCHARGE ON CAMPSITE SIZE AND AVAILABILITY

FINAL REPORT

by

Lisa Kearsley and Katherine Warren

Grand Canyon National Park
Division of Resources Management
National Park Service
in cooperation with the
Glen Canyon Environmental Studies

May 1993

United States Department of the Interior

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GRAND CANYON NATIONAL PARK
P.O. BOX 129
GRAND CANYON, ARIZONA 86023-0129

IN REPLY REFER TO:
L7619(GRCA-8213)

Memorandum

To: David Wegner, Program Manager, Glen Canyon Environmental Studies

From: Chief, Resources Management Division, Grand Canyon National Park

Subject: Final Report - "River Campsites in Grand Canyon National Park: Inventory and Effects of Discharge on Campsite Size and Availability"

Enclosed you will find a transmittal memorandum from Lisa Kearsley explaining refinements in the final report (also enclosed) which she and Kathy Warren have completed. If you have questions, please call Lisa at (602) 556-7457 or Kathy at (602) 638-7757.

George E. Neusaenger

George E. Neusaenger

Enclosures 2

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Memorandum

Date: May 27, 1993

To: All recipients of the May 1993 *Final Report* of *River Campsites in Grand Canyon National Park: Inventory and Effects of Discharge on Campsite Size and Availability* who have already received the May 1992 version of this report

From: Lisa Kearsley, Division of Resources Management, National Park Service, Grand Canyon National Park

Subject: Explanation of the *Final Report*

As a result of some adjustments on the 1991 inventory and on the matched sites in the 1973, 1983, and 1991 inventories after acquiring 1973 aerial photographs, we have made some minor changes to the 1992 version of this study. These changes are incorporated in the enclosed *Final Report*, which was completed May 1993.

In the interest of saving you time in discerning the differences between the 1992 report and the 1993 final report, I have listed below all the changes in the final report:

1. The 1991 inventory now consists of 226 campsites above the new high water zone--the 1992 report consisted of 219 camps. The number of small camps has changed from 57 to 45, the number of medium camps has changed from 77 to 93, and the number of large camps has changed from 85 to 88. The number of low water sites has changed from 42 to 37. Along with alterations of individual sites' small, medium, and large size classes, there are slight changes in their status as primary versus secondary camps. These inventory changes are seen in Table 1, Figure 3, Appendix D, and Appendix F. For those interested in seeing case by case changes in the 1991 inventory, write to me, I will send you a copy of these changes. All inventoried campsites are now identified on photocopies of aerial photographs, along with camps labeled in the 1973 inventory and our best judgement on camps inventoried in 1983.

2. These adjustments to the 1991 inventory have resulted in slight changes to the following figures:

a) *Figure 6 - 1991 inventory campsites per mile by size class* - Small camps have changed in critical reaches from .22/mile to .21, and in non-critical reaches from .27 to .19. Medium camps have changed in critical reaches from .23/mile to .25, and in non-critical reaches from .36 to .47. Large camps have not changed in critical reaches and have changed in non-critical reaches from .48/mile to .51.

b) *Figure 7 - 1983 campsites which are considered no longer useable as campsites: categorized as to reason* - The percentage of eroded and overgrown 1983 camps remains unchanged. The percentage of eroded/overgrown camps has changed from 21% to 20%, and that of camps lost for "other" reasons has changed from 4% to 5%.

c) *Figure 8 - 1983 camps ... separated into critical and non-critical reaches* - In critical reaches, the percentage of eroded/overgrown and other camps remains unchanged, the percentage of eroded camps has changed from 76% to 71%, and that of overgrown camps has changed from 10% to 15%. In non-critical reaches, the percentage of overgrown and other camps remains unchanged, the percentage of eroded camps has changed form 25% to 27%, and that of eroded/overgrown camps has changed from 24% to 23%.

d) *Figure 9 - Change in campsite size for 133 matched campsites in the 1973, 1983, and 1991 inventories* - In the comparison between the 1973 and 1983 inventories, the percentage of camps that have increased in size has changed from 20.5% to 17%, those that have decreased in size have changed from 12% to 14%, and those that have reamained the same have changed from 67.5% to 69%. In the comparison between 1983 and 1991 inventories, increase has changed from 3% to 5%, decrease has changed from 49% to 46%, and same has chaged from 48% to 49%. In the comparison between 1973 and 1991 inventories, increase has changed from 8% to 5%, decrease has changed from 43% to 41%, and same has changed from 49% to 54%.

d) All other figures remain unchanged.

3. All text remains essentially the same, except for the last paragraph on page 14, describing the outcome of campsites labeled in 1983 as "new and enlarged" campsites. Please re-

read this paragraph. As stated before, all changes are minor so do not affect any of the conclusions in this report.

Lisa Kearsley

Lisa Kearsley
Biological Technician
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encl: May 1993 Final Reports

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ABSTRACT

A 1991 inventory of campsites along the Colorado River corridor in Grand Canyon National Park shows that campsites have dramatically decreased in both number and size in the past 20 years. Campsites were inventoried between Lees Ferry and Diamond Creek and were compared with previous inventories done in 1973 (Weeden 1975) and 1983 (Brian & Thomas 1984). This inventory documents a total of 226 campsites available above the new high water zone (25,000-28,000 cfs); this is a 32% reduction in the number of campsites since 1973, and a 48% reduction in the number of sites since 1983. Comparisons between campsites documented for all three inventories showed that of the sites remaining, approximately 45% have decreased in size class.

Loss of campsites is primarily attributed to erosion and vegetation growth. In what were termed "critical reaches"--primarily narrow stretches of the river where the number of available campsites is limited--erosion is the primary cause of campsite loss since 1983, with 71% loss attributed to erosion, and 15% loss attributed to vegetation growth. In non-critical reaches, vegetation growth is the primary cause of campsite loss since 1983, with nearly 50% loss attributed to vegetation growth, and 27% attributed to erosion.

Carrying capacity in the river corridor is most limited in critical reaches. These are in Marble Canyon between river mile 11 and 40, the Upper Granite Gorge surrounding Phantom Ranch, and the Muav Gorge above and below Havasu Canyon. Critical reaches have fewer campsites per mile than non-critical reaches at 0.7 versus 1.1 camps/mile respectively, and have less than half the number of large campsites (0.20 large sites/mile) as non-critical reaches (0.51 large sites/mile).

In a comparison of the effects of dam discharge on campsite availability due to exposed camping area, low discharges from Glen Canyon Dam increase the number of available campsites. The 1991 inventory identified 37 "low water" sites that become available when dam releases are reduced to discharges of 15,000 cfs and less. Both critical and non-critical reaches have the same proportion of low water campsites.

To determine the effects of dam discharge on campsite size, 125 campsites were measured at different discharges. For these sites, campsite area increased an average of 35% when dam flows were decreased from 25,000 cfs to 5,000 cfs. Increases in campable area were documented for 73% of all measured campsites when flows were decreased from 25,000 to 15,000 cfs, 46% of the sites when flows were further decreased to 8,000 cfs, and 31% of the sites when flows were further decreased to 5,000 cfs. Beach areas in critical and non-critical reaches changed in the same manner in response to changing dam discharges. In an analysis of campsites according to size class (small, medium, large), 36% of the small and medium sites increased in area enough to also increase in size class when dam releases were reduced from 25,000 cfs to 15,000 cfs.

Boat mooring at campsites was also evaluated for 129 sites under different flow regimes. Mooring quality was significantly improved at constant flows, with 60% rated fair/good at fluctuating flows, and 90% rated fair/good at either high or low constant flows, .

Campsites were also inventoried from Glen Canyon Dam to Lees Ferry, and from Diamond Creek to Pearce Ferry. Campsites from Glen Canyon Dam to Lees Ferry were also measured at different discharges.

INTRODUCTION

Sediment deposits along the Colorado River in the Grand Canyon serve as campsites for river runners and as habitat for vegetation and wildlife. Since the completion of Glen Canyon Dam in 1963, there has been a noticeable loss of suitable campsites due to erosion, lack of replacement with incoming sediments, tributary floods, debris flows, and human impacts (Schmidt & Graf 1990, Schmidt et al. 1989, Glen Canyon Environmental Studies (GCES) 1988, Webb et al. 1987, Beus et al. 1985, Valentine & Dolan 1979, Howard & Dolan 1976). The gradual loss of campsite space along the Colorado River is a concern because of the area's intense use. More than 20,000 river runners travel the Colorado River each year through the Grand Canyon, more than 50,000 anglers and river runners use the river between Glen Canyon Dam and Lees Ferry, and unknown numbers of Lake Mead motor boaters use the river below Diamond Creek (Colorado River Mgmt. Plan 1989, U.S. Department of the Interior 1984). Sites are most often limited to space above the 25-28,000 cubic feet per second (cfs) water line, which was the normal high daily flow during the high use season between May 1 and September 30 prior to implementation of interim flows (U.S. Bureau of Reclamation 1990). Alternatives for the Glen Canyon Dam Environmental Impact Statement (EIS) include options that would include constant flows at various water levels and fluctuating flows with various highs (Department of the Interior 1991). The number and size of available campsites may vary between alternatives.

There are two main purposes of this study. The first is to inventory existing campsites and to compare inventory results with previous inventories to evaluate changes in campsite number and size. The second is to assess the difference in the number and size of campsites available at various flow levels. Effects of flows on mooring quality are also evaluated. Results of this study will provide information to help evaluate alternatives for the Glen Canyon Dam EIS. The study also provides baseline information which will be used for development of a long-term monitoring program for Colorado River campsites. It is not the purpose of this study to assess human impacts to campsites. This issue has been addressed by several previous studies (Phillips et al. 1986, Carothers 1981, Valentine & Dolan 1979, Howard & Dolan 1976).

Hypotheses

The study was designed around the following null hypotheses:

1. H°: There has been no change through time in the number and size of campsites in the Colorado River corridor.
2. H°: Discharge has no influence on the number of campsites available.
3. H°: Discharge has no influence on the availability of campsites in critical versus non-critical reaches.
4. H°: Discharge has no influence on the area of available campsites.
5. H°: Discharge has no influence on the quality of mooring at campsites.

The alternative hypotheses state that there has been change through time in the number and size of campsites, and that discharge does influence the number, availability, size, and mooring quality of campsites.

Objectives

Several objectives were developed from these hypotheses:

1. Inventory campsites in the river corridor between Glen Canyon Dam and Lees Ferry, between Lees Ferry and Diamond Creek, and from Diamond Creek to Pearce Ferry at 25-28,000 cfs, the normal summer season maximum daily discharge level.

2. Compare changes in campsite number and size between the 1973, 1983, and current inventory from Lees Ferry to Diamond Creek.

3. Determine the influence of discharge from Glen Canyon Dam on the number of campsites available due to exposed camping area on
   a. all sites between Glen Canyon Dam and Lees Ferry
   b. all sites between Lees Ferry and Diamond Creek
   c. critical vs. non-critical reaches between Lees Ferry and Diamond Creek

4. Determine the influence of discharge from Glen Canyon Dam on campsite area for
   a. all sites between Glen Canyon Dam and Lees Ferry
   b. all sites in critical reaches between Lees Ferry and Diamond Creek:

RM 11.0-40.8	Soap Creek to Buckfarm
RM 76.5-116.0	Hance to Elves Chasm
RM 131.0-139.0	Deer Creek Area
RM 139.0-164.0	Fishtail to Tuckup

   c. a sample of sites within each non-critical reach between Lees Ferry and Diamond Creek:

RM 0-11.0	Lees Ferry to Soap Creek
RM 40.8-76.5	Buckfarm to Hance Rapid
RM 116.0-131.0	Elves Chasm to above Deubendorff Rapid
RM 164.0-226.0	Tuckup to Diamond Creek

Objectives 3 and 4 were evaluated at constant discharges of 5,000, 8,000, and 15,000 cfs, and for fluctuating flows with a maximum of 25-28,000 cfs. This includes evaluation of sites that are newly available at lower flows.

5. Evaluate the influence of discharge on mooring quality for all sites indicated in objective 4.

6. Evaluate the effects of campsite size and availability on carrying capacity of the river corridor.

BACKGROUND

Glen Canyon to Lees Ferry

The Colorado River corridor above Lees Ferry is managed by Glen Canyon National Recreation Area (GCNRA). Use in this reach is mostly day-use by fishermen and day rafters, with over 50,000 visitors in this sixteen mile reach each year (U. S. Department of the Interior 1984). Most parties camping in Glen Canyon range from 2-6 people (Brown pers. comm. 1991). At present, camping is permitted at six designated campsites in this corridor, with each site able to accommodate two or three parties.

In 1984 a recreation plan was developed (U.S. Department of the Interior 1984) which recommended that 50 campsites be established in this reach. That plan is no longer being implemented, and resource managers at GCNRA are currently doing research to develop a new plan for the area (Harris pers. comm. 1990). The results of the present study are meant to contribute to the new plan. By identifying suitable sites for camping and estimating each site's carrying capacity at each water level, recommendations can be made as to which areas are best suited for such use.

Lees Ferry to Diamond Creek

This reach of river is managed by Grand Canyon National Park. Over 20,000 people run the river every year, primarily between May 1 and September 30 (Cherry pers. comm. 1991).

This study provides the third inventory of campsites in the river corridor. Of the two campsite inventories done previously, both had limitations in methodologies and circumstances which make them difficult to use for comparison as baseline studies. The 1973 inventory by Weeden et al. (1975) was never officially completed because the principal investigator, Yates Borden, passed away before the study was completed. However, a list of sites from the 1973 inventory is available, along with a complete set of color photo slides taken of each site from the river. The 1983 inventory done by Nancy Brian and John Thomas was conducted in the fall following an abnormal season of spill releases. The high water dramatically reworked, aggraded, and degraded sediment deposits (Schmidt & Graf 1990). Since then, further erosion, vegetation encroachment, and mass wasting have significantly changed the campsites (GCES 1988). The current study has the advantage of being completed during a "normal" water year, which has been preceded by six years of "normal" dam operations. Flows during 1991 are normal in the sense that they have not involved spill releases above 31,500 cfs. However, research flows to test effects of various possible alternatives to current dam operations were ongoing from June 1990 through July 1991.

Certain reaches of the river in the Lees Ferry to Diamond Creek stretch are limited in the number of suitable campsites available. These are: Marble Canyon (RM 11-40.8), Upper Granite Gorge (RM 76.5-116), Muav Gorge (RM 139-164), and Lower Granite Gorge (RM 226-270). Scarcity of sites in these areas is mainly due to geologic characteristics of the reach (Schmidt & Graf 1990).

Campsites are used on a first-come, first-served basis, with no reservation or designated campsite system in use. Aside from a few restricted areas, river runners are allowed to camp any place they find suitable along the river corridor (Colorado River Mgmt. Plan 1989). In general, there is a one camp-one party rule; this is sometimes broken when a trip cannot find a suitable campsite at the end of the day, so must "double camp" with another trip. The maximum group size for commercial river trips is 36, and that for private trips is 16.

Diamond Creek to Pearce Ferry

The Lower Gorge and Lake Mead National Recreation Area extend from Diamond Creek (RM 226 L) to Pearce Ferry. Many commercial and private trips take passengers out at Whitmore Wash or Diamond Creek. However, 39% of passengers that float the river above Diamond Creek continue on to Lake Mead. Most trips that carry passengers through the Lower Gorge spend only one or two nights in that 54 mile stretch (Cherry pers. comm. 1991). Power boats shuttle most passengers from approximately RM 240 out to Pearce Ferry or South Cove on Lake Mead.

No previous inventory or monitoring of campsites has been done in this reach other than a casual inventory of camps documented in "The Colorado River in Grand Canyon" (Stevens 1983). That inventory was done in the early 1980's prior to the 1983 floods.

Mooring Quality

Mooring quality depends on river level and magnitude of fluctuation. Ideal conditions for mooring include easy pull-in and pull-out, a deep eddy to tie off or anchor in, low velocity or an absence of nearshore waves, a sandy bottom, and easy access to the site for loading and unloading of gear.

For fluctuating flows, the greater the magnitude of fluctuations, the lesser the mooring quality. This is because overnight changes in water level usually necessitate periodic boat management, which requires boatmen to waken several times during the night to monitor the situation and adjust mooring lines when needed. To not do so could result in stranding of boats on beaches if flows are dropping at night, or boats washing up on rocks when flows rise at night. Where beaches have steeper slopes, managing boats under fluctuating flows is easier because there is less horizontal displacement of the shoreline during fluctuations. A few sites are not commonly used because of the impacts of fluctuating flows on mooring quality. This occurs at sites where dropping water levels result in exposure of rocks that could damage boats. In some cases, boatmen will moor their boats at alternate sites for the night where rocks and stranding potential can easily be avoided, moving boats to the camp access area when needed for loading gear (Grand Canyon River Guides Focus Group 1991).

In contrast to preferences for steep slopes during fluctuating flows, sites with low angle beach faces are preferred during constant flows. With low angle slopes, access to the site and unloading and loading of gear is easier. Constant flows above 15,000 cfs may present problems wave action at some sites. Constant flows below 15,000 cfs may present the problems of shallow rocks and steep access to sites. However, experienced boatmen rarely will reject a site at constant flows due to mooring, as mooring problems can easily be evaluated and solved on site under constant flow conditions (Grand Canyon River Guides Focus Group 1991).

METHODS

Inventory

Three different reaches of the river were evaluated in this study: the Glen Canyon reach from Glen Canyon Dam to Lees Ferry, the Grand Canyon reach from Lees Ferry to Diamond Creek, and the Lower Gorge reach from Diamond Creek to Pearce Ferry. Because of different recreational use patterns sustained by the three reaches, they were analyzed separately. Camps were identified by mileage downstream from Lees Ferry, in reference to Stevens (1983) to within 0.1 miles. As was done in the 1983 inventory, areas between Lees Ferry and Diamond Creek which are prohibited to camping were not included in the inventory (Colorado River Management Plan 1989).

The Grand Canyon reach between Lees Ferry and Diamond Creek was further divided into "critical" and "non-critical" reaches based on campsite availability. A "critical" reach was defined as any contiguous stretch of river in which the number of available campsites is limited due to geological characteristics, high demand due to attraction sites, or other logistical factors. These reaches differ only slightly from reaches described as "narrow" (Schmidt & Graf 1990), which are characterized by geomorphology (Appendix A). The Deer Creek reach (RM 131-139) is different from the other critical reaches in that many campsites are found within this reach. However, numerous attraction sites also within this reach create intense use of the campsites. It is not uncommon for most of the sites to be occupied during the high-use season, and much competition occurs for these sites (Quartaroli pers. com. 1991). Several of the critical reaches used in this report are combinations of two "narrow" reaches that are contiguous. A "non-critical" reach was defined as any stretch of river in which campsites are plentiful, and little competition for the majority of sites occurs. Non-critical reaches usually occur in river stretches defined as "wide" (Schmidt and Graf 1990). A map showing both this study's critical and non-critical reaches is shown in Figure 1.

For the purposes of the study's inventory, a campsite was defined by the following criteria:

1. There is space sufficient for 10 or more people plus a standard river runner kitchen and toilet in a non-desperate, non-emergency situation.
2. The camp area is above the high season high-water mark of 25-28,000 cfs and below the old high-water zone.
3. There is access between the mooring and camping areas.
4. The area is not overgrown by vegetation.

This definition closely resembles the definitions used in the 1973 and the 1983 inventores.

"Low water" camps were also included in the inventory. These fit the above definition except they are available only at flows of 15,000 cfs and less.

Several approaches were used to establish the baseline inventory:

1. Comparison with 1983 inventory of river campsites: river trips in August and October 1990 were used to re-inventory available sites. With river guides' knowledge and some on-site observation, currently available and used sites were compared with those listed in 1983.

2. Focus Groups with Grand Canyon river guides: Two Focus Group sessions were held with experienced (10+ years) Grand Canyon river guides. The primary purpose of the sessions was to draft from memory, with the assistance of river guidebooks, a list of sites currently used on the river between Lees Ferry and Diamond Creek. Focus Groups with guides also served to identify critical and non-critical reaches and to help design the methods of the study.

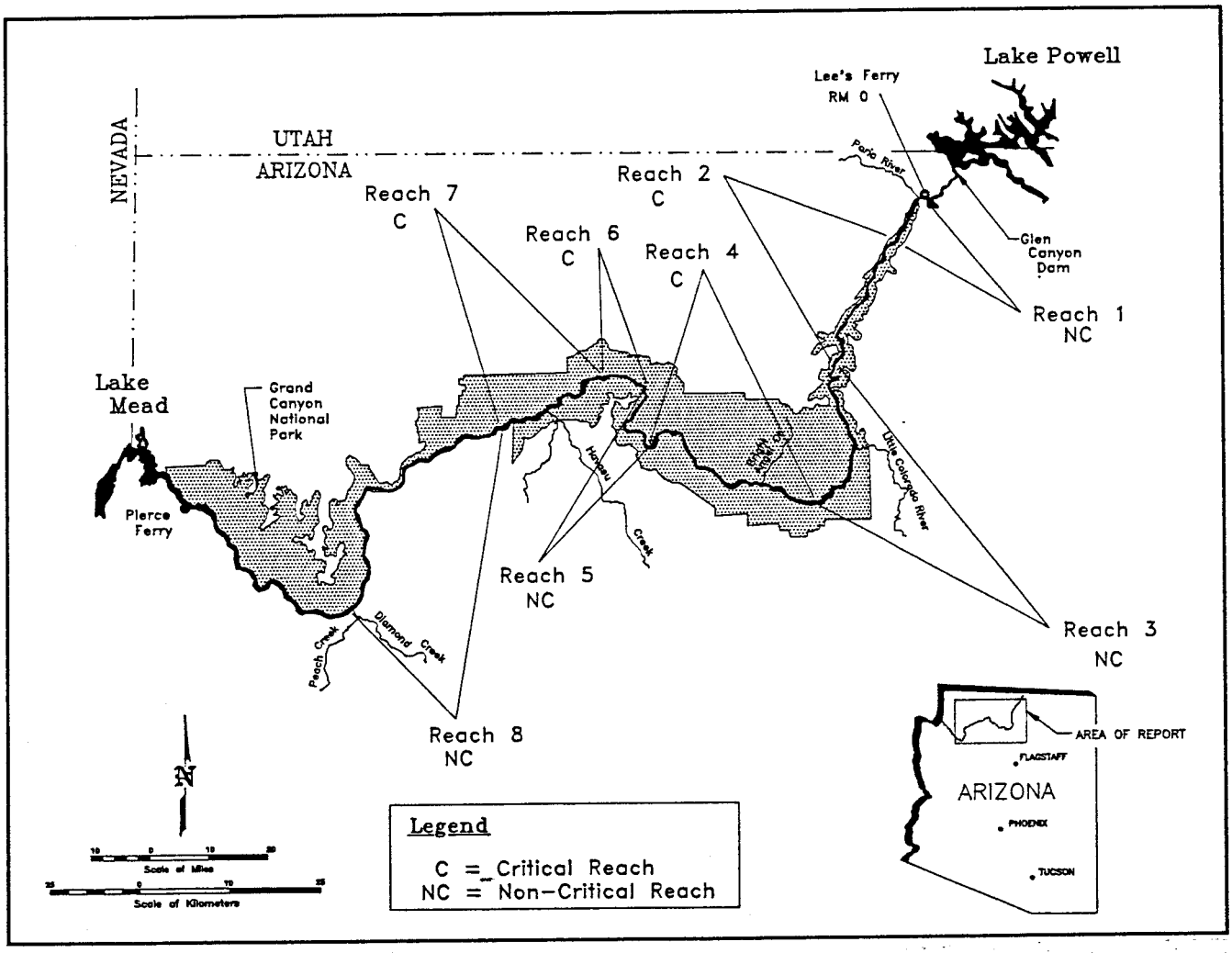


Figure 1. Map of Colorado River showing this study's critical and non-critical reaches

3. On-river observation: Both the 1983/1990 inventory comparison list and Focus Group list were verified on river in March and May, 1991. The following river guides accompanied the two trips to provide input based on their considerable Grand Canyon river experience: March - Richard Quartaroli and Dennis Silva; May - Nancy Brian, Deb Peterson, and Dennis Silva. Nancy Brian was particularly valuable in helping us to ensure consistency between 1983 and 1991 inventory methods. On these trips, sites no longer considered useable were noted, and the reason they could no longer be used was recorded. Sites not previously recorded but which met the above criteria for designation as a campsite were added to the inventory. Where ambiguity existed regarding a particular site's status, a short visit was made to the site to determine whether it should be included in the inventory.

All camps recorded in 1991 are documented on 7.5 minute USGS topographic maps and on photocopies of 1990 aerial photographs which are kept in bound sets at Division of Resources Management at Grand Canyon National Park. Photos were also taken of sites from the river at 5,000, 8,000, and 15,000 cfs. These photos will serve as permanent records to use in evaluating changes in sites over time.

Written evaluations on campsites were done using a form for each site being evaluated for size and mooring quality. A general description, assessment of mooring quality, and estimated carrying capacity was recorded for each site. Original data are on file at Grand Canyon National Park, Resources Management Division.

Campsites were categorized as being either "primary" or "secondary" according to the camp's quality, and consequently, the type of use it receives. Primary camps include those that are normally considered destination sites during the high use season; secondary camps are those that are available but may be chosen only if no suitable primary camp is available. Secondary camps are generally less popular because they may be hot, scrubby, or are within visual or auditory range of another camp.

Determining whether a camp is "primary" or "secondary" is based on a number of subjective factors affecting campsite quality. To facilitate this decision-making, we created an index to assess positive and negative attributes of the site (Appendix B). The index is tallied by adding a point for each positive attribute and subtracting a point for each negative attribute. If the total of points is one or greater, it can be considered a primary site. If the total number is zero or less, the site can be considered secondary. Based on this index, the range in camp quality varies considerably between individual camps.

Carrying capacity of sites was estimated using small, medium, and large size classes. Size classes are based on the sizes of river-rafting groups in the canyon: small (1-12 people), medium (13-24 people), large (25-36 people). Estimates for each site were made by consensus of Focus Groups of river guides and by on-site evaluation in which the approximate number of sleeping sites was counted. An estimated number of people was made by counting spaces potentially large enough for a tent, and allowing adequate space for a kitchen. Because people generally camp with a friend or spouse, the number of tent spaces was multiplied by two to arrive at carrying capacity (Quartaroli pers. comm. 1991). Guide surveys were also used for a sample of sites, asking respondents to estimate the "comfortable" carrying capacity of each site listed. Answers in these surveys were compared with size class designation from the Focus Groups and from the on-site evaluations to check for similarity in carrying capacity estimates.

In comparing 1991 results with the 1983 inventory, it was necessary to adjust size class designations for 1983 camps because Brian and Thomas used different parameters for their categories. Their size classes were: small (15-20 people), medium (21-30 people), and large (31-40 people). Since the 1983 "small" size class roughly matches the 1991 "medium", all camps defined as small in 1983

were called medium for comparative purposes. Likewise, the 1983 "medium" size class closely matches our "large", so all 1983 medium camps are called large camps for comparison. Since the 1983 inventory did not recognize sites comparable to our small category, we consider this size class unevaluated for 1983.

Carrying capacity of the Glen Canyon campsites was determined using a different size class system since group sizes rarely exceed six people. Size classes for Glen Canyon refer to the number of parties the site could comfortably accommodate, versus the number of people as is used for the Grand Canyon sections of river. Thus, "small" = one party, "medium" = two parties, and "large" = three parties. This also corresponds well with the current camping situation in Glen Canyon, where designated sites are set up for one to three groups.

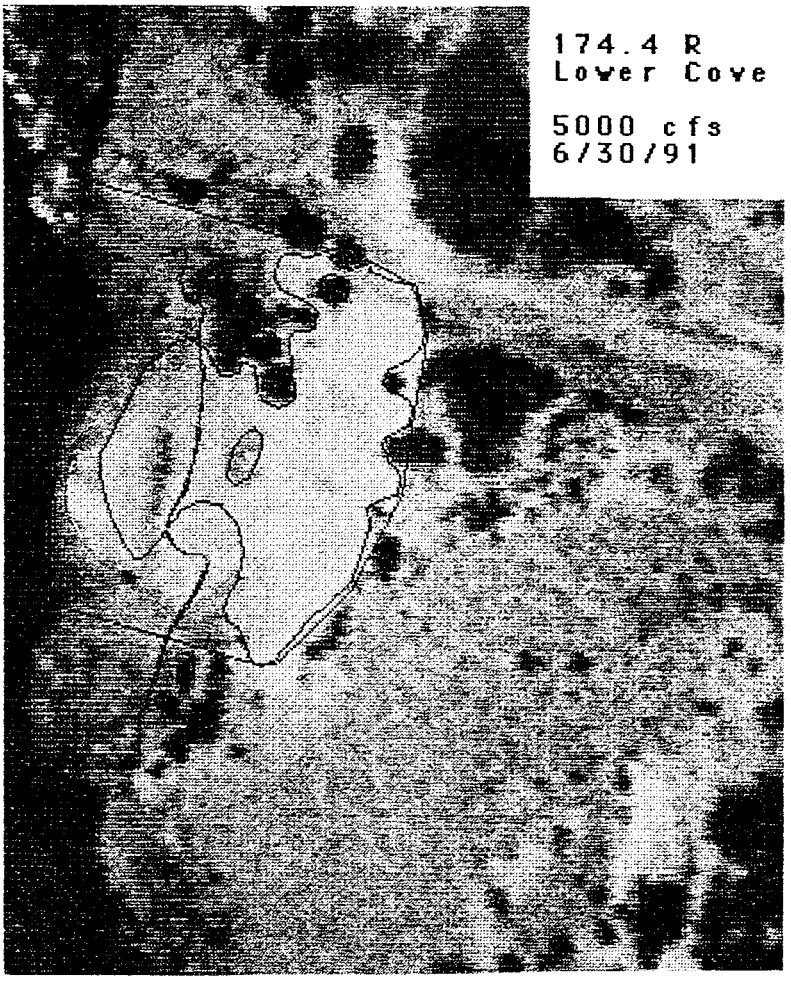
Campsite Area

Measurements of campsites were performed for 89% (84/94) of all camps in critical reaches and for 24% (41/169) of all camps in non-critical reaches. Although our objective was to measure all known sites in critical reaches, several were omitted due to logistical constraints.

The area of campsites at different flow levels was determined by the following methods: Laser xerox copies of aerial photos taken in June of 1990 at 5,000 cfs were made of each campsite to be measured. While visiting each site, useable area was assessed and outlined on the laser copy (Figure 2). Useable area includes any area that is relatively flat (less than 8 degree slope), non-cobbled, non-vegetated, and non-marshy. While some of these spaces may be "used" for purposes of sitting, playing, or other recreation, they are not considered useable space because they do not contribute to the overnight carrying capacity of the site. The location of the 25,000-28,000 cfs water line was also outlined on each laser copy. This was assessed primarily by Dennis Silva by observing drift, wet sand, cut banks, and vegetation lines. Previous studies have determined that vegetation lines are a good approximation of the high water zone (Schmidt & Graf 1990).

Using the laser copies as guides, useable camp area was measured from aerial videotapes taken during the constant research flows of 5,000, 8,000, and 15,000 cfs. These flow levels were part of the research flows designed for study of dam management alternatives for the Glen Canyon Dam EIS. Aerial videotapes at each of these flow levels were taken with a Sony 3/4" format video camera attached to a helicopter with a Tyler mount. The helicopter maintained an elevation of 1,800 to 2,000 feet above the river during videotaping.

The primary tool being used to measure campsite area was the Map and Image Processing System (MIPS) software. MIPS was used to capture and save video images of each site at each of the constant flows, and measure campsite area at each flow level to the nearest meter. Each image was calibrated while visiting the site by measuring the distance between two fixed points visible in the video image, usually two large trees or shrubs, with a 60-meter measuring tape. These endpoints were delineated on the screen using a caliper measuring tool; the distance measured on site was then entered into the computer file. The planimeter tool was used to outline the perimeter of each useable area for the site using the laser copy as a reference (Figure 2). For areas that are not visible from the air, such as space under overhangs, beneath vegetation, or space that is too small to be discerned on the video images (i.e. small separated sleeping areas). Measurements were made in the field by taking the length and width of the area to the nearest half meter. The nature of these hand measured sites renders them small in area relative to size class, in comparison to more contiguous spaces measured by MIPS. Thus, we have differentiated between the two types of sites, noting the former



Laser xerox copy with campable area and 25,000-28,000 cfs line delineated

MIPS printout with the same delineated

Figure 2. Examples of a laser xerox copy and a MIPS printout of a campsite.

as "HM" (hand-measured) and the latter as "MIPS" (measured on MIPS) (Appendices H & J). Analyses of measurement type compared to area indicate significant differences between the two types of areas.

Based on several MIPS accuracy tests, measurements of delineated campsite area were estimated to be 95% accurate. When comparing MIPS measurements with ground based survey measurements (Beus & Avery in prep.) of the same delineated area of three campsites, MIPS measurements were within 98% of ground survey measurements. Repeated measurements of the same area both on the same video image and on different video images of the same campsite were 96% accurate. Areas measured from video images were within 90.5% of areas measured from laser xeroxes.

The following statistical tests were performed on campsite data. To compare differences in area between size classes, area data were log transformed and tested using a one-way ANOVA. To compare differences in area between discharges, area data were scaled to represent the percent change in area between discharges. One-way ANOVA and T-tests were performed on arcsine square-root transformations of percentage data to determine area changes between discharges; one-way ANOVA and Tukey tests were performed on the same to determine differences in area between different sets of discharge changes.

Mooring Quality

Mooring quality was assessed at 129 sites for high constant, low constant, and fluctuating flows. "High constant" and "low constant" were defined in this study as constant flows above 15,000 cfs and below 15,000 cfs respectively. For each flow regime, mooring was rated as either "fair/good" or "poor/bad". Factors taken into consideration were potential for stranding, presence of rocks, and surf intensity.

RESULTS

1991 Inventory

Glen Canyon Dam to Lees Ferry

Eighteen sites in Glen Canyon are recognized by this study as being either currently designated or suitable for designation as campsites; 12 are available at 25,000-28,000 cfs and less, and 6 are available at 15,000 cfs or less. (Appendix C).

Lees Ferry to Diamond Creek

The 1991 inventory of river campsites recognized 263 campsites between Lees Ferry and Diamond Creek. Of these, 172 were classified as primary, 54 as secondary (two as "constant high water only" [flows of 20,000-30,000 cfs] camps, and one, Roy's Beach [RM 87.5R] as available only by special use permit), and 37 as low water camps (Appendix D). A summary of this inventory breaks down sites by reach into small, medium, and large size classes (Table 1).

Table 1. Summary of 1991 Inventory Campsites

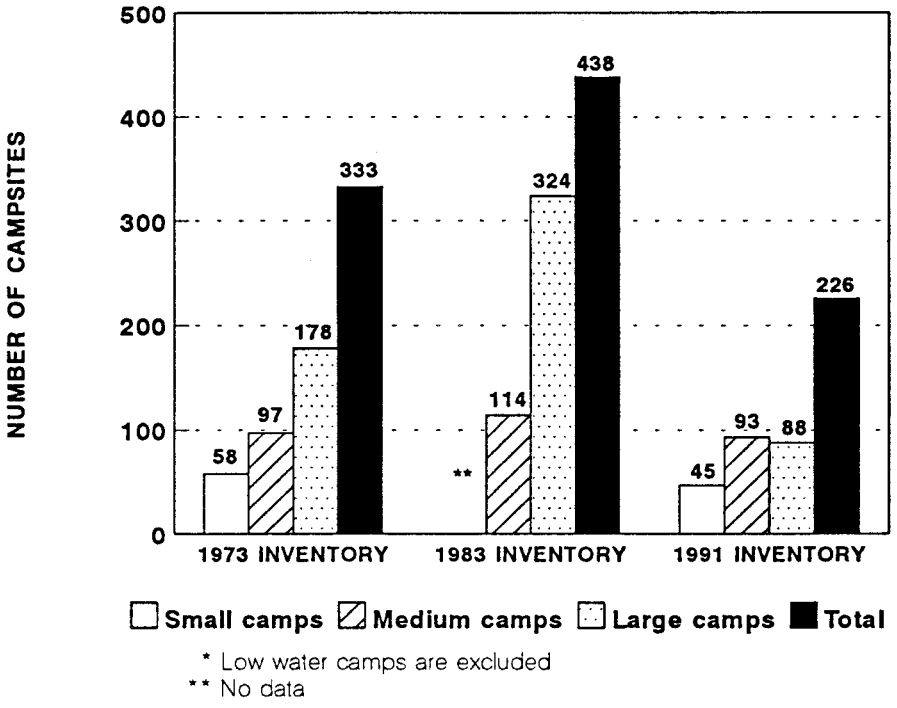
REACH NO	REACH TYPE	MILEAGE	SMALL CAMPS 1°	SMALL CAMPS 2°	SMALL CAMPS LW	MEDIUM CAMPS 1°	MEDIUM CAMPS 2°	MEDIUM CAMPS LW	LARGE CAMPS 1°	LARGE CAMPS 2°	LARGE CAMPS LW	ALL CAMPS 1°	ALL CAMPS 2°	ALL CAMPS LW
1	NC	RM 0-11	0	0	1	1	0	0	2	0	0	3	0	1
2	C	RM 11-40.8	5	2	4	6	0	3	7	1	0	18	3	7
3	NC	RM 40.8-76.5	0	4	2	6	8	0	27	1	0	33	13	2
4	C	RM 76.5-116	6	3	2	7	2	1	7	1	0	20	6	3
5	NC	RM 116-131	1	2	3	5	3	0	5	2	0	11	7	3
6	DC	RM 131-139	1	0	0	8	3	0	6	0	0	15	3	0
7	C	RM 139-164	4	0	5	6	3	2	3	0	0	13	3	7
8	NC	RM 164-226	11	6	10	24	11	4	24	2	0	59	19	14
		TOTALS	28	17	27	63	30	10	81	7	0	172	54	37

Note: Reaches are numbered according to this study's 1991 inventory.
NC = Non-critical reaches, C = Critical reaches, DC = Deer Creek reach.
1° = primary camps, 2° = secondary camps, LW = low water camps.

A comparison of the 1991 inventory with 1973 (Appendix E) and 1983 (Appendix F) inventories shows a marked decrease in the total number of camps from both years, with 333 camps in 1973, 438 in 1983, and 226 in 1991 (Figure 3). This is a 32% reduction in number from 1973-1991, and a 48% reduction in number from 1983-1991. The decrease in campsite number between 1973 and 1991 is greater for large sites, with a 51% reduction in number. The number of medium sites has remained relatively the same, and the number of small sites has decreased by 22%. We excluded low water camps and Roy's Beach in inventory comparisons since these camps were not considered according to 1973 and 1983 criteria.

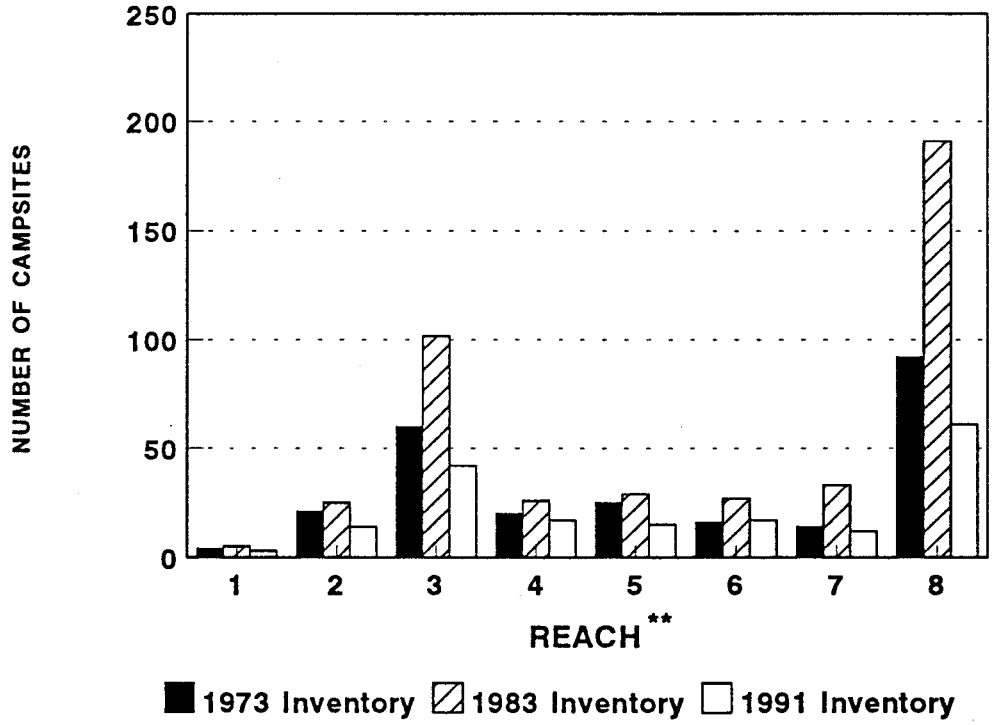
The pattern of change in the total number of camps between inventories is similar for all reaches of the river with an increase in the number of sites between 1973 and 1983, and a decrease in number

Figure 3. Number of campsties* by inventory, broken down into small, medium, and large size classes



* Low water camps are excluded
** No data

Figure 4. Number of campsites* by reach for each inventory



* Low water camps and small camps are excluded
** Reaches as defined by present study

of sites for all reaches between 1983 and 1991 (Figure 4). This increase in number between 1973 and 1983 was attributed to new sites created by new and enlarged deposits left by 1983 floods (Schmidt & Graf 1990, Brian & Thomas 1984).

In a comparison of the three inventories, the number of campsites per mile is presently lower than either 1973 or 1983, with the greater decrease from 1983 to present. The present inventory records 1.0 campsites/mile while the 1973 and 1983 inventories had approximately 1.5 and 1.9 campsites/mile respectively. When separated into critical and non-critical reaches, the decrease in number of campsites per mile is greater in non-critical reaches (Figure 5).

In a comparison of the number of campsites per mile between reaches in the present survey, critical reaches (excluding the Deer Creek reach) have significantly fewer sites per mile than non-critical reaches at 0.7 and 1.1 sites/mile respectively (Mann-Whitney test, $u = 9$; $p = .05$) (Figure 5). The Deer Creek reach (RM 131-139) has more sites per mile than any other reach of the river at 2.3 sites/mile. Because of this difference from other critical reaches, it is shown separately for this comparison.

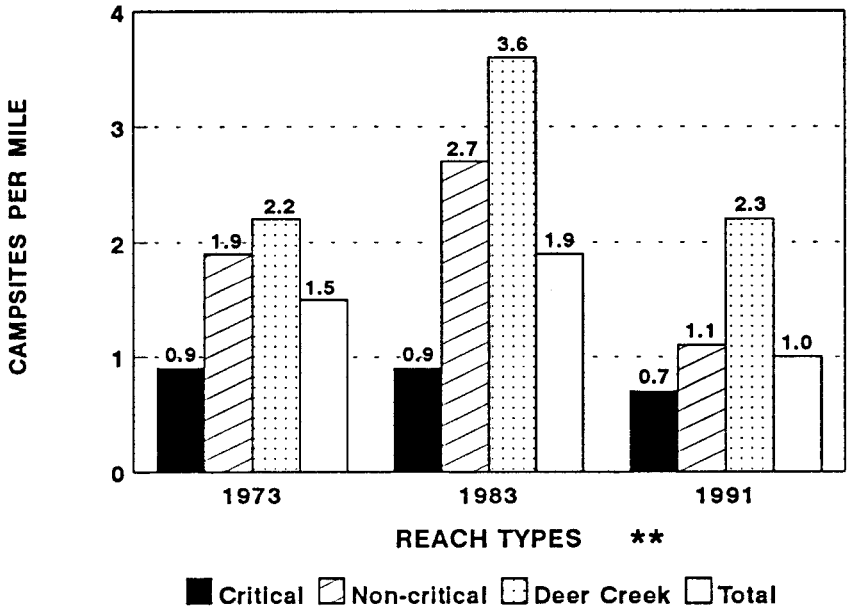
When separated into small, medium, and large size classes, critical reaches (excluding the Deer Creek reach) have disproportionately more small campsites per mile and fewer large campsites per mile than non-critical reaches. While there are approximately 1.6 campsites per mile in non-critical reaches for every campsite in critical reaches, non-critical reaches have over twice the number of large camps per mile (.51/mile vs .20/mile) and have approximately the same number of small camps per mile (.19/mile vs .21/mile) than critical reaches (Figure 6).

The results of this study show that the decrease in numbers of sites between 1983 and 1991 is attributed to two major causes: erosion and vegetation growth. Two hundred thirty-six camps have changed since 1983 so that they are considered no longer useable as campsites. Thirty-four percent (81) of these show signs of erosion (i.e. sand deposit is completely gone, has eroded to a size not adequate for a party of ten or more, or is heavily cobbled). Forty-one percent (97) are covered with vegetation dense enough to render them unsuitable for camping. Twenty percent (47) show both signs of erosion and overgrowth. A small group of sites are no longer available for "other" reasons. Five are off limits to camping under the 1989 Colorado River Management Plan; two are only available at constant flows above 30,000 cfs; two are too difficult to moor at because of swift currents; one is now used as a helipad; one is now considered contiguous with an adjacent camp (Figure 7).

By separating camps into critical and non-critical reaches of the river, we can see that erosion is a more significant cause for loss of useable campsites in critical reaches, accounting for 71% of campsites lost (Figure 8). Only 15% of campsites no longer considered useable in critical reaches were lost to vegetation encroachment, and 7% to a combination of erosion and vegetation growth. In contrast, vegetation growth was the major cause for loss of campsites in non-critical reaches, accounting for 47% of sites lost, while loss of 27% of sites was attributed to erosion. A combination of erosion and overgrowth was observed for 23% of camps degraded in non-critical reaches. These observations are consistent with the conclusions of Schmidt and Graf (1990).

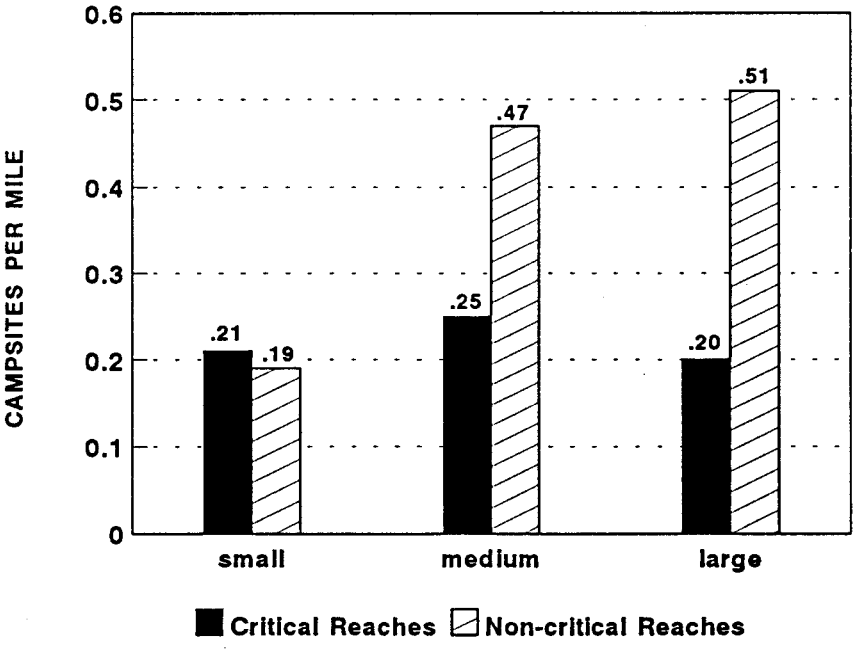
The 1983 inventory labeled 136 campsites as new or enlarged deposits; these deposits predominated in reaches where camps are already relatively abundant, and their presence as well as their increased size is more transient than 1983 camps not labeled as such. Most of the new or enlarged deposits (81%, 110) were in non-critical reaches so their presence did little to help increase the carrying capacity. The percentage of these deposits remaining as useable camps in 1991 is only half that of 1983 camps not labeled as new or enlarged deposits (24% and 50% respectively). The proportions of loss resulting from erosion and overgrowth on these deposits is the same as that of 1983 campsites not labeled as new or enlarged; however, a higher percentage of these deposits which remain have decreased in size class from large/medium to medium/small (82% versus 46%).

Figure 5. Number of campsites* per mile for 1973, 1983, and 1991 inventories



* Low water camps are excluded
** 1983 inventory does not include "small camps"

Figure 6. 1991 inventory campsites* per mile by size class



* low water camps are excluded

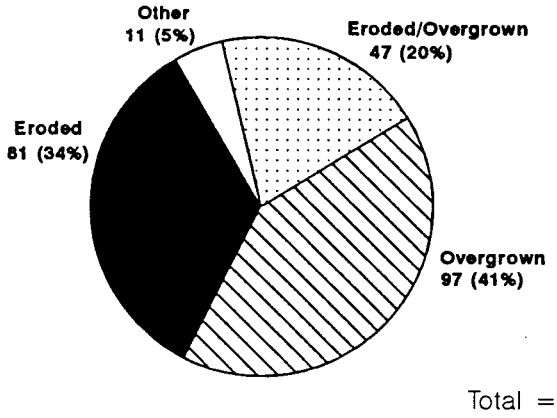


Figure 7. 1983 campsites which are considered no longer useable as campsites; categorized as to reason

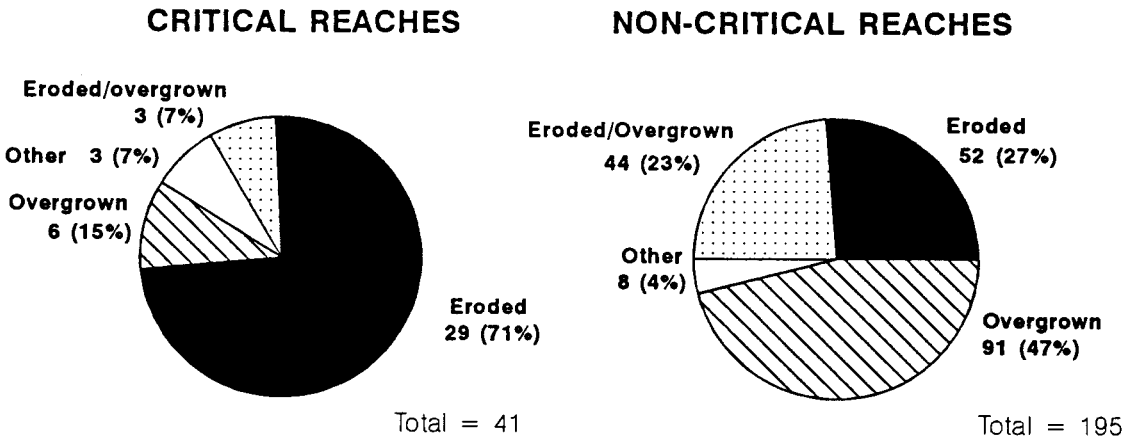


Figure 8. 1983 campsites which are considered no longer useable as campsites; separate into critical and non-critical reaches, categorized as to reason

The change in campsite size between years was compared for 133 camps that were documented for all three inventories (Fig. 9, Appendix G). The comparison shows that roughly equal proportions of matched camps increased and decreased in size (17% and 14% respectively) between 1973 and 1983. Most of the increase in size was attributed to sand aggradation during the 1983 floods (Schmidt & Graf 1990, Brian & Thomas 1984). In comparisons between both 1973 and 1983 with the 1991 inventory, very little aggradation has occurred (6 [5%]) whereas 41%-46% percent of the matched sites have decreased in size. The overall trend over time, despite the deposition of sands by the 1983 floods, has been a marked decrease in campsite size.

Photographs of campsites taken in 1992 compared with those taken in previous years show this decrease in campsite size visually. Two such comparisons, Jackass (RM 8.0R) and Stone Creek (RM 132.0R) are shown with photos taken in the early 1980's and in 1992 (figures 10 & 11). In both campsites, sand deposits have decreased so that the deposits have changed from convex to concave profiles. The river at 25,000 cfs now covers large expanses of sand which in 1981 would still be exposed at this water level. These campsites are considerably smaller, particularly at the 25,000 cfs level, than they were in 1983.

Diamond Creek to Pearce Ferry

Thirteen sites were inventoried as currently used camps in the Lower Gorge reach. These are listed along with those documented in Stevens (1983) in Appendix H. Ten of the 20 camps documented in Stevens have changed so that they are considered no longer useable as campsites. Vegetation growth caused by sediment deposition in Lake Mead, and erosion as a result of power boat traffic and fluctuating flows from Glen Canyon Dam appear to be major influences on the useability and condition of campsites. All but one are unuseable because of vegetation growth. During the field season in which the inventory was conducted, Scorpion Island (RM 278.6) was not useable because it was surrounded by mud flats due to low lake levels.

The small number of camps in this reach (approximately one every four miles) makes it a critical reach. Further loss would be a limitation to recreation. Those that are currently used have been expanded over the years by cutting back vegetation, hence the trend in increased size of camps compared to Stevens' inventory.

Campsite Availability At Low Discharges

Glen Canyon Dam to Lees Ferry

In an assessment of the effects of dam discharge on campsite availability due to beach exposure at lower flows, six campsites have no adequate space available for camping at flows of 25,000 cfs or greater (Appendix C). Two of these sites become available at flows lower than 15,000 cfs (-6.1L, -6.5R); four become available at flows of 15,000 cfs or less (-6.1R, -6.7L, -7.0L, -13.2L).

Lees Ferry to Diamond Creek

This inventory documented 37 "low water" campsites, available only at discharges of 15,000 cfs and less (Appendix D). Fifteen (41%) of these are in critical reaches of river, while 22 (59%) occur in non-critical reaches. The number of low water camps per mile in critical versus non-critical reaches are almost identical: 0.15/mile--critical, and 0.18/mile--non-critical. There are many more sand bars of adequate size exposed at low discharges; however, we chose to exclude sand bars that offered no protection from wind or sun, since such sites would be highly undesirable for camping.

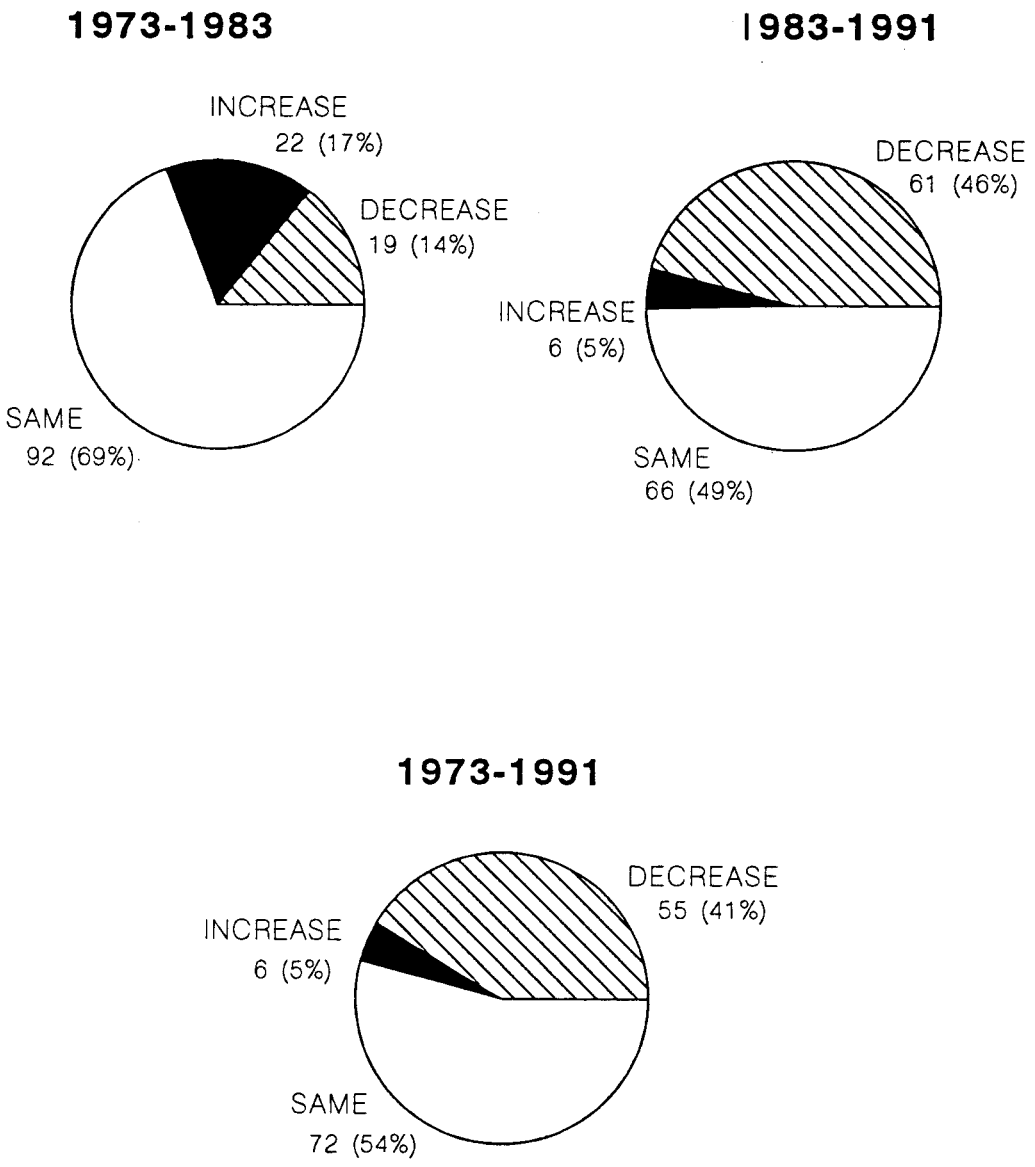
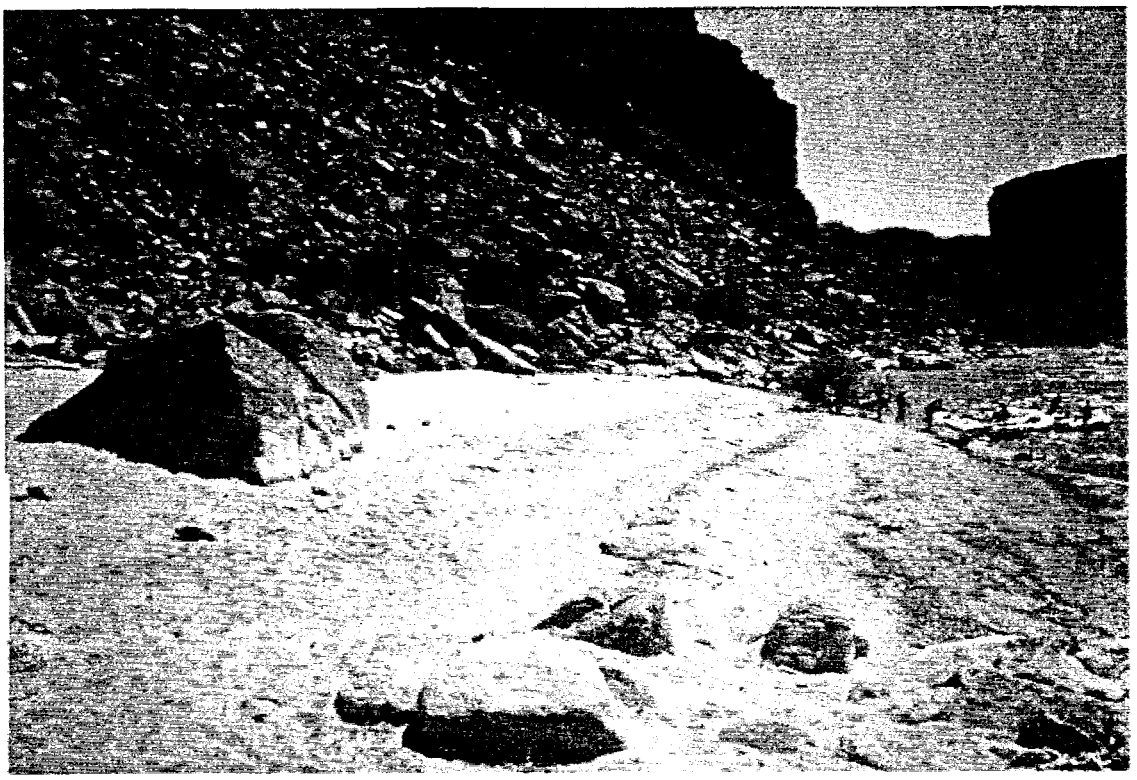


Figure 9. Change in campsite size for 133 matched campsites in the 1973, 1983, and 1991 inventories

Figure 10. 1983 to 1992 campsite photo comparison

Jackass (RM 8.0 L) campsite; photo taken August 1983

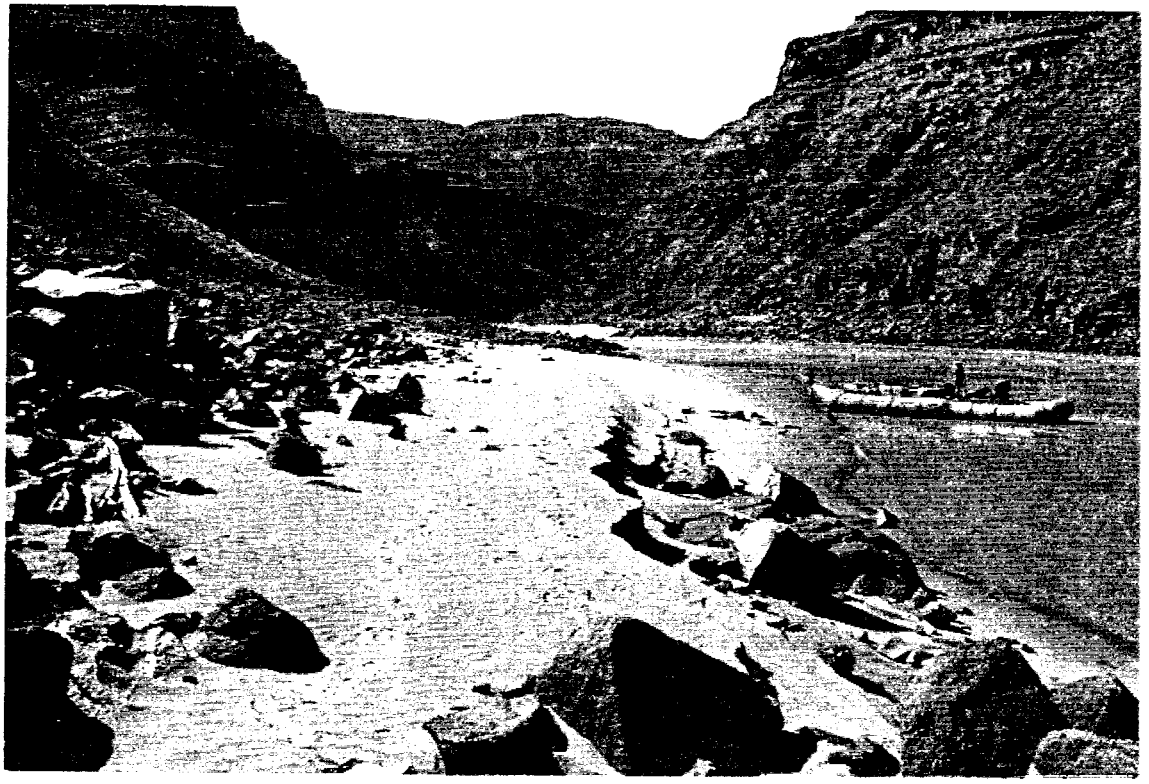


Jackass campsite; photo taken March 1992

Figure 11. 1981 to 1992 campsite photo comparison

Stone Creek (RM 132.0 R) campsite; photo taken May 1981

Stone Creek campsite; photo taken March 1992



Campsite Area and Carrying Capacity

Glen Canyon Dam to Lees Ferry

Of the 12 sites available at 25,000-28,000 cfs in Glen Canyon, nine are primarily located on terraces above the 25,000 cfs water line so that they did not change in campable area when flows were reduced from 25,000 cfs to 15,000 cfs. One site (-14.8R) changed in area enough to increase a size class at 15,000 cfs, and two (-9.0R, -11.1L) changed in area but are rated large sites at all flows (Appendix I).

The topography of beaches in Glen Canyon is such that area between 15,000 cfs and 25,000 cfs is generally too steep for camping, and therefore does not add to the size of the camp when exposed. With the exception of four sites which remain the same size at all flow levels, there is an average increase of nearly 50% in campable area when river stage drops from 15,000 cfs to 8,000 cfs, and an average increase of 25% in area when river stage drops from 8,000 cfs to 5,000 cfs.

Lees Ferry to Diamond Creek

The following results are from the 125 measured campsites. A list of these sites and their areas at different discharges is included in Appendix J.

The percent change in area of campsites between discharges for critical reaches was found not to be significantly different than that for non-critical reaches at any discharge level. Therefore, these data are presented with critical and non-critical reaches combined.

The average areas for small, medium, and large campsites at each discharge in 1991 are listed in Table 2. Although there is tremendous variability among size classes for campsite area, the classes still average out into discrete ranges. One-way ANOVAs of log-transformed area versus size class for both 25,000 cfs and 5,000 cfs data indicate significant differences between size classes ($F=42.26$, $p<.05$ and $F=34.00$, $p<.05$). Tukeys pairwize comparisons further verify significant differences between size classes ($p<.05$).

Table 2. Average area in m^2 of campsites by size class and discharge for 1991

DISCHARGE IN CUBIC FEET PER SECOND

SIZE CLASS	25,000	15,000	8,000	5,000
SMALL ALL	222	247	331	368
SMALL HM	126	136	207	211
SMALL MIPS	274	309	400	454
MEDIUM ALL	460	459	603	670
MEDIUM HM	342	339	407	436
MEDIUM MIPS	546	531	722	810
LARGE ALL	1089	1299	1641	1797
LARGE HM	392	572	655	705
LARGE MIPS	1390	1620	2076	2279
ALL ALL	717	855	1091	1199
ALL HM	324	420	495	531
ALL MIPS	930	1078	1397	1541

Note: Low water campsites not included. HM = hand measured sites, MIPS = MIPS measured sites.

The average percent change in area between discharges for all sites shows significant loss of area at all discharges (5,000-8,000 cfs $t = 7.193$, $p < .05$; 5,000-15,000 cfs $t = 10.927$, $p < .05$; 15,000-25,000 cfs $t = 11.071$, $p < .05$; 5,000-25,000 cfs $t = 38.370$, $p < .05$) (figure 12). However, although loss in beach area from 5,000 to 8,000 cfs was statistically significant, we cannot treat it as such because its area loss of 5% falls within our 5% error of measurement.

Comparisons of percent change in campsite area between discharges showed that percent area changes are significantly different:

Table 3. Matrix of Probabilities that Pairs of Percent Area Changes Between Discharges are the Same.

CHANGE IN DISCHARGE K=1000 cfs

	5k-8k	5k-15k	15k-25k	5k-25k
5k-8k	1.00			
5k-15k	0.00	1.00		
15k-25k	0.00	0.04	1.00	
5k-25k	0.00	0.00	0.01	1.00

These tests show that the percent area lost between each change in discharge is different from percent area lost between all other changes in discharge.

On average, campsites lost more area per cfs change in discharge above 15,000 cfs than below 15,000 cfs. The percent area lost between 5,000-15,000 cfs at 18% is significantly different from the percent lost between 15,000-25,000 cfs at 25%, even though the change in discharge is equal.

When looking at actual meters lost by being submerged when discharges changed from 5,000 to 25,000 cfs, small campsites lost an average of 419 m^2, medium camps lost 311 m^2, and large camps lost 690 m^2. Although large campsites lose more area at this change in discharge, this loss for many camps is not important in terms of carrying capacity. The campable area of most large camps far exceeds that needed for the maximum trip size of 36 passengers; a substantial decrease in area still provides ample room for everyone. This loss in area is more important for small and medium camps, as the loss in area decreases the number of people the campsite can accommodate.

As a result of this change in area from high to low flows, many of the campsites increased in size class with decreased flows. Thirty-six percent of those classed as small or medium camps at 25,000 cfs increased in size class with a decrease in flow to 15,000 cfs. The number of sites increasing in size class was not significantly different between critical and non-critical reaches. Small and medium sites that did increase in size class increased in area an average of 669 and 1040 m^2 respectively, while those that did not increase in size class increased 205 and 85 m^2 respectively.

An assessment of the numbers of sites affected by the different flow levels shows that most campsites gained campable area when flows decreased from 25,000 to 15,000 cfs. Unless otherwise indicated, there was no significant difference between critical and non-critical reaches in the following figures. Seventy-three percent of all campsites measured increased in campable area when discharge was decreased from 25,000 to 15,000 cfs; 46% of the camps continued to increase in area when discharge dropped to 8000 cfs, and 31% continued to increase in area when discharge

Figure 12. Percent beach area inundated by water between discharges

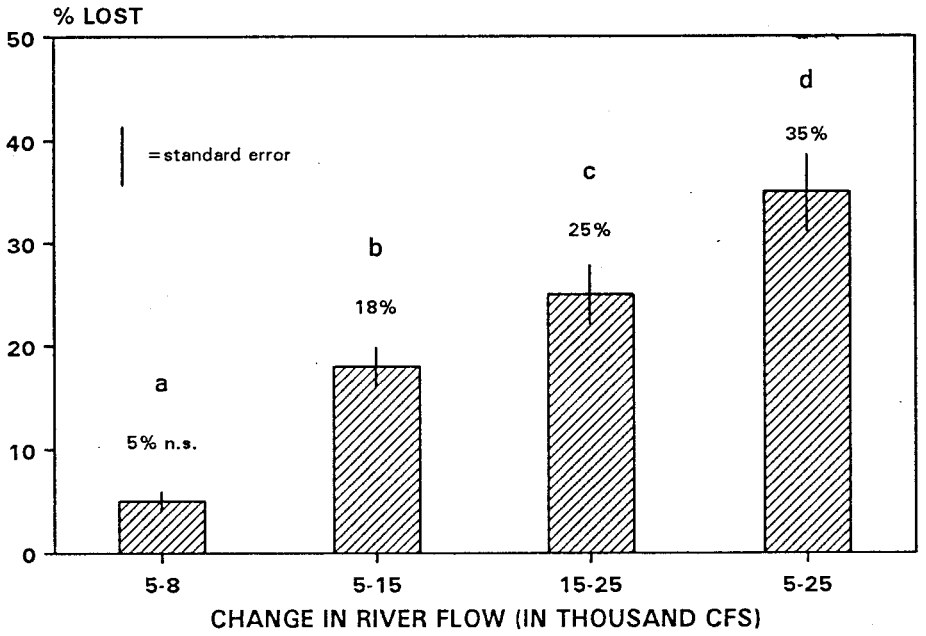
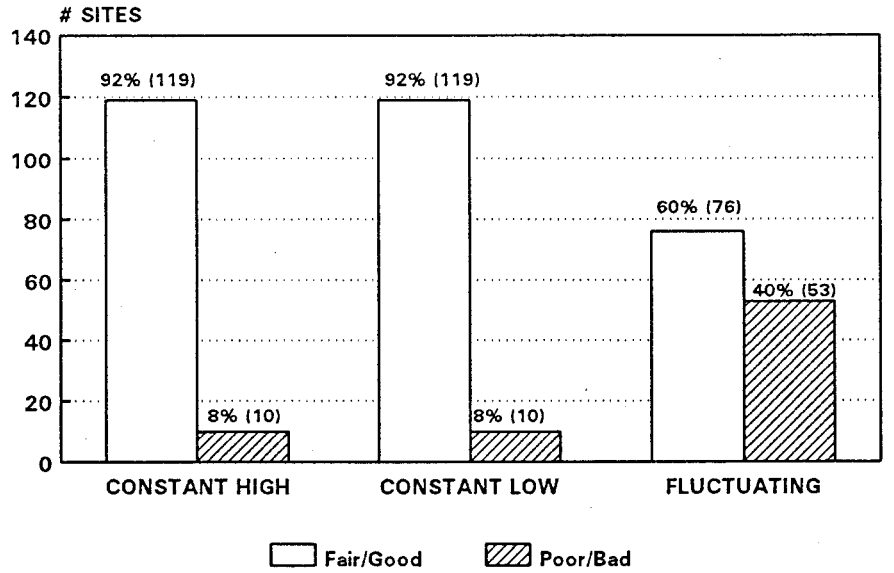


Figure 13. Mooring quality under constant high, constant low, and fluctuating discharges



Note: Constant high = > 15,000 cfs, Constant low < 15,000 cfs, Fluctuating = a range of at least 10,000 cfs

dropped to 5000 cfs. Seventeen percent of the campsites showed change in area only between 25,000 and 15,000 discharges. The numbers of these sites were significantly different between critical and non-critical reaches ($X^2 = 14.2$, $p < .05$), with 10% of the sites in critical reaches and 32% in non-critical reaches having this pattern. All campsites had gently sloping, sandy beach faces along the region where they decreased in campable area; below this region the exposed area was either too steep (>8% grade) or rocky to be considered campable. Twenty-three percent of the campsites showed no change in campable area between all flow levels. All of these sites had either steep or armored beach faces.

Mooring Quality

Glen Canyon Dam to Lees Ferry

Since there are essentially no rapids in the Glen Canyon reach, there are few problems with surf or rocks at moorings. Constant flows allow fair to good access at all of the sites, although shallow areas must be negotiated at most sites. Under fluctuating flows, however, stranding becomes a problem, and poor mooring conditions are created at all sites.

Lees Ferry to Diamond Creek

Under present conditions influencing channel and beach face geometry, an analysis of 129 campsites indicates that for constant flows there was no difference in quality of mooring between high (>15,000 cfs) and low (<15,000 cfs) flow levels. Only 8% (10) of the camps exhibited poor mooring conditions under high or low constant flows. Fluctuating flows (range of 10,000 cfs or greater) created poor mooring conditions for 40% (53) of the camps (Figure 13). Constant flows are significantly better for mooring quality primarily because overnight boat management problems are eliminated.

Although 64% of the camps which were rated as Fair/Good at constant flows remained at this rating for fluctuating flows, this does not mean their mooring quality did not decrease. Mooring quality for all camps is poorer under fluctuating than constant flows. However, during fluctuating flows, most camps have just one or two "trouble areas" combined with alternatives in boat placement so that minimal nighttime readjustment is required. Only those sites which have multiple problems and/or trouble areas (e.g. surfy conditions combined with numerous near-surface rocks), and have no good alternative mooring sites, have been rated with Poor/Bad mooring.

DISCUSSION

Inventory Comparison Between Years

Results reported by Brian and Thomas (1984) differ from this study in comparisons between 1973 and 1983 inventories. Brian and Thomas state that there was a "decrease in size and number of campsites in the upper reaches and a corresponding increase in lower reaches." Re-analysis of the 1983 data reveals that the number of campsites actually increased in all reaches between 1973 and 1983 as shown in Figure 4. Both studies do agree that based on comparisons of matched camps, the change in camp size between 1973-1983 shows a decrease in size of camps above Kanab Creek (RM 143.5 R) and a corresponding increase in the size of camps below Kanab Creek. However, in the 1983-1991 size comparison of 133 matches camps, only 36% of the matched sites above Kanab Creek decreased in size between 1983 and 1991, while 60% of those below Kanab Creek decreased in size. Therefore, a trend of greater increase in size of camps in lower reaches and greater decrease in size of camps in upper reaches does not appear to have continued.

For an overall assessment of change in campsite sizes over time, the 1973 to 1991 comparison is perhaps the most valid and relevant, since this comparison shows the longer term changes, and has the most equitable comparison of size classes (Figure 9). Because the 1973 study used numbers of people versus size class ranges to indicate carrying capacity of each campsite, those sites could more easily be translated to the 1991 size classes. The differences in the 1983 and 1991 size classes resulted in a slight skew of size class changes from "decrease" to "no change."

Social Parameters Influencing Campsite Size

A definition of carrying capacity can be divided into three major components: physical, ecological, and sociological (Shelby & Heberlein 1986). This study focuses primarily on physical carrying capacity (number and area of available campsites), although a sociological element is included in determining the size class of each site. While physical carrying capacity provides information on the areas of campsites and how this changes between years and between river flows, there are other factors which cannot necessarily be measured. These vagaries are the result of human behavior, preferences, and perception.

Social space is one such influencing factor. People living together in a limited area tend to prefer a certain amount of personal space, especially in a wilderness setting (Manning 1986; Shelby & Heberlein 1986). People also tend to choose their space based on features of a landscape. For example, someone will usually choose to camp near a tree or large rock versus in the middle of a barren area. The existence of landscape features is therefore important in serving as screens and for aesthetic purposes. Privacy for toilet use is also desirable, and is generally provided by screening vegetation or boulders. Thus, a bare sandbar may be perceived as "smaller", in terms of carrying capacity, than a site of equal size that has natural features to divide the space, providing privacy for individuals.

Buffer zones are necessary for certain use areas at a campsite. Unloading and loading areas where boats are moored, space around the kitchen, access paths to sleeping areas and toilet facilities are all necessary space which is normally not considered available for sleeping.

Perception of the carrying capacity and quality of a site also varies by reach based on the availability of sites in the area. We call this the Quartaroli Corollary, after boatman Richard Quartaroli, who described to us that camps in critical reaches are perceived as "larger" and "better" than camps of approximately equal size and quality in non-critical reaches. This is because there are more large, high

quality campsites to choose from in non-critical reaches, and fewer in critical reaches. Others have previously noted this bias (Shelby & Heberlein 1986, Weeden et al. 1975).

Effects of Discharge on Campsite Size

General observation and logic will confirm that many sites are larger at lower flow levels than at higher flow levels since more area is exposed. However, the newly exposed areas of many campsites do not add significantly to the carrying capacity of a site because they are too steep or rocky to use for kitchen space or sleeping area. If different flow regimes result in different channel or beach face geometry, this result can change.

During fluctuating flows, the location of a camp will determine what time of day maximum and minimum flows will reach the site (Stevens 1983 pp. 56-57). Although there may be additional space available at night if flows are dropping throughout the night, these areas cannot be considered useable under fluctuating flows for several reasons. Primarily, it is difficult to know when flows can be expected to begin rising, which would displace people potentially using the area. Evening and morning water at such a site would probably be high, even if the water was low during most of the night. Thus, when setting up camp, a group settles above the high water. Lastly, it is simpler to teach passengers one set of protocol for camp establishment, rather than to complicate the trip with minor exceptions to procedures, i.e. "Always camp above the high water mark, or you might get wet!" However, weekend flows are generally expected to be low, are more reliable and predictable, and are commonly taken advantage of in choosing sites when weekend flows are expected to arrive at an area (Grand Canyon River Guides Focus Group 1991).

Effects of Campsite Availability on Carrying Capacity

As indicated by the inventories, campsites have dramatically decreased in size and number over the past twenty years. Not only has there been a 32% reduction in the number of campsites since 1973, this decrease has been greater for large sites. This decrease in the number of large sites is especially critical for commercial trips which run virtually all of the large size trips in the Canyon (Cherry pers. comm. 1991). Campsites are most restricted in critical reaches by scarcity and smaller size of sites (Table 1, Appendix A). There are fewer sites per mile in critical reaches (0.7 sites/mile versus 1.1 sites/mile in non-critical reaches) (Fig. 5), and large sites are limited, with fewer than half the number of large sites per mile in critical than in non-critical reaches. When determining carrying capacity, one needs to focus primarily on these critical reaches.

Carrying capacity of the river corridor for river trips is dependent on a complex of factors, including ecological impacts of recreational use, sociological preferences of recreational users, and logistics of river trips such as launch dates, trip length, and group sizes (Borden 1976). Consequently, carrying capacity along the river corridor is difficult to determine. However, an evaluation of physical carrying capacity in the first critical reach and its associated use can be done by comparing information on available campsites with information on past river trips, such as number, size, and itinerary of trips.

The following information was collected from 1991 trip statistics (Cherry pers. comm. 1992) and from 1989 and 1990 trip itineraries (Jalbert, unpublished data). Between May 1-Sept. 30 1991, 834 trips launched from Lees Ferry. 61% of the trips were commercial motor trips, 17% were commercial oar trips, and 22% were private trips (primarily oar trips). Of commercial motor trips leaving Lees Ferry, 47% were large (25-36 people), 46% were medium (13-24 people), and 7% were small(1-12 people). Of commercial oar trips, 51% were large, 47% were medium, and 2% were small. Private trips are allowed a maximum of 16 people, so no trips were large, 50% were medium, and 50% were small.

An analysis of trip itineraries of 118 river trips in 1989-1990 provided information on trips camped within the first critical reach:

Percent trips camped in first critical reach (RM 11.0-40.8)

	first night	second night	third night	fourth night
commercial motor (n=60)	95%	0%		
commercial oar (n=32)	94%	84%	0%	
private (n=26)	81%	88%	19%	4%

June is the busiest month on the river; in June 1991, 8-10 trips launched per day for 50% of the days (Cherry pers. comm. 1991). With two consecutive days of 9 launches per day, an average of 13 separate trips, primarily medium and large trips, camp within the first critical reach in one night.

Combining the above information with the current campsite inventory, the first critical reach is at the upper limit of its physical carrying capacity. At 25,000 cfs, this critical reach has 7 large, 6 medium, and 7 small campsites. Campsites availability is further restricted because small and medium trips often choose medium and large camps, and logistical constraints restrict trips to choosing only the camps they can reach by late afternoon. This reach has more campsites per mile than either the critical reach surrounding Phantom Ranch (Reach 4) or the critical reach in the Muav Gorge (Reach 7), so the physical carrying capacity of these lower reaches would be less.

If dam discharge were reduced to 15,000 cfs, the number and size of available campsites in the first critical reach would increase substantially. One medium camp would increase in size class to large, 5 small camps would increase in size class to medium or large, and 7 low water camps would be available. However, these increases in number and size of campsites are likely to change as different flow patterns implemented after summer 1991 alter beach morphology and size.

CONCLUSIONS

All null hypotheses in this study were rejected except H° number 3, which states that discharge has no influence on the availability of campsites in critical versus non-critical reaches. All other null hypotheses, stating that discharge does not influence the number, availability, size, and mooring quality of campsites, and that there has been no change through time in the number and size of campsites, were rejected.

A comparison of the 1973, 1983, and 1991 inventories shows an overall decrease in number and size of campsites. While the spill releases of 1983 did increase the number and size of campsites, most of the new campsites were in non-critical reaches where campsites are relatively abundant, and the flood induced changes were only temporary. For at least the past 20 years, dam induced changes of the river and its flow pattern have resulted in an overall loss of campsites and decrease in size of the remaining campsites. Loss of campsites is attributed primarily to erosion and vegetation growth; most campsites in critical reaches were lost due to erosion, and most campsites in non-critical reaches were lost due to vegetation growth.

This study has shown that reduced dam discharges with reduced fluctuations in discharge can help alleviate carrying capacity problems over the short term by increasing the amount of exposed camping area. When dam discharges did not exceed 15,000 cfs, 37 low water campsites became available, most campsites (73% of those measured) increased in exposed area which is useable for camping, and 36% of the camps classed as small or medium at 25,000-28,000 cfs increased in enough exposed camping area so that they increased in size class. When dam discharges were reduced from 15,000 to 8,000 cfs, nearly half (46%) of measured campsites continued to increase in campable area.

However, the assessments of campsite size and measurements of campsite area at different discharge levels are for the campsites as they were in 1991. These "instantaneous" increases in number and size of campsites with decreased flow will undoubtably change as the size and geometry of beaches change in response to different discharge patterns. Predictions on how different discharge patterns will physically change the beaches are beyond the scope of this study.

Reduced dam discharges with reduced fluctuations in discharge increase the physical carrying capacity of campsites at the Grand Canyon by exposing more campsite area. It is hoped that different discharge patterns implemented as a result of the Glen Canyon Dam Environmental Impact Statement will stabilize or reduce the loss of campsites over the long term.

Dam alternatives are listed below in order of descending preference based on campsite size and availability. While they are listed in this order, the differences between the first four alternatives are slight, whereas differences between the first four and the last three alternatives are substantial. One caution should be noted: the following effects of dam alternatives on campsites are for campsites in their present condition. Different flow patterns are likely to change beach morphology and size, thus changing the number of campsites, size classes of campsites, and the amount of campsite area at different discharges.

1. Year-Round Steady Flow Alternative

This would be the best alternative for campsites. With no fluctuations, campers could use the entire exposed camping area without regard for inundations of the campsite during the night, and mooring quality would be good. During years when annual river volumes are 11.0 maf or less (so river levels would be 15,000 cfs or less), the discharge level would be low enough for the use of low water campsites. Also during these years 36% of the small and medium campsites would increase in size class to medium or large.

2. Existing Monthly Volume Steady Flow Alternative

This steady flow alternative would also allow campers to use the entire exposed camping area without regard to inundations of the campsite, and would provide good mooring quality. Although monthly volumes would increase during the summer, flows would usually be low enough (15,000 cfs or less) so that low water campsites would be available and many small and medium campsites would increase in class size.

3. Seasonally Adjusted Steady Flow Alternative

Effects of this flow alternative would be the same as that of the "Existing Monthly Volume Steady Flow" alternative, except during May-June the minimum flow of 18,000 cfs would not allow use of many low water camps, and fewer campsites would increase in size class.

4. Low Fluctuating Flow Alternative

A maximum daily fluctuation rate of 5,000-8,000 cfs will enable campers to use approxomately 80-95% of the exposed camping area on average and will cause mooring quality to be slightly poorer than the constant flow alternatives. When flows are below 10,000 cfs, low water sites will be available, and 36% of the small and medium sites will increase in size class. A 10,000 cfs flow is low enough so that a 5000-8000 cfs change/day still allow for low water sites and increased size classes.

5. Moderate Fluctuating Flow Alternative

In comparison with the low fluctuating flow alternative, moderate fluctuations will decrease the amount of exposed camping area that can be used, and will decrease mooring quality. Low water sites and increased size classes of campsites would occur only when minimum flows are between 5,000 and 10,000 cfs. When minimum flows are higher, these areas will become inundated.

6. High Fluctuating Flow Alternative

Conditions under the high fluctuating flow alternative will be poorer than under the moderate fluctuating flow alternative with less camping area available above the high water and poorer mooring conditions. Mooring conditions decrease in quality due to increased monitoring of changing water

levels and a higher potential for boat stranding. Low water sites will virtually never by useable, and increased size classes and areas of campsites will virtually never occur because the 15,000-22,000 daily fluctuations will inundate the exposed areas.

7. No Action Alternative

Daily fluctuations with no restrictions and a high ramping rate under this alternative provide for the least amount of useable campsite area available and create the worst mooring quality of any other alternative. Low water sites are not available, and any exposed area below 25,000-28,000 cfs cannot be used because of the high and rapid fluctuations allowed under this alternative.

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Appendix A

Reach Systems Used for Campsite Analysis

Brian and Thomas, 1983

Reach	Miles	Locations
1	0-31.5	Lees Ferry to South Canyon
2	31.6-61.2	South Canyon to Little Colo. River Confluence
3	61.3-90.0	Little Colo. River Confluence to Horn Creek
4	90.1-121.0	Horn Creek to Blacktail Canyon
5	121.1-143.5	Blacktail Canyon to Kanab Creek
6	143.6-179.4	Kanab Creek to Lava Falls
7	179.5-208.8	Lava Falls to Granite Park
8	208.9-225.7	Granite Park to Diamond Creek

Present Study, 1991

Reach	Type*	Miles	Locations
1	NC	10-11.0	Lees Ferry to Soap Creek
2	C	11.0-40.8	Soap Creek to Buckfarm
3	NC	40.8-76.5	Buckfarm to Hance Rapids
4	C	76.5-116.0	Hance Rapids to Elves Chasm
5	NC	116.0-131.0	Elves Chasm to Above Deubendorff
6	DC	131.0-139.0	Above Deubendorff to Fishtail
7	C	139.0-164.0	Fishtail to Tuckup
8	NC	164.0-226.0	Tuckup to Diamond Creek

* NC = Non-critical, C = Critical, DC = Deer Creek reach (critical)

Schmidt and Graf, 1988

Reach	Type*	Miles	Locations/Physiographic Province
1	W	1-11.0	Lees Ferry to Soap Creek/Permian
2	N	11.1-22.5	Soap Creek to 22.5-mile/Supai Gorge
3	N	22.6-39.9	22.5-mile to Buckfarm/Redwall Gorge
4	W	40.0-61.5	Buckfarm to LCR/Lower Marble Canyon
5	W	61.6-77.4	LCR to Hance/Furnace Flats
6	N	77.5-117.8	Hance to Elves Chasm/Upper Granite Gorge
7	N	117.9-125.5	Elves Chasm to Below Fossil/Aisles
8	N	125.6-139.9	Below Fossil to 140/Middle Granite Gorge
9	N	140.0-159.9	140-mile to 160-mile/Muav Gorge
10	W	160.0-213.8	160-mile to 214-mile/Lower Canyon
11	N	213.8-225.0	214 to Diamond Creek/Lower Ganite Gorge

* W = Wide, N = NarrowAppendix D

Appendix B

Quality Index for CO River Campsites

River Mile_____ Location_____

Positive Attributes		Negative Attributes	
Mooring (25-28k)		Mooring (25-28k)	
	quiet ____		surfy ____
	deep ____		shallow ____
	sandy ____		rocky ____
Access (25-28k)		Access (25-28k)	
	low angle ____		steep ____
	close ____		far ____
Shade/Protection		Shade/Protection	
	trees ____		no trees ____
	cliff/overhang ____		no cliff or overhang ____
Location		Location	
	logistic* ____		no advantage ____
	attraction** ____		no attraction ____
Use Area		Use Area	
	sandy/ledge ____		rocky/scrubby ____
	flat ____		steep ____
Features		Features	
	aesthetic*** ____		unaesthetic ____
Privacy		Privacy	
	yes ____		no ____
Total ____		Total ____	
Grand Total ____		1'/2' ____	

* location in reference to certain areas in the canyon (e.g. proximity to Phantom Ranch and other take-in/take-out points) and proximity to attraction sites (e.g. LCR, Havasu)

** location in reference to whether an attraction site is accessible from the camp

*** Indicate the "attractiveness" of the camp. e.g. Martha's Camp (RM 38.3L) is considered aesthetic because of the dramatic amphitheatre there. If there is nothing especially attractive about the camp, the camp should be labeled as "unaesthetic."

Mooring Quality Under Varying Flow Regimes

Discharge Regime	Quality Fair/Good	Poor/Bad
Constant high (>15K)		
Constant low (<15)		
Fluctuating (10K range)		

Appendix C

Beach Availability Study
Glen Canyon National Recreation Area Sites

Mile*	Side	HWsize**	LWsize	Name	Use***
3.0	L	L	L	Cave Canyon	Day
6.1	R	n/a	M	Big Sandy	Day
6.1	L	n/a	M	Little Sandy	Day
6.2	R	M	M	Six-mile Camp	Camp
6.5	R	n/a	M	Survey site	Day
6.7	L	n/a	M	No Name	Day
7.0	L	n/a	M	South Finger Rock	Day
7.5	L	S	S	Seven Mile	Camp
8.4	R	L	L	Twin Stripes	Camp
9.0	R	L	L	Nine Mile	Camp
10.0	L	L	L	Petroglyphs	Day
10.5	R	S	M	Faatz Inscription	Day
11.1	L	L	L	Ferry Swale	Camp
12.5	R	S	L	Twelve-and-a-half	Day
13.2	L	n/a	L	Above Honey Draw	Day
13.6	R	L	L	Ropes Trail	Camp
14.3	L	S	S	Pump Station	Day
14.8	R	S	M	Fifteen Mile	Day

* Miles are measured upstream from Lees Ferry
** HWsize = camp size (small, medium, large) at high water (25,000-28,000cfs)
LWsize = camp size at low water (15,000 cfs and less)
*** Use indicates whether the site is currently a designated campsite or is for day use only

Appendix D

1991 Inventory of Grand Canyon River Campsites
*** = In Steven's Guide # = sites recorded as degraded by 1983 high water flows**

Mile	Side	Reach	Name	Size	Comments 1991
5.8	R*#	Noncrit.	Six-mile Wash	M	primary
8.0	R*	Noncrit.	Badger	L	primary
8.0	L*	Noncrit.	Jackass	L	primary
8.5	L	Noncrit.	Below Jackass	S	low water camp
11.0	R*	Crit.	Soap Creek	M	primary
11.8	L*	Crit.	Brown's Inscr.	S	secondary, ledge camp
12.2	L*	Crit.	Below Salt Water	S	low water camp
12.8	R	Crit.	Thirteen-mile	S	low water camp, ledge camp
16.4	L*	Crit.	Hot Na Na Wash	M	primary
17.0	R*#	Crit.	House Rock	S	primary
18.0	L*	Crit.	Eighteen Mile Wash	S	low water camp
18.1	L*#	Crit.	Eighteen Mile Ledges	L	primary, ledge camp
19.0	R*	Crit.	Nineteen Mile Canyon	M	primary
19.1	L*	Crit.	Lower Nineteen	S	primary
19.9	L*	Crit.	Twenty mile	S	primary
20.4	R*	Crit.	Upper North Canyon	L	primary
20.5	R*	Crit.	Lower North Canyon	L	Constant high water only
21.5	L	Crit.	Twentytwo mile Wash	S	low water camp
21.9	R*	Crit.	Twentytwo mile	M	low water camp
23.0	L*	Crit.	Above Indian Dick	L	primary
23.7	L#	Crit.	Lone Cedar	S	secondary
24.5	L*	Crit.	Twenty four and half	M	primary
26.3	L*	Crit.	Above Tiger Wash	M	low water camp
29.3	L*	Crit.	Shinumo Wash	L	primary
30.4	R*	Crit.	Fence Fault	S	primary
31.6	R*	Crit.	South Canyon	L	primary
33.6	L*	Crit.	Below Redwall	S	primary
34.0	L	Crit.	Little Redwall	M	primary
34.8	L*	Crit.	Nautiloid	L	primary
37.7	L*	Crit.	Tatahatso	M	primary
38.3	L*	Crit.	Martha's Camp	L	primary
39.0	R	Crit.	Redbud Alcove	M	low water camp
40.9	R*	Noncrit.	Upper Buckfarm	S	secondary
41.0	R*	Noncrit.	Lower Buckfarm	L	primary
43.2	L*#	Noncrit.	Anasazi Bridge	L	primary
43.3	L*	Noncrit.	Lower Anasazi	L	primary
43.8	L*#	Noncrit.	Pres. Harding	L	primary
44.2	L*	Noncrit.	Eminence Break	L	primary
44.6	L	Noncrit.	No Name	S	secondary
44.8	L*	Noncrit.	Willie Taylor Camp	M	secondary
46.9	L	Noncrit.	Duck in the Quack	S	secondary
47.2	R*	Noncrit.	Upper Saddle	L	primary
47.3	R*	Noncrit.	Lower Saddle	L	primary
50.0	R*	Noncrit.	Fifty-mile Camp	L	primary
51.2	L*	Noncrit.	Fiftyone-mile Camp	M	secondary
51.4	L*	Noncrit.	No Name	L	secondary
51.8	R*	Noncrit.	Little Nankoweap	M	primary
52.6	R*	Noncrit.	Upper Nankoweap	L	primary
53.0	R*	Noncrit.	Main Nankoweap	L	primary
53.2	R	Noncrit.	Lower Nankoweap	L	primary

56.2	R*	Noncrit.	Kwagunt	L	primary
56.7	R*	Noncrit.	No Name	M	secondary
57.5	R	Noncrit.	Malagosa	M	secondary
57.5	L	Noncrit.	Opp. Malagosa	M	secondary
58.2	R*	Noncrit.	Awatubi	L	primary
58.6	L*	Noncrit.	Below Awatubi Left	L	primary
59.0	R	Noncrit.	Below Awatubi Right	L	primary
59.8	R	Noncrit.	Sixty-mile	S	low water camp
60.8	R	Noncrit.	Opp. Salt Deposits	M	secondary
61.0	L	Noncrit.	Sixtyone-mile	M	secondary
61.2	R*	Noncrit.	Above LCR	L	primary
61.6	R	Noncrit.	Below LCR	S	low water camp
61.7	R	Noncrit.	Below LC Island	M	primary
62.6	R*#	Noncrit.	Crash Canyon	L	primary
64.7	R*	Noncrit.	Carbon	L	primary
65.5	R*	Noncrit.	Lava Canyon	L	primary
65.7	L*	Noncrit.	Palisade Ck.	M	primary
66.3	L	Noncrit.	Above Espejo	L	primary
66.8	L*	Noncrit.	Espejo	M	secondary
68.4	R	Noncrit.	Tanner	L	primary
69.8	R	Noncrit.	Lower Basalt	M	primary
71.0	L*	Noncrit.	Cardenas	L	primary
71.9	R*	Noncrit.	Upper Unkar	L	primary
72.3	L*	Noncrit.	Unkar	M	primary
73.6	R	Noncrit.	Below Granary	L	primary
74.0	R	Noncrit.	No Name	S	secondary
74.1	R*	Noncrit.	Upper Rattlesnake	L	primary
74.3	R*	Noncrit.	Lower Rattlesnake	M	primary
75.6	L*	Noncrit.	Neville's Camp	L	primary
75.8	R*	Noncrit.	Papago Camp	L	primary
76.6	L*	Crit.	Hance	M	primary
78.9	L	Crit.	Below Sockdolager	S	secondary
81.3	L*	Crit.	Grapevine	L	primary
84.0	R*	Crit.	Clear Creek	S	low water camp
84.4	L*	Crit.	Above Zoro	S	low water camp
87.1	L*	Crit.	Upper Cremation	M	primary
87.2	L*	Crit.	Lower Cremation	L	primary
87.3	R	Crit.	Roy's Beach	M	by permit only
89.3	R	Crit.	Below Pipe Creek	L	secondary
90.9	L	Crit.	Upper Ninetyone	S	primary
91.1	R	Crit.	New Trinity	M	primary
91.6	R*#	Crit.	Old Trinity	S	secondary
92.3	L*	Crit.	Above Salt Creek	M	primary
93.4	L*	Crit.	Granite Monument	L	primary
94.3	R	Crit.	Ninetyfour Right	S	primary
94.9	L*	Crit.	Hermit	S	primary
96.0	R*	Crit.	Ninetysix-mile	M	primary
96.1	L*	Crit.	Schist	L	primary
98.0	R*	Crit.	Upper Crystal	M	primary
98.2	R	Crit.	Lower Crystal	M	secondary
102.8	R	Crit.	New Shady Grove	S	primary
103.8	R*	Crit.	Emerald	S	primary
107.8	L*#	Crit.	Ross Wheeler	S	primary
108.0	R	Crit.	Parkins' Inscr.	M	low water camp
108.2	R*	Crit.	Lower Bass	L	primary
109.4	R*#	Crit.	One-ten mile	L	primary

114.3	R*	Crit.	Upper Garnet	M	primary
114.5	R*	Crit.	Lower Garnet	L	primary
115.5	R	Crit.	No Name	S	secondary
117.5	R	Noncrit.	Below Elves Right	S	low water camp
118.1	R*	Noncrit.	Oneeighteen	S	primary
118.5	L	Noncrit.	Oneeighteen-1/2	M	primary
119.0	R*	Noncrit.	Onenineteen-mile	L	primary
119.2	R	Noncrit.	No Name	S	secondary
119.5	L*	Noncrit.	Onenineteen-1/2	M	primary
119.8	L*	Noncrit.	Onetwenty-mile	L	primary
120.0	L	Noncrit.	Opp. Blacktail	S	secondary
120.0	R*	Noncrit.	Upper Blacktail	M	primary
120.1	R*	Noncrit.	Lower Blacktail	M	secondary
120.2	L*	Noncrit.	No Name	S	low water camp
120.9	L	Noncrit.	Below Blacktail	M	primary
121.5	L	Noncrit.	No Name	L	secondary, ledge camp
122.2	R*	Noncrit.	Onetwentytwo-mile	L	primary
122.7	L*	Noncrit.	Upper Forster	L	primary
124.3	L*	Noncrit.	Above Fossil	M	secondary
124.9	L	Noncrit.	Fossil	M	secondary
125.4	L*	Noncrit.	Below Fossil	L	primary
125.5	L	Noncrit.	No Name	L	secondary
125.6	R	Noncrit.	No Name	S	low water camp
126.5	R*	Noncrit.	Randy's Rock	M	primary
131.1	R*	Crit. DC	Below Bedrock	S	primary
131.8	R	Crit. DC	Galloway	L	primary
132.0	R*	Crit. DC	Stone Creek	M	primary
133.0	L*	Crit. DC	Onethirtythree Mile	L	primary
133.5	R*	Crit. DC	Racetrack	M	primary
133.8	R*	Crit. DC	Upper Tapeats	L	primary
133.9	R*	Crit. DC	Lower Tapeats	M	secondary
134.2	L*	Crit. DC	Below Tapeats	M	constant high water only
134.6	L*	Crit. DC	Owl Eyes	L	primary
136.0	L	Crit. DC	Junebug	M	primary
136.2	L*	Crit. DC	Opp. Deer Creek	M	primary
136.3	L*	Crit. DC	Below Deer Creek	M	primary
136.8	L*	Crit. DC	Poncho's Kitchen	L	primary
136.9	L	Crit. DC	Football Field	M	secondary
137.0	L*	Crit. DC	Backeddy	L	primary
137.9	L*	Crit. DC	Doris	M	primary
138.2	L*	Crit. DC	No Name	M	primary
138.4	L*#	Crit. DC	No Name	M	primary
139.0	R*	Crit.	Fishtail	L	primary
139.8	L	Crit.	Oneforty-mile	M	secondary
140.3	L	Crit.	Below Oneforty	S	low water camp
143.3	L*	Crit.	Above Kanab	M	primary
143.5	R*	Crit.	Mouth Kanab	S	low water camp
144.2	R	Crit.	Below Kanab	S	low water camp
145.1	L	Crit.	Above Olo	S	primary
145.6	L*	Crit.	Olo Canyon	S	low water camp
147.9	R	Crit.	Opp. Matkat Canyon	M	primary
148.4	L*	Crit.	Matkat Hotel	S	primary
148.5	L	Crit.	Below Matkat	S	low water camp
150.3	L*#	Crit.	Upset Hotel	M	primary
151.3	R	Crit.	Upper Ledges	M	low water camp, ledge camp
151.5	R*	Crit.	Ledges	L	primary, ledge camp

153.5	R	Crit.	Sinyala	S	primary
155.7	R*	Crit.	Last Chance	M	primary
156.3	R*	Crit.	Last Last Chance	M	secondary
157.7	R*#	Crit.	First Chance	M	primary
158.2	R	Crit.	Onefiftyeight-mile	M	secondary, ledge camp
158.5	R*	Crit.	Second Chance	M	primary
160.0	L#	Crit.	Onesixty-mile	S	primary
160.7	R*	Crit.	Onesixtyone-mile	M	low water camp
162.2	L	Crit.	Onesixtytwo-mile	L	primary
164.5	R*	Noncrit.	Tuckup Canyon	L	primary
164.8	L	Noncrit.	Below Tuckup	S	primary
164.9	R	Noncrit.	Onesixtyfive-mile	S	low water camp
166.5	L*	Noncrit.	Upper National	M	primary
166.6	L*	Noncrit.	Lower National	L	primary
167.0	L	Noncrit.	Below National	S	primary
167.2	L*	Noncrit.	No Name	M	primary
168.0	R	Noncrit.	Fern Glen	L	primary
168.3	R	Noncrit.	Below Fern Glen	S	low water camp
169.8	L	Noncrit.	Oneseventy-mile	S	low water camp
171.0	R*	Noncrit.	Stairway Canyon	L	primary
171.6	L*	Noncrit.	Mohawk	L	primary
172.1	L*	Noncrit.	Below Mohawk	M	secondary
172.8	L	Noncrit.	No Name	M	secondary
173.0	R*	Noncrit.	Oneseventythree-mile	M	primary
174.3	R	Noncrit.	Upper Cove	M	secondary
174.4	R*	Noncrit.	Lower Cove	L	primary
174.7	R	Noncrit.	Below Cove	S	secondary
176.0	L	Noncrit.	Below Red Slide	L	primary
176.8	L	Noncrit.	Above Honga	S	secondary
177.1	L*	Noncrit.	Honga Spring	L	primary
177.7	L*	Noncrit.	Above Anvil	M	primary
178.0	R	Noncrit.	Vulcan's Anvil	S	secondary
179.0	L*	Noncrit.	Above Lava	M	primary
179.2	L	Noncrit.	Just Above Lava	S	secondary
179.7	R*	Noncrit.	Below Little Lava	L	primary
180.0	R	Noncrit.	One-eighty Mile	M	primary
181.8	R	Noncrit.	Oneeightytwo	S	primary
182.5	L	Noncrit.	Hell's Hollow	S	primary
182.5	R	Noncrit.	Upper Chevron	L	primary
182.6	R	Noncrit.	Lower Chevron	L	primary
182.8	R*	Noncrit.	Below Hell's Hollow	M	secondary
182.8	L*	Noncrit.	No Name	M	primary
183.0	L	Noncrit.	Below Old Helipad	S	primary
184.5	L	Noncrit.	No Name	M	primary
185.3	R	Noncrit.	No Name	M	low water camp
185.5	R	Noncrit.	No Name	M	primary
186.0	L	Noncrit.	One-eightysix Mile	M	primary
186.2	L*	Noncrit.	No Name	L	primary
187.4	L	Noncrit.	Below Helipad	M	low water camp
188.0	R*	Noncrit.	Whitmore Wash	L	primary
188.2	R	Noncrit.	Lower Whitmore	M	primary
189.0	L	Noncrit.	No Name	S	secondary
189.5	L	Noncrit.	No Name	S	primary
189.7	L	Noncrit.	No Name	L	secondary
190.0	R*	Noncrit.	Oneninety-mile	S	low water camp
190.3	L	Noncrit.	No Name	S	primary

191.0	R	Noncrit.	No Name	S	low water camp
191.8	L*	Noncrit.	Oneninetytwo-mile	L	primary
192.2	R	Noncrit.	No Name	M	secondary
192.8	L	Noncrit.	Oneninetythree-mile	M	secondary
194.1	L*	Noncrit.	Hualapai Acres	L	primary
194.4	L*	Noncrit.	Oneninetyfour-mile	M	primary
196.4	L*	Noncrit.	Frogy Fault	L	primary
196.5	L	Noncrit.	Below Frogy	S	primary
198.5	R*	Noncrit.	Parashant	M	primary
199.5	L	Noncrit.	Above Island Left	S	low water camp
199.6	R	Noncrit.	Opp. Island	S	low water camp
200.4	R	Noncrit.	Hematite Mine	M	primary
200.5	L	Noncrit.	No Name	M	primary
201.2	R	Noncrit.	Two-o-one Mile	M	primary
202.0	R*	Noncrit.	Two-o-two mile	L	primary
202.5	R	Noncrit.	No Name	M	secondary
204.5	R*	Noncrit.	Below Spring Canyon	M	primary
206.6	R	Noncrit.	Indian Canyon	S	primary
207.4	L	Noncrit.	No Name	M	secondary
208.8	L*	Noncrit.	Granite Park	L	primary
209.4	R	Noncrit.	No Name	M	primary
209.5	R	Noncrit.	No Name	L	secondary
210.0	R	Noncrit.	Two-ten-mile Camp	M	secondary
210.7	R	Noncrit.	No Name	L	primary
211.0	L	Noncrit.	No Name	S	low water camp
211.2	L	Noncrit.	Two-eleven-mile	M	primary
211.5	R*	Noncrit.	Upper Fall Canyon	M	secondary
211.7	R	Noncrit.	Lower Fall Canyon	S	primary
212.9	L*	Noncrit.	Pumpkin Springs	L	primary
213.5	L	Noncrit.	Below Pumpkin	S	low water camp
214.3	R*	Noncrit.	No Name	M	low water camp
215.0	L	Noncrit.	Twofifteen mile	S	primary
215.6	R*	Noncrit.	Opp. Three Springs	S	low water camp
216.4	R	Noncrit.	Below Three Springs	M	primary
216.8	L	Noncrit.	No Name	S	secondary
217.5	L	Noncrit.	Below 217 Rapid	M	low water camp
219.8	R*	Noncrit.	Upper Twotwenty	L	primary
219.9	R*	Noncrit.	Middle Twotwenty	L	primary
220.0	R*	Noncrit.	Lower Twotwenty	M	primary
221.2	R*	Noncrit.	Twotwentyone-mile	M	primary
222.0	L*	Noncrit.	Twotwentytwo-mile	L	primary
222.5	R*	Noncrit.	Twotwentytwo-1/2	M	primary
223.0	R	Noncrit.	Twotwentythree	M	secondary
223.4	L*	Noncrit.	No Name	M	primary
224.5	L*	Noncrit.	Last Before Diamond	L	primary

Appendix E

1973 Inventory of Grand Canyon River Campsites
Weeden et al.

Mile	Side	Site name	Capacity
2.7	R	Cathedral Wash	30.0
5.8	R	Rock Fall	20.0
7.9	L	Jackass	40.0
7.9	R	Badger	40.0
17.1	R	House Rock	40.0
18.2	L	Upper 18-mile	20.0
18.3	L	Lower 18-mile	40.0
19.3	L	Nineteen-mile	20.0
20.0	L	Twenty-mile	40.0
21.5	L	Twentyone-five	30.0
21.8	R	Twentytwo-mile	30.0
22.3	L	Unnamed	30.0
22.4	L	Unnamed	40.0
23.2	L	Twentythree-mile	40.0
24.9	L	Twentyfive-mile	20.0
26.2	L	Georgie's	40.0
26.7	L	Tiger Wash	20.0
28.2	R	Unnamed	10.0
29.0	R	Twentynine-mile	10.0
29.2	L	Shinumo	40.0
30.3	R	Thirty-mile	40.0
31.5	R	South Canyon	40.0
33.5	L	Thirtythree five	30.0
33.9	L	Rock Point Cave	30.0
34.7	L	Nautiloid	40.0
35.1	L	Thirtyfive-mile	15.0
36.0	L	Thirtysix-mile	10.0
37.2	R	Thirtyseven-mile	10.0
37.3	L	Tatahatso	10.0
37.6	L	Thirtyseven five	40.0
38.6	L	Thirtyeight five	30.0
39.8	L	MCD site	15.0
40.1	L	Forty-mile	15.0
40.9	R	Buckfarm	40.0
41.0	R	Below Buckfarm	25.0
41.3	R	Loper's Boat	40.0
41.5	R	Royal Arches	10.0
41.9	L	Unnamed	20.0
42.1	L	Unnamed	15.0
43.2	L	Unnamed	30.0
43.4	L	Unnamed	15.0
44.2	L	Unnamed	25.0
44.5	L	Unnamed	40.0
44.7	L	Unnamed	40.0
45.0	L	Unnamed	15.0
45.8	L	Unnamed	25.0
46.8	R	Triple Alcoves	20.0
47.1	R	Saddle	40.0
48.3	R	Unnamed	15.0

49.5	L	Unnamed	35.0
49.9	R	Unnamed	40.0
50.0	R	Unnamed	35.0
50.6	L	Unnamed	30.0
51.4	L	Unnamed	25.0
51.6	L	Unnamed	35.0
51.9	R	Little Nankoweap	40.0
52.0	R	Unnamed	20.0
52.5	R	Unnamed	40.0
53.0	R	Nankoweap	40.0
53.1	L	Unnamed	40.0
53.3	L	Unnamed	40.0
53.6	R	Unnamed	20.0
53.7	R	Unnamed	20.0
53.9	L	Fiftyfour-mile	30.0
54.2	R	Unnamed	25.0
54.5	R	Unnamed	25.0
56.6	R	Unnamed	40.0
56.8	L	Unnamed	20.0
57.4	R	Malagosa	30.0
57.7	L	Unnamed	35.0
58.5	L	Unnamed	30.0
59.0	L	Unnamed	30.0
62.4	R	Unnamed	20.0
63.3	R	Unnamed	20.0
63.6	L	Hopi Salt Mine	30.0
63.9	L	Unnamed	30.0
64.5	R	Carbon Creek	25.0
65.5	L	Tanner Mine	40.0
66.1	L	Unnamed	40.0
66.4	L	Unnamed	40.0
66.9	L	Espejo	25.0
67.3	L	Comanche	35.0
68.0	R	Tanner	40.0
68.1	R	Unnamed	40.0
68.7	L	Lower Tanner	40.0
68.8	L	Unnamed	40.0
69.5	R	Basalt Canyon	25.0
69.5	L	Unnamed	40.0
69.9	L	Unnamed	30.0
70.2	L	Unnamed	40.0
70.5	R	Unnamed	40.0
72.1	L	Unnamed	40.0
73.4	L	Unnamed	40.0
73.7	L	Unnamed	20.0
73.7	R	Unnamed	15.0
73.9	R	Unnamed	40.0
74.0	R	Seventyfour-mile	40.0
74.2	L	Unnamed	10.0
74.3	L	Unnamed	15.0
74.3	R	Unnamed	30.0
74.7	L	Unnamed	10.0
74.9	R	Escalante	15.0
75.5	L	Neville's	40.0
76.4	R	Unnamed	10.0
76.5	L	Hance	40.0

77.1	L	Unnamed	20.0
78.8	L	Sockdolager	30.0
81.1	L	Grapevine	40.0
82.6	R	Eightytwo five	10.0
84.0	R	Clear Creek	15.0
84.4	L	Zoroaster	10.0
85.7	L	Cremation	8.0
87.1	L	Last Chance	40.0
88.0	L	Unnamed	40.0
89.3	R	Unnamed	40.0
91.1	L	Unnamed	15.0
91.2	R	Ninetyone-mile	25.0
91.5	R	Trinity	20.0
92.2	L	Unnamed	15.0
93.2	L	Upper Granite	30.0
93.3	L	Lower Granite	40.0
93.9	R	Unnamed	10.0
95.8	L	Old Dune	8.0
95.9	L	Ninetysix-mile	30.0
96.5	L	Boucher	10.0
99.1	L	Tuna Rapids	8.0
99.1	R	Tuna Creek	12.0
99.5	R	Hundred-mile	40.0
102.9	R	Gem	15.0
103.1	R	One-o-three mile	12.0
103.8	R	Pegmatite Still	15.0
105.6	R	One-o-five five	10.0
106.8	R	One-o-seven mile	30.0
107.5	R	Unnamed	40.0
107.7	L	Unnamed	40.0
107.9	R	Bass Rapids	40.0
108.2	R	Bass Crossing	10.0
108.3	R	Lower Bass	40.0
112.5	R	Waltenberg	10.0
114.3	R	Garnet	40.0
114.5	R	Onefourteen five	40.0
115.4	L	Unnamed	12.0
115.7	R	Unnamed	15.0
117.0	L	Elves Chasm	25.0
117.4	L	Unnamed	12.0
117.7	L	Stephen Aisle	25.0
118.5	L	Apache Terrace	40.0
118.7	R	Unnamed	40.0
118.8	L	Unnamed	30.0
119.2	R	Onenineteen R	40.0
119.2	L	Onenineteen L	20.0
119.7	L	Unnamed	40.0
119.9	L	Onetwenty mile	15.0
120.1	R	Blacktail	40.0
120.2	L	Unnamed	20.0
120.5	L	Onetwenty Five	30.0
121.6	L	Onetwentyone Five	40.0
121.7	L	Unnamed	40.0
121.9	L	Unnamed	40.0
122.0	R	Onetwentytwo	40.0
122.2	L	Unnamed	40.0

122.7	L	Upper Forster	40.0
122.8	L	Lower Forster	40.0
123.5	L	Enfilade	40.0
124.4	L	Onetwentyfour Five	40.0
125.2	L	Unnamed	40.0
125.4	L	Unnamed	40.0
125.5	L	Onetwentyfive five	40.0
126.2	L	Unnamed	10.0
126.3	R	Unnamed	40.0
127.7	L	Narrows	30.0
131.0	R	Bedrock	40.0
131.6	R	Upper Dubby	25.0
131.9	R	Lower Dubby	30.0
132.1	L	Onethirtytwo	15.0
133.1	L	Onethirtythree	40.0
133.9	R	Tapeats	40.0
134.2	L	Bonita	40.0
134.5	L	Onethirtyfour five	40.0
136.0	L	Granite Narrows	30.0
136.2	L	Upper Deer Ck.	40.0
136.4	L	Unnamed	40.0
136.5	L	Onethirtysix five	40.0
137.0	L	Onethirtyseven	40.0
137.1	L	Unnamed	40.0
137.7	L	Unnamed	15.0
137.9	L	Unnamed	40.0
138.3	L	Unnamed	40.0
138.5	L	Onethirtyeight five	40.0
138.9	R	Fishtail	40.0
139.4	R	Unnamed	40.0
139.4	L	Unnamed	20.0
139.7	L	Upper Oneforty	40.0
139.9	L	Lower Oneforty	35.0
143.3	L	Kanab Rapids	30.0
145.4	L	Olo Canyon	40.0
148.3	L	Matkatamiba	10.0
149.8	R	Upset Rapids	15.0
151.6	R	Arts Ledge	40.0
152.3	L	Unnamed	25.0
153.8	L	Sinyala	30.0
155.6	R	Unnamed	25.0
158.1	R	Cork Spring	15.0
158.6	R	Unnamed	30.0
159.8	L	Unnamed	40.0
160.7	R	Unnamed	15.0
163.9	L	Onesixtyfour mile	30.0
164.5	R	Tuckup	40.0
166.5	L	Upper National	40.0
166.6	L	Lower National	40.0
166.9	L	Unnamed	25.0
167.2	L	Unnamed	20.0
168.1	R	Fern Glen	40.0
169.3	L	Unnamed	12.0
169.9	L	Unnamed	10.0
170.9	R	Unnamed	25.0
171.1	R	Stairway	20.0

171.4	L	Mohawk	25.0
172.1	L	Unnamed	20.0
172.8	L	Unnamed	40.0
173.2	R	Unnamed	20.0
173.5	L	Unnamed	20.0
174.2	R	Upper Cove	40.0
174.3	R	Middle Cove	40.0
175.8	L	Unnamed	40.0
176.3	R	Saddle Horse	12.0
177.1	L	Unnamed	40.0
177.6	L	Unnamed	40.0
177.8	L	Vulcan's Anvil	12.0
178.6	L	Unnamed	12.0
178.9	L	Unnamed	12.0
179.0	L	Unnamed	12.0
179.7	R	Lower Lava	40.0
180.2	L	Unnamed	30.0
180.6	L	Unnamed	12.0
180.7	L	Unnamed	12.0
180.9	R	Unnamed	25.0
181.4	R	Unnamed	12.0
181.6	L	Volcanic Ash Cliff	40.0
182.0	R	Unnamed	40.0
182.2	R	Unnamed	25.0
182.5	R	Unnamed	40.0
182.7	L	Unnamed	30.0
182.8	L	Unnamed	20.0
182.9	R	Unnamed	30.0
182.9	L	Unnamed	35.0
183.8	L	Unnamed	20.0
184.5	L	Unnamed	40.0
184.6	L	Unnamed	40.0
184.8	R	Unnamed	25.0
184.9	R	Unnamed	12.0
185.5	R	Unnamed	40.0
185.6	R	Unnamed	12.0
185.6	L	Unnamed	20.0
186.0	L	One-eightysix Mile	40.0
186.2	L	Unnamed	30.0
187.0	L	Unnamed	40.0
187.0	R	Unnamed	20.0
187.2	L	Unnamed	40.0
187.5	R	Whitmore Trail	20.0
188.0	R	Whitmore Rapids	30.0
188.2	R	Lower Whitmore	40.0
188.6	R	Unnamed	12.0
189.4	L	Unnamed	12.0
189.6	L	Unnamed	20.0
190.2	L	Unnamed	12.0
190.8	R	Unnamed	20.0
190.9	R	Unnamed	12.0
191.2	R	Unnamed	40.0
191.4	L	Unnamed	12.0
191.5	L	Unnamed	12.0
191.7	L	Oneninetytwo	30.0
192.2	R	Unnamed	40.0

192.6	L	Unnamed	40.0
192.9	L	Oneninetythree	40.0
193.1	R	Boulder Wash	20.0
193.6	L	Unnamed	12.0
193.7	L	Unnamed	20.0
194.0	L	Unnamed	30.0
194.0	R	Oneninetyfour	40.0
194.3	R	Unnamed	12.0
194.6	L	Unnamed	20.0
194.7	L	Unnamed	12.0
195.0	R	Unnamed	20.0
195.1	L	Unnamed	25.0
196.4	L	Oneninetysix	20.0
197.1	L	Unnamed	12.0
197.7	L	Unnamed	20.0
197.8	L	Unnamed	12.0
198.0	R	Unnamed	30.0
198.5	R	Parashant	40.0
198.9	R	Unnamed	40.0
199.5	R	Unnamed	12.0
200.1	R	Unnamed	30.0
200.3	R	Unnamed	40.0
200.5	L	Unnamed	20.0
200.8	R	Unnamed	12.0
201.4	L	Unnamed	20.0
201.9	R	Unnamed	40.0
202.5	R	Unnamed	40.0
203.0	R	Unnamed	12.0
203.4	R	Unnamed	12.0
203.5	R	Unnamed	30.0
203.9	R	Unnamed	25.0
204.9	L	Unnamed	12.0
206.2	R	Unnamed	12.0
207.2	R	Unnamed	20.0
207.6	L	Unnamed	40.0
207.7	L	Unnamed	12.0
207.8	L	Unnamed	12.0
207.9	L	Unnamed	25.0
208.0	L	Unnamed	25.0
208.8	L	Granite	40.0
209.2	R	Unnamed	20.0
209.5	R	Unnamed	35.0
209.7	L	Unnamed	20.0
209.7	R	Unnamed	20.0
210.7	L	Unnamed	15.0
211.6	R	Fall	40.0
212.7	R	Unnamed	25.0
212.9	L	Pumpkin	40.0
215.5	R	Unnamed	12.0
216.0	L	Unnamed	20.0
219.1	R	Trail	40.0
219.7	R	Upper 220 Mile	40.0
219.8	R	Unnamed	12.0
219.9	R	Lower 220	40.0
221.2	R	Unnamed	20.0
222.0	L	Twotwentytwo	40.0

222.1	L	Unnamed	40.0
222.4	R	Unnamed	20.0
223.0	L	Unnamed	20.0
223.4	R	Unnamed	20.0
225.7	L	Diamond	40.0

Appendix F

1983 Inventory of Grand Canyon River Campsites
* = enlarged deposit in 1983 ** = new deposit in 1983

Mile	Side	Reach	Name	Size	Status 1991
2.0	L*	nc		L	NU-illegal, above Bridge
3.0	R	nc	Cathedral	S	NU-illegal, above Bridge
8.0	R	nc	Badger	L	large primary
8.0	L	nc	Jackass	L	large primary
10.2	L*	nc		S	NU-eroded
11.5	R**	c	Lower Soap Creek	L	NU-eroded
12.0	L**	c	Brown Inscription	L	small secondary, ledges
12.4	L	c	Salt Water Wash	S	small, low water
16.5	L	c	Hot Na Na Wash	S	medium primary
18.2	L	c	Eighteen Mile	M	small, low water
19.0	R	c	Nineteen-mile Can.	M	medium primary
19.2	L	c	Nineteen Mile Left	S	small primary
20.0	L	c	Twenty mile	M	small primary
20.5	R	c	North Canyon	M	large primary
21.5	L	c	Upper and Lower	S	small, low water
22.7	R	c	Above Indian Dick	S	NU-eroded
22.8	L	c	Above Indian Dick	L	large primary
24.5	L	c	Twentyfour and half	M	medium primary
24.7	L	c		S	NU-eroded
26.5	L	c	Above Tiger Wash	M	medium, low water
29.3	L	c	Shinumo Wash	M	large primary
30.3	R	c	Thirty mile	L	NU-eroded
30.4	R*	c		M	small primary
31.5	R	c	South Canyon	L	large primary
33.7	L	c	Below Redwall	M	small primary
33.8	L	c	Little Redwall	S	medium primary
34.8	L	c	Nautiloid	S	large primary
37.5	L	c	Tatahatso	S	medium primary
38.4	L	c	Martha's Camp	S	large primary
38.8	L*	c		S	NU-eroded
40.9	R	nc	Upper Buckfarm	M	small secondary
41.0	R	nc	Lower Buckfarm	M	large primary
42.3	L	nc		M	NU-overgrown
42.8	L*	nc		M	NU-overgrown
43.3	L	nc		L	large primary
43.5	R	nc	Triple Alcoves	M	NU-eroded
44.6	L	nc	Eminence Break	M	large primary
44.8	L	nc	Willie Taylor Camp	S	medium secondary
45.3	R	nc		M	NU-overgrown
46.0	L	nc		S	NU-overgrown
46.5	R	nc	Mid Triple Alcoves	M	NU-overgrown
46.6	R	nc	Low Triple Alcoves	M	NU-overgrown
47.2	R	nc	Saddle Camp	L	large primary
47.3	R	nc	Below Saddle	M	large primary
47.5	L**	nc		S	NU-overgrown
47.7	L	nc		L	NU-overgrown
47.8	R*	nc		S	NU-overgrown
47.8	L*	nc		S	NU-overgrown
48.0	L*	nc		S	NU-overgrown

49.7	L	nc		M	NU-overgrown
49.9	L**	nc		L	NU-eroded, flat bar-no pro
49.9	R	nc		S	large primary
50.0	R	nc		L	NU-eroded
50.2	L	nc		M	NU-eroded, flat bar-no pro
50.6	L	nc		M	NU-overgrown
51.0	R*	nc		S	NU-overgrown
51.4	R*	nc		S	NU-overgrown
51.5	L	nc		S	large secondary
51.8	R	nc	Little Nankoweap	S	medium primary
52.3	R	nc		M	NU-eroded
52.5	R	nc		M	NU-eroded
52.7	R	nc	Upper Nankoweap	L	large primary
53.0	R	nc	Main Nankoweap	L	large primary
53.0	L	nc		S	NU-eroded
53.2	R**	nc	Lower Nankoweap	M	large primary
53.4	L	nc		S	NU-overgrown
53.4	R	nc		M	NU-overgrown
53.8	L	nc		S	NU-overgrown
54.0	L*	nc		S	NU-overgrown
54.0	R**	nc		L	NU-eroded, flat bar-no pro
54.2	R	nc		M	NU-overgrown
54.4	L*	nc		S	NU-overgrown
54.6	L**	nc		L	NU-overgrown
54.7	L**	nc		L	NU-overgrown
55.0	L*	nc		M	NU-overgrown
55.2	L	nc		M	NU-overgrown
55.4	L**	nc		M	NU-overgrown
56.2	R	nc	Upper Kwagunt	L	large primary
56.4	R	nc	Middle Kwagunt	M	large secondary
56.5	R	nc	Lower Kwagunt	L	medium secondary
56.8	L	nc		L	NU-overgrown
57.0	L*	nc		L	NU-overgrown
57.5	R	nc	Malagosa	L	medium secondary
57.5	L	nc	Opp. Malagosa	S	medium secondary
58.2	R	nc	Awatubi	L	large primary
58.7	L	nc		L	large primary
58.8	R**	nc	Below Awatubi	M	large primary
59.0	L	nc		L	NU-overgrown
59.5	R**	nc		S	NU-overgrown
59.8	R	nc	Sixty mile Canyon	M	small, low water
60.0	L**	nc		S	NU-eroded, steep
60.5	R*	nc		M	medium secondary
61.2	R	nc	Dogbane	M	large primary
61.8	L**	nc	Little CO Island	L	NU-illegal, LCR water
61.9	R*	nc		S	medium primary
62.3	R**	nc		S	NU-eroded, overgrown
62.4	R	nc	Above Crash Canyon	M	large primary
64.5	R	nc	Carbon	L	large primary
65.5	R	nc	Lava Canyon	M	large primary
65.6	L	nc	Palisade Ck.	L	large primary
66.0	R**	nc		L	NU-eroded, rocky
66.5	L	nc		L	large primary
66.8	L	nc	Espejo	M	medium secondary
67.7	L*	nc		S	NU-overgrown
67.8	R*	nc	Upper Tanner	L	NU-rocky, constant HW (>30K)

68.0	R	nc		L	NU-rocky, constant HW (>30K)
68.2	R	nc	Tanner	M	large primary
68.6	L	nc	Tanner Point	M	NU-rocky, current
69.0	L	nc		S	NU-eroded, rocky
69.6	R	nc	Upper Basalt	L	NU-overgrown
69.8	R	nc	Lower Basalt	L	medium primary
70.3	R	nc		L	NU-overgrown
70.5	R	nc		L	NU-overgrown
71.3	R	nc		L	NU-illegal, arch. res.
71.7	L*	nc		S	NU-eroded, overgrown
72.1	L	nc	Unkar	L	medium primary
72.5	R	nc	Upper Unkar	S	NU-overgrown
72.6	R	nc	Lower Unkar	S	NU-overgrown
72.7	L	nc		L	NU-overgrown
73.1	R	nc	Below Unkar	L	NU-overgrown
73.3	L	nc		M	NU-overgrown
73.7	R	nc	Below Granary	L	large primary
74.4	L	nc		L	NU-overgrown
74.5	R	nc	Lower seventy-four	M	medium primary
74.6	L*	nc		L	NU-overgrown
74.6	R*	nc		L	NU-overgrown
74.7	L	nc		M	NU-overgrown
74.8	L*	nc	Escalante	S	NU-eroded
75.0	R	nc		M	NU-overgrown
75.5	L	nc	Nevilles Beach	L	large primary
75.8	R	nc	Across from Papago	M	large primary
76.4	L	c	Hance	M	medium primary
81.3	L	c	Grapevine	M	large primary
87.1	L	c	Cremation	M	medium primary
89.5	R	c	Below Pipe Creek	M	large secondary
90.8	L**	c		S	small primary
91.2	R	c	Ninety-one Mile	S	medium primary
92.1	L	c		S	medium primary
93.4	L	c	Granite Monument	S	large primary
93.6	L	c	Lower Granite	M	NU-eroded, rocky, current
94.3	R	c	Ninety-four Mile	M	small primary
94.7	L	c	Hermit	S	small primary
95.4	R**	c		S	medium primary
95.6	L	c	Ninety-six Mile	S	large primary
96.7	L	c	Boucher Creek	L	NU-eroded, rocky
98.1	R	c	Upper Crystal	L	medium primary
98.3	R	c	Lower Crystal	L	medium secondary
103.8	R	c	Hundred-four Mile	S	small primary
107.7	R	c	Above Bass Rapid	S	NU-eroded
108.0	R	c	Upper Bass	S	medium, low water
108.2	R	c	Lower Bass	L	large primary
108.6	R	c	Shinumo	S	NU-illegal, water resource
114.0	R	c	Onefourteen-mile	S	medium primary
114.5	R	c	Garnet	S	NU-eroded
115.4	L	c	Above Elves Chasm	S	NU-eroded
115.5	R	c		M	small secondary
115.6	R	c	Below Elves Chasm	S	NU-eroded
117.2	L	nc		S	NU-eroded
118.1	R	nc		S	small primary
118.6	L	nc		M	medium primary
118.6	R	nc	Sedge	S	NU-eroded

118.8	R*	nc		L	NU-eroded
119.0	R	nc		M	large primary
119.1	L*	nc		S	NU-eroded
119.3	R	nc		M	small secondary
119.4	L	nc		L	medium primary
119.8	L	nc	Onetwenty-mile Camp	L	large primary
119.8	R*	nc		S	NU-eroded, overgrown
120.0	R	nc	Upper Blacktail	M	medium primary
120.0	L	nc	Opp. Blacktail	M	small secondary
120.2	R	nc	Lower Blacktail	S	medium primary
120.5	L	nc		S	medium primary
121.8	L	nc		S	NU-eroded
122.2	R	nc	Onetwentytwo-mile	L	large primary
122.2	L	nc		L	NU-eroded, rocky
122.6	L	nc	Upper Forester	L	large primary
123.0	L	nc	Lower Forester	M	NU-eroded, steep
123.2	L	nc	Enfilate Point	L	NU-eroded
124.0	R**	nc		S	NU-eroded
124.6	L	nc		S	medium secondary
124.8	L*	nc		L	NU-eroded
124.9	L*	nc		L	medium secondary
125.2	R**	nc		S	NU-eroded
125.8	L	nc	Below Fossil	L	large primary
126.0	L	nc		S	large secondary
126.5	R	nc	Randy's Rock	M	medium primary
131.0	R	nc	Above Dubby	S	small primary
131.3	R*	c		M	NU-eroded
131.8	R	c	Just Above Dubby	M	large primary
132.0	R	c	Stone Creek	L	medium primary
133.0	L	c		L	large primary
133.1	L	c		M	NU-eroded
133.7	R	c	Racetrack	S	medium primary
133.8	R**	c	Mouth Tapeats	L	large primary
133.9	R	c		M	NU-contig. with above
133.9	R	c	Lower Tapeats	L	medium secondary
134.1	L	c		M	medium primary
134.5	L**	c		M	NU-eroded, rocky
134.8	L	c	Owl Canyon	L	large primary
134.8	R	c	Above Gran. Narrows	M	NU-eroded
134.9	R	c		M	NU-eroded
136.2	L	c	Opp. Deer Creek	L	medium primary
136.5	L	c		L	medium primary
136.6	L	c	Poncho's Kitchen	L	large primary
136.7	L	c		L	medium secondary
136.8	L	c		L	large primary
137.3	L*	c		M	NU-overgrown
137.3	R*	c		S	NU-overgrown
137.5	L	c		M	NU-overgrown
137.7	L	c		M	NU-overgrown
137.8	L	c	Below Doris	L	medium primary
138.0	L	c		L	medium primary
138.7	R**	c		S	NU-eroded, steep
139.0	R	c	Fishtail	L	large primary
139.5	L	c		S	NU-eroded
139.8	L	c	Oneforty-mile	L	medium secondary
140.3	L**	c		M	small, low water

141.0	L**	c		S	NU-eroded, overgrown
141.4	L	c		S	NU-eroded
142.5	R*	c		S	NU-eroded
143.0	R*	c		S	NU-eroded
143.4	L	c	Above Kanab	M	medium primary
143.5	R	c	Kanab Creek	L	small, low water
145.1	L**	c	Above Olo	M	small primary
145.5	L	c	Olo Canyon	L	small, low water
147.7	R*	c	Spring Opp. MatKat	S	NU-eroded, overgrown
147.8	R	c	Opp. MatKat	M	medium primary
148.4	L	c	Lower MatKat	L	small primary
149.7	R	c	Upset	S	NU-loud, swift current
151.8	R	c	Ledges	L	large primary
153.5	R**	c	Sinyala	M	small primary
155.0	R	c	Lower Rock Falls	S	NU-eroded, steep
155.7	R	c	Last Chance	S	medium primary
156.2	R	c	Last Last Chance	M	medium secondary
156.5	L	c	Dead Last Chance	S	NU-eroded, desperate
157.8	L**	c		S	NU-eroded
158.5	R	c		M	medium primary
159.3	R	c		M	NU-eroded, steep
160.4	L	c		M	NU-eroded, steep
161.6	R*	c		S	NU-eroded, overgrown
162.0	L*	c		S	NU-eroded
162.5	L**	c		M	large primary, ledges
163.0	R*	c		S	NU-eroded
163.2	R**	c		M	NU-eroded
163.5	L**	c		S	NU-eroded
163.9	L	c		M	NU-eroded
164.5	R	nc	Tuckup Canyon	L	large primary
165.0	L*	nc		M	small primary
165.0	R*	nc		S	small, low water
165.2	R*	nc	Below Riffle	M	NU-eroded
165.7	L*	nc		L	NU-eroded
165.8	L*	nc		S	NU-eroded
166.0	L*	nc		S	NU-eroded
166.5	L	nc	Upper National	L	medium primary
166.6	L	nc	Lower National	L	large primary
166.7	L*	nc		L	NU-overgrown
166.8	L	nc		M	small primary
166.9	R*	nc		S	NU-overgrown
167.0	L	nc		M	small primary
167.0	R*	nc		M	NU-overgrown
167.2	R*	nc		M	NU-overgrown
167.3	R**	nc		M	NU-eroded, overgrown
167.5	R	nc	Above Fern Glen	M	NU-overgrown
168.0	R	nc	Fern Glen	L	large primary
169.4	L	nc		M	NU-eroded, overgrown
169.6	L*	nc		L	NU-eroded, overgrown
169.7	L*	nc		S	NU-eroded, overgrown
169.8	L*	nc		S	small, low water
169.9	L	nc		S	NU-eroded, overgrown
170.2	L*	nc		L	NU-eroded, overgrown
170.5	L*	nc		M	NU-eroded, overgrown
170.9	R	nc	Upper Stairway	L	NU-eroded, overgrown
171.0	R	nc	Apex Stairway	L	large primary

171.1	R	nc	Lower Stairway	M	NU-eroded, overgrown
171.5	L	nc	Mohawk	L	large primary
172.0	R*	nc		L	NU-eroded, overgrown
172.3	L	nc		L	NU-overgrown
172.4	L*	nc		L	medium primary
172.8	L	nc		M	medium secondary
173.0	R	nc		M	medium primary
173.8	L	nc		L	NU-overgrown
174.2	R	nc	Above Cove	M	medium secondary
174.3	R	nc	Cove Canyon	L	large primary
174.5	L	nc	Slade's Beach	L	NU-eroded, rocky
175.0	R*	nc		M	small secondary
175.7	R**	nc		L	NU-eroded
176.0	L	nc		L	large primary
176.1	R*	nc		M	NU-overgrown
176.5	R	nc		S	NU-eroded, steep
176.6	R**	nc		M	NU-overgrown
177.0	R*	nc		M	NU-eroded, overgrown
177.0	L	nc	Honga Spring	L	large primary
177.7	L	nc		L	medium primary
177.8	L	nc		L	NU-overgrown
178.0	L	nc	Anvil Camp	L	NU-overgrown
178.0	R	nc	Vulcan's Anvil	S	small secondary
178.2	L	nc		L	NU-overgrown
178.2	R*	nc		L	NU-overgrown
178.4	R*	nc		S	NU-overgrown
179.0	L	nc	Above Lava	L	medium primary
179.2	L	nc	Just Above Lava	L	small secondary
179.4	R	nc	Lava Falls	M	NU-eroded
179.6	R	nc	Below Son of Lava	L	large primary
179.9	R*	nc	One-eighty Mile	M	medium primary
180.7	R	nc	Below Lava Cliffs	L	NU-eroded
180.7	L	nc		L	NU-eroded
181.0	R	nc		L	NU-eroded
181.6	L	nc		M	NU-overgrown
181.8	R	nc		L	small primary
181.9	L**	nc		L	NU-overgrown
182.0	R	nc		L	NU-overgrown
182.1	R	nc		L	NU-overgrown
182.2	L*	nc		M	NU-overgrown
182.4	L*	nc	Hell's Hollow	M	small primary
182.8	R	nc	Below Hell's Hollow	L	medium secondary
182.9	L	nc	Helicopter Pad	M	NU-overgrown
183.0	L	nc	Below Old Helipad	L	small primary
184.5	R	nc		L	NU-eroded, overgrown
184.6	L	nc		L	medium primary
184.6	R	nc		L	NU-eroded, overgrown
185.0	R	nc		M	NU-eroded
185.2	R**	nc		M	NU-eroded
185.3	R	nc		L	NU-eroded
185.5	R	nc		M	medium secondary
185.8	L	nc		L	NU-eroded, overgrown
186.0	R*	nc		L	NU-eroded, overgrown
186.0	L	nc		M	medium primary
186.2	L	nc		L	large primary
186.6	R*	nc		L	NU-overgrown

187.0	L	nc		L	NU-helipad
187.4	L	nc		M	medium, low water
187.5	R	nc	Whitmore Trail	L	NU-overgrown
187.6	R**	nc	Whitmore Picto	L	NU-overgrown
188.0	R	nc	Whitmore Wash	L	large primary
188.1	R	nc	Lower Whitmore	L	medium primary
188.4	R	nc		M	NU-overgrown
188.8	L*	nc		L	small, secondary
189.2	R*	nc		M	NU-eroded
189.3	R*	nc		M	NU-eroded, overgrown
189.5	L	nc		L	small primary
190.5	R*	nc		M	NU-eroded, overgrown
190.6	L*	nc		L	NU-overgrown
190.7	R	nc		M	NU-eroded, overgrown
191.2	R	nc		L	NU-overgrown
191.4	L	nc		M	NU-eroded, overgrown
191.8	L	nc	Oneninetytwo-mile	L	large primary
191.9	L	nc		M	NU-overgrown
192.2	R	nc		M	medium secondary
192.3	R	nc		M	NU-eroded, overgrown
192.7	L	nc	Oneninetythree-mile	M	medium secondary
193.2	R	nc		M	NU-eroded, overgrown
193.6	L	nc		L	NU-eroded, overgrown
194.2	L	nc	Hualapai Acres	L	large primary
194.4	L**	nc		L	medium primary
194.7	L	nc	Oneninetyfour-mile	L	NU-overgrown
195.4	R*	nc		S	NU-eroded, overgrown
195.5	R*	nc		M	NU-overgrown
196.0	R	nc		L	NU-overgrown
196.2	R*	nc		L	NU-eroded, overgrown
196.3	R*	nc		L	NU-eroded, overgrown
196.7	L	nc	Oneninetysix-mile	L	large primary
198.5	R	nc	Upper Parashant	L	medium primary
198.6	R	nc	Lower Parashant	S	NU-eroded, overgrown
199.0	R	nc		L	NU-eroded
199.2	R	nc		L	NU-eroded
200.0	L*	nc		L	NU-overgrown
200.5	R	nc	Hematite Mine	L	medium primary
200.6	R	nc		S	NU-overgrown
201.0	R	nc		M	small secondary
201.1	R*	nc		M	NU-overgrown
201.4	L	nc		M	NU-eroded
201.6	L*	nc		M	NU-overgrown
202.0	R	nc		M	large primary
202.1	R**	nc		M	NU-eroded, overgrown
202.5	L	nc		L	NU-eroded, overgrown
202.7	R**	nc		S	medium secondary
203.0	R	nc	Lava Cliff	L	NU-eroded, overgrown
203.5	R	nc		M	NU-overgrown
203.6	R	nc		L	NU-overgrown
204.0	R	nc	Warm Springs	L	NU-eroded, overgrown
204.1	R*	nc		M	NU-overgrown
204.2	L**	nc		S	NU-overgrown
204.5	R	nc	Spring Canyon	L	medium, primary
205.5	R**	nc		M	NU-overgrown
206.1	L**	nc		S	NU-eroded, overgrown

206.7	R	nc	Indian Canyon	M	small primary
207.0	R*	nc		S	NU-eroded, overgrown
207.1	L	nc		M	NU-eroded, overgrown
207.2	L	nc		L	NU-overgrown
207.4	L	nc		M	medium secondary
207.6	R	nc		M	NU-eroded, overgrown
207.8	L	nc		M	NU-overgrown
208.1	R	nc		S	NU-overgrown
208.5	L	nc		L	NU-overgrown
208.8	R	nc	Opp. Granite Park	S	NU-eroded, scrubby
208.8	L	nc	Granite Park	L	large primary
209.4	R	nc		M	medium primary
209.5	R	nc		L	large secondary
210.0	L*	nc		M	NU-eroded
210.0	R	nc		M	medium secondary
210.5	R**	nc		L	large primary
210.6	R**	nc		S	medium, low water
210.8	L	nc		L	small, low water
211.0	L*	nc		L	medium primary
211.1	L*	nc		L	NU-eroded
211.5	R	nc	Fall Canyon	L	medium secondary
212.2	R**	nc		S	NU-eroded
212.3	R*	nc		M	NU-eroded
212.6	L	nc	Pumpkin Springs	L	large primary
212.8	R	nc		L	NU-eroded
213.5	L**	nc		S	small, low water
214.0	R	nc	Twofourteen-mile	S	NU-eroded, overgrown
214.3	R	nc		M	medium, low water
215.0	L**	nc		L	small primary
215.8	R	nc	Opp. Three Springs	M	small, low water
216.4	R**	nc		S	medium primary
216.5	R**	nc		M	NU-overgrown
216.6	R*	nc		M	NU-eroded, overgrown
219.3	R	nc	Trail Canyon	M	NU-eroded, overgrown
219.8	R	nc	Upper Twotwenty	L	large primary
219.9	R	nc	Twotwenty-mile	L	large primary
220.0	R	nc	Lower Twotwenty	M	medium primary
221.2	R	nc		L	medium primary
221.4	L*	nc		S	NU-overgrown
221.5	R	nc		L	NU-eroded, overgrown
221.7	L*	nc		L	NU-overgrown
222.0	L	nc	Twotwentytwo-mile	L	large primary
222.0	R*	nc		M	NU-eroded, overgrown
222.1	L	nc		M	NU-eroded
222.5	R	nc		L	medium primary
222.7	L*	nc		M	NU-overgrown
223.0	L	nc		S	NU-eroded, overgrown
223.4	R	nc		L	NU-eroded, overgrown
223.4	L**	nc		M	medium primary
223.7	L	nc	Twotwentyfour-mile	S	NU-eroded
224.5	L	nc		L	large primary
224.5	R	nc		M	NU-overgrown
225.4	R	nc		M	NU-overgrown

Appendix G

Matched Sites Between 1973, 1983, and 1991 Inventories

Mile73	Mile83	Mile91			Size73	Size83	Size91
7.9	8.0	8.0	L	Jackass	L	L	L
7.9	8.0	8.0	R	Badger	L	L	L
16.5	16.5	16.4	L	Hot Na Na Wash	S	M	M
18.2	18.2	18.0	L	Eighteen Mile Wash	M	L	S
19.3	19.2	19.1	L	Lower Nineteen	M	M	S
20.0	20.0	19.9	L	Twenty mile	L	L	S
21.5	21.5	21.5	L	Twentytwo-mile Wash	L	M	S
22.4	22.8	23.0	L	Above Indian Dick	L	L	L
26.2	26.5	26.3	L	Georgie's	L	L	M
29.2	29.3	29.3	L	Shinumo	L	L	L
31.5	31.5	31.6	R	South Canyon	L	L	L
33.5	33.7	33.6	L	Below Redwall	L	L	S
33.9	33.8	34.0	L	Little Redwall	L	M	M
34.7	34.8	34.8	L	Nautiloid	L	M	L
37.6	37.5	37.7	L	Tatahatso	L	M	M
38.6	38.4	38.3	L	Martha's Camp	L	M	L
40.9	41.0	41.0	R	Lower Buckfarm	L	L	L
43.2	43.3	43.3	L	Lower Anasazi	L	L	L
44.5	44.6	44.2	L	Eminence Break	L	L	L
44.7	44.8	44.8	L	Willie Taylor Camp	L	M	M
47.1	47.2	47.2	R	Upper Saddle	L	L	L
50.0	50.0	50.0	R	Fifty-mile Camp	L	L	L
51.4	51.5	51.4	L	No Name	L	L	L
52.5	52.7	52.6	R	Upper Nankoweap	L	L	L
53.0	53.0	53.0	R	Main Nankoweap	L	L	L
56.6	56.4	56.7	R	No Name	L	L	L
57.4	57.5	57.5	R	Malagosa	L	L	M
57.7	57.5	57.5	L	No Name	L	M	M
58.5	58.7	58.6	L	Below Awatubi Left	L	L	L
64.5	64.5	64.7	R	Carbon Creek	L	L	L
65.5	65.6	65.7	L	Palisade Creek	L	L	M
66.4	66.5	66.3	L	Above Espejo	L	L	L
66.9	66.8	66.8	L	Espejo	L	L	M
69.5	69.8	69.8	R	Lower Basalt	L	L	M
72.1	72.1	72.3	L	Unkar	L	L	M
73.7	73.7	73.6	R	Below Granary	S	L	L
74.3	74.5	74.3	R	Lower Rattlesnake	L	L	M
75.5	75.5	75.6	L	Neville's Camp	L	L	L
76.5	76.4	76.6	L	Hance	L	L	M
81.1	81.3	81.3	L	Grapevine	L	L	L
87.1	87.1	87.2	L	Lower Cremation	L	L	L
89.3	89.5	89.3	R	Below Pipe Creek	L	L	L
91.1	90.8	90.9	L	Upper 91-mile	S	M	S
91.2	91.2	91.1	R	New Trinity	L	M	M
92.2	92.1	92.3	L	Above Salt Creek	S	M	M
93.2	93.4	93.4	L	Granite	L	M	L
95.9	95.6	96.1	L	Schist	L	M	L
103.8	103.8	103.8	R	Emerald	S	M	S
107.9	107.7	108.0	R	Parkins' Inscrip.	L	M	M
108.3	108.2	108.2	R	Lower Bass	L	L	L
114.3	114.0	114.3	R	Upper Garnet	L	M	M

114.5	114.5	114.5	R	Lower Garnet	L	M	L
118.5	118.6	118.5	L	One-eighteen-1/2	L	L	M
118.7	119.0	119.0	R	Onenineteen-mile	L	L	L
119.2	119.3	119.2	R	Unnamed	L	L	S
119.7	119.8	119.8	L	Onetwenty-mile	L	L	L
119.9	120.0	120.0	L	Opp. Blacktail	S	L	S
120.1	120.2	120.1	R	Lower Blacktail	L	M	M
122.0	122.2	122.2	R	Onetwentytwo	L	L	L
122.7	122.6	122.7	L	Upper Forster	L	L	L
124.4	124.6	124.3	L	Above Fossil	L	M	M
125.4	125.8	125.4	L	Below Fossil	L	L	L
125.5	126.0	125.5	L	Unnamed	L	M	L
126.3	126.5	126.5	R	Randy's Rock	L	L	M
131.0	131.0	131.1	R	Below Bedrock	L	M	S
131.6	131.8	131.8	R	Galloway	L	L	L
131.9	132.0	132.0	R	Stone Creek	L	L	M
133.1	133.0	133.0	L	Onethirtythree-mile	L	L	L
133.9	133.9	133.9	R	Lower Tapeats	L	L	M
134.2	134.1	134.2	L	Below Tapeats	L	L	M
134.5	134.8	134.6	L	Owl Eyes	L	L	L
136.2	136.2	136.2	L	Opp. Deer Creek	L	L	M
136.4	136.5	136.3	L	Below Deer Creek	L	L	M
137.0	136.6	136.8	L	Poncho's Kitchen	L	L	L
137.1	136.8	137.0	L	Backeddy	L	L	L
137.9	137.8	137.9	L	Doris	L	L	M
138.3	138.0	138.2	L	Unnamed	L	L	M
138.9	139.0	139.0	R	Fishtail	L	L	L
139.7	139.8	139.8	L	Onforty-mile	L	L	M
143.3	143.4	143.3	L	Above Kanab	L	L	M
145.4	145.5	145.6	L	Olo Canyon	L	L	S
148.3	148.4	148.4	L	Matkat Hotel	S	L	S
155.6	155.7	155.7	R	Last Chance	L	M	M
158.6	158.5	158.5	R	Second Chance	L	L	M
159.8	160.4	160.0	L	Onesixty-mile	L	L	S
164.5	164.5	164.5	R	Tuckup Canyon	L	L	L
166.5	166.5	166.5	L	Upper National	L	L	M
166.6	166.6	166.6	L	Lower National	L	L	L
166.9	166.8	167.0	L	Below National	L	L	S
167.2	167.0	167.2	L	Unnamed	M	L	M
168.1	168.0	168.0	R	Fern Glen	L	L	L
169.9	169.7	169.8	L	Oneseventy-mile	S	M	S
171.4	171.5	171.6	L	Mohawk	L	L	L
172.1	172.4	172.1	L	Below Mohawk	M	L	M
172.8	172.8	172.8	L	Unnamed	L	L	M
173.2	173.0	173.0	R	Oneseventythree-mile	M	L	M
174.2	174.2	174.3	R	Upper Cove	L	L	M
174.3	174.3	174.4	R	Cove Canyon	L	L	L
175.8	176.0	176.0	L	Below Red Slide	L	L	L
177.1	177.0	177.1	L	Honga Spring	L	L	L
177.6	177.8	177.7	L	Above Anvil	L	L	M
179.0	179.0	179.0	L	Above Lava	S	L	M
179.7	179.6	179.7	R	Below Little Lava	L	L	L
182.9	182.8	182.8	R	Below Hell's Hollow	L	L	M
182.9	183.0	183.0	L	Below Old Helipad	L	L	S
184.5	184.6	184.5	L	Unnamed	L	L	M
185.6	185.5	185.5	R	Unnamed	S	L	M

186.0	185.8	186.0	L	One-eightysix Mile	L	L	M
186.2	186.0	186.2	L	Unnamed	L	L	L
187.2	187.4	187.4	L	Below Helipad	L	L	M
188.0	188.0	188.0	R	Whitmore Wash	L	L	L
188.2	188.1	188.2	R	Lower Whitmore	L	L	M
189.4	189.5	189.5	L	Unnamed	S	L	S
192.2	192.2	192.2	R	Unnamed	L	L	M
194.0	194.2	194.1	L	Hualapai Acres	L	L	L
198.5	198.6	198.5	R	Parashant	L	M	M
200.3	200.5	200.4	R	Hematite Mine	L	L	M
201.9	202.0	202.0	R	Two-o-two Mile	L	L	L
202.5	202.7	202.5	R	No Name	L	L	L
207.6	207.4	207.4	L	Unnamed	L	L	M
208.8	208.8	208.8	L	Granite Park	L	L	L
209.2	209.4	209.4	R	Unnamed	M	L	M
209.5	209.5	209.5	R	Unnamed	L	L	L
209.7	210.0	210.0	R	Two-ten Mile Camp	M	L	M
212.9	212.6	212.9	L	Pumpkin Springs	L	L	L
215.5	215.8	215.6	R	Opp. Three Springs	S	L	S
219.7	219.8	219.8	R	Upper Two-twenty	L	L	L
219.8	219.9	219.9	R	Middle Two-twenty	S	L	L
219.9	220.0	220.0	R	Lower Two-twenty	L	L	M
221.2	221.2	221.2	R	Twotwentyone-mile	M	L	M
222.0	222.0	222.0	L	Twotwentytwo-mile	L	L	L
222.4	222.5	222.5	R	Twotwentytwo-1/2	M	L	M
223.4	223.4	223.4	L	No Name	M	L	M

Appendix H

Lower Gorge and Lake Mead Inventory of River Campsites
*** = in Stevens' Guide**

Mile	Side	Location	SG size	Size 91	Status 1991
229.0	L*	Travertine Canyon	S	M	useable
230.5	L*	Travertine Falls	S	M	useable
235.0	L*	Bridge Canyon	S	M	useable
236.0	R*	Gneiss Canyon	S	M	useable
238.5	L*	No Name	S	n/a	overgrown
239.6	R*	Separation Canyon	S	M	useable
241.5	R*	Twofortyone-mile	S	M	useable
241.5	L	No Name	n/a	S	useable
242.0	R	Twofortytwo-mile	n/a	M	useable
243.1	R*	Twofortythree-mile	S	L	useable
246.0	L*	Spencer Canyon	S	n/a	overgrown
246.3	R*	Lava Cliffs	S	S	useable
248.2	R*	Surprise Canyon	S	n/a	overgrown
249.6	R	No Name	n/a	M	useable
252.2	L*	Reference Point	M	n/a	overgrown
257.0	R	Twofiftyseven Bar	n/a	M	useable
259.5	R*	Burnt Springs Canyon	M	L	useable
260.1	L*	Quartermaster Canyon	S	n/a	overgrown
262.0	R*	Below Wards Cave	S	n/a	overgrown
262.4	R*	No Name	M	n/a	overgrown
268.5	R*	No Name	M	n/a	overgrown
274.5	L*	Columbine Falls	M	n/a	overgrown
274.8	L*	Below Columbine	M	n/a	overgrown
278.6	n/a*	Scorpion Island	M	n/a	mud flats

Appendix I

Campsite Area Data for Glen Canyon

Mile	Side	Name	HWsize	LWsize	HM/MIPS	5K	5–25K	8K	5–8K	15K	8–15K	25K	15–25K
3.0	L	Cave Canyon	3	3	MIPS	1477.0	1.00	1477.0	1.00	1477.0	1.00	1477.0	1.00
6.1	R	Big Sandy		2	MIPS	928.0	0.00	928.0	1.00	532.0	0.57	0.0	0.00
6.1	L	Little Sandy		2	MIPS	1531.0	0.00	1356.0	0.89	0.0	0.00	0.0	1.00
6.2	R	Six–mile Camp	2	2	HM	243.0	1.00	243.0	1.00	243.0	1.00	243.0	1.00
6.5	R	Survey site		2	MIPS	1577.0	0.00	1297.0	0.82	0.0	0.00	0.0	1.00
6.7	L	No Name		2	MIPS	1230.0	0.00	1230.0	1.00	312.0	0.25	0.0	0.00
7.0	L	South Finger Rock		2	MIPS	1718.0	0.00	1182.0	0.69	420.0	0.36	0.0	0.00
7.5	L	Seven Mile	1	1	HM	218.0	1.00	218.0	1.00	218.0	1.00	218.0	1.00
8.4	R	Twin Stripes	3	3	MIPS	1092.0	0.71	1092.0	1.00	776.0	0.71	776.0	1.00
9.0	R	Nine Mile	3	3	MIPS	591.0	0.52	538.0	0.91	379.0	0.70	309.0	0.82
10.0	L	Petroglyphs	3	3	MIPS	1265.0	0.61	1095.0	0.87	768.0	0.70	768.0	1.00
10.5	R	Faatz Inscription	1	2	MIPS	2865.0	0.10	2157.0	0.75	299.0	0.14	299.0	1.00
11.1	L	Ferry Swale	3	3	MIPS	2251.0	0.15	1225.0	0.54	628.0	0.51	343.0	0.55
12.5	R	Twelve–and–a–	1	3	MIPS	1987.0	0.20	1245.0	0.63	389.0	0.31	389.0	1.00
13.2	L	Above Honey Draw		3	MIPS	4118.0	0.00	3146.0	0.76	1092.0	0.35	0.0	0.00
13.6	R	Ropes Trail	3	3	HM	151.0	1.00	151.0	1.00	151.0	1.00	151.0	1.00
14.3	L	Pump Station	1	1	MIPS	279.0	0.60	279.0	1.00	167.0	0.60	167.0	1.00
14.8	R	Fifteen Mile	1	2	MIPS	1728.0	0.10	1233.0	0.71	775.0	0.63	192.0	0.25

	5K	8K	15K	25K
AVG/HM	204	204	204	204
AVG/MIPS	1642	1299	616	524
AVG/ALL	1403	1116	539	444
AVG/LG	1616	1246	708	637
AVG/MED	1477	1203	430	243
AVG/SM	249	249	193	253

HWsize: size class of site when flows are greater that 15,000 cfs
LW size: size class of site when flows are 15,000 cfs or less
1: one group of 2–6 persons, 2: two groups of 2–6 persons, 3: three groups of 2–6 persons
MIPS: indicates whether measured primarily by MIPS or hand–measured (HM)
5K, 8K, 15K, 25K: indicates area in square meters at a particular flow level where K refers to thousands of cubic feet per second
5–25K,5–8K,8–15K,15–25K: indicates the percentage of camp area remaining
when flows are increased from 5–25, 5–8, 8–15, 15–25 thousand cfs

Appendix J

Campsite Area Data for Grand Canyon

Mile	Side	Reach	Name	HWsize	LWsize	MIPS	5K	5–25K	8K	5–8K	15K	8–15K	25K	15–25K
8.0	L	nc	Jackass	3	3	MIPS	5583	0.57	4561	0.82	3866	0.85	3205	0.83
8.0	R	nc	Badger	3	3	MIPS	2513	1.00	2513	1.00	2513	1.00	2513	1.00
11.0	R	c	Soap Creek	2	2	MIPS	584	1.00	584	1.00	584	1.00	584	1.00
12.2	L	c	Below Salt Water	0	2	MIPS	1648	0.01	1214	0.74	791	0.65	14	0.02
16.4	L	c	Hot Na Na Wash	2	3	MIPS	2124	0.52	1911	0.90	1314	0.69	1105	0.84
17.0	R	c	Lower House Rock	1	2	HM	1387	0.15	1321	0.95	837	0.63	207	0.25
18.0	L	c	Upper 18–mile	0	1	MIPS	255	0.31	255	1.00	255	1.00	78	0.31
18.1	L	c	Lower 18–mile	3	3	MIPS	843	0.81	843	1.00	739	0.88	685	0.93
19.0	R	c	Upper 19–mile	2	2	MIPS	334	1.00	334	1.00	334	1.00	334	1.00
19.1	L	c	Lower 19–mile	1	2	MIPS	480	0.33	473	0.99	375	0.79	157	0.42
19.9	L	c	Twenty mile	1	2	MIPS	569	0.35	569	1.00	459	0.81	198	0.43
20.4	R	c	Upper North Canyon	3	3	HM	499	0.81	499	1.00	499	1.00	403	0.81
20.5	R	c	Lower North Canyon	3	0	MIPS	1735	1.00	1735	1.00	1735	1.00	1735	1.00
21.5	L	c	Twenty–two mile Wash	0	1	MIPS	1044	0.05	766	0.73	349	0.46	49	0.14
21.9	R	c	Twentytwo–mile	0	2	MIPS	2085	0.06	1107	0.53	1014	0.92	117	0.12
23.0	L	c	Twentythree mile	3	3	MIPS	1291	0.84	1291	1.00	1250	0.97	1089	0.87
23.7	L	c	Lone Cedar	1	2	HM	212	0.35	212	1.00	192	0.91	65	0.34
24.5	L	c	Twenty four and half	3	3	HM	228	1.00	228	1.00	228	1.00	228	1.00
26.3	L	c	Above Tiger Wash	0	2	MIPS	628	0.00	534	0.85	302	0.57		
29.3	L	c	Shinumo Wash	3	3	MIPS	1663	0.94	1641	0.99	1608	0.98	1559	0.97
30.4	R	c	Below Thirty mile	1	3	MIPS	3132	0.22	3025	0.97	1541	0.51	694	0.45
31.6	R	c	South Canyon	3	3	MIPS	1517	1.00	1517	1.00	1517	1.00	1517	1.00
33.6	L	c	Below Redwall	1	1	HM	240	0.68	240	1.00	233	0.97	164	0.70
34.0	L	c	Little Redwall	2	2	HM	264	1.00	264	1.00	264	1.00	247	0.94
34.8	L	c	Nautiloid	3	3	HM	323	0.82	323	1.00	323	1.00	264	0.82
37.7	L	c	Tatahatso	2	2	MIPS	650	1.00	650	1.00	650	1.00	650	1.00
38.3	L	c	Martha's Camp	3	3	HM	353	0.87	353	1.00	353	1.00	308	0.87
39.0	R	c	Redbud Alcove	0	2	MIPS	2826	0.09	2794	0.99	736	0.26	246	0.33
41.0	R	nc	Lower Buckfarm	3	3	MIPS	1920	0.71	1804	0.94	1460	0.81	1367	0.94
44.2	L	nc	Eminence	3	3	MIPS	2404	0.45	2094	0.87	1651	0.79	1088	0.66
47.1	R	nc	Lower Saddle	3	3	MIPS	7265	0.19	7265	1.00	2979	0.41	1413	0.47
53.0	R	nc	Main Nankoweap	3	3	HM	853	0.94	853	1.00	853	1.00	806	0.94

Mile	Side	Reach	Name	HWsize	LWsize	MIPS	5K	5–25K	8K	5–8K	15K	8–15K	25K	15–25K
56.2	R	nc	Kwagunt	3	3	MIPS	2638	0.76	2638	1.00	2638	1.00	1999	0.76
59.8	R	nc	Sixty mile Canyon	0	1	MIPS	682	0.25	555	0.81	270	0.49	173	0.64
61.6	R	nc	Below LC Island	2	3	MIPS	1516	0.49	1273	0.84	909	0.71	746	0.82
66.8	L	nc	Espejo	2	2	MIPS	463	1.00	463	1.00	463	1.00	463	1.00
74.1	R	nc	Upper Rattlesnake	3	3	MIPS	1427	1.00	1427	1.00	1427	1.00	1427	1.00
74.3	R	nc	Lower Rattlesnake	2	2	MIPS	334	0.81	334	1.00	318	0.95	269	0.85
75.6	L	nc	Neville's	3	3	MIPS	3358	0.80	3171	0.94	3017	0.95	2700	0.89
75.8	R	nc	Papago	3	3	MIPS	4055	0.11	2755	0.68	1224	0.44	445	0.36
76.6	L	c	Hance	2	2	MIPS	949	0.56	809	0.85	709	0.88	532	0.75
81.3	L	c	Grapevine	3	3	MIPS	1811	1.00	1811	1.00	1811	1.00	1811	1.00
84.0	R	c	Clear Creek	0	1	HM	463	0.17	463	1.00	143	0.31	77	0.54
84.4	L	c	Above Zoroaster	0	1	MIPS	798	0.01	716	0.90	627	0.88	10	0.02
87.1	L	c	Upper Cremation	2	2	HM	239	1.00	239	1.00	239	1.00	239	1.00
87.2	L	c	Lower Cremation	3	3	HM	239	1.00	239	1.00	239	1.00	239	1.00
89.3	R	c	Below Pipe Creek	3	3	MIPS	824	1.00	824	1.00	824	1.00	824	1.00
90.9	L	c	Upper 91–mile	1	1	MIPS	231	0.31	231	1.00	231	1.00	72	0.31
91.1	R	c	Lower 91–mile	2	2	MIPS	265	1.00	265	1.00	265	1.00	265	1.00
92.3	L	c	Above Salt Creek	2	2	MIPS	443	1.00	443	1.00	443	1.00	443	1.00
93.4	L	c	Granite	3	3	HM	1257	0.25	898	0.71	838	0.93	314	0.37
94.3	R	c	Ninetyfour Mile Right	2	2	HM	373	0.41	373	1.00	286	0.77	152	0.53
94.9	L	c	Hermit	1	1	MIPS	134	1.00	134	1.00	134	1.00	134	1.00
96.0	R	c	Ninetysix–mile	2	2	HM	847	0.35	484	0.57	314	0.65	299	0.95
96.1	L	c	Schist	3	3	HM	608	0.80	608	1.00	598	0.98	488	0.82
97.8	R	c	Upper Crystal	1	2	HM	552	0.33	552	1.00	442	0.80	181	0.41
102.8	R	c	New Shady Grove	1	1	MIPS	149	0.77	149	1.00	123	0.83	114	0.93
103.8	R	c	Emerald	1	1	MIPS	189	1.00	189	1.00	189	1.00	189	1.00
107.8	L	c	Ross Wheeler	1	2	MIPS	568	0.30	568	1.00	447	0.79	168	0.38
108.0	R	c	Parkins' Inscr.	0	2	MIPS	782	0.11	769	0.98	624	0.81	83	0.13
108.2	R	c	Lower Bass	3	3	MIPS	1358	0.82	1358	1.00	1335	0.98	1114	0.83
109.4	R	c	Oneten Mile	3	3	MIPS	2323	0.22	2063	0.89	1302	0.63	514	0.39
114.3	R	c	Upper Garnet	2	2	MIPS	495	0.95	495	1.00	472	0.95	472	1.00
114.5	R	c	Lower Garnet	3	3	HM	333	0.98	333	1.00	333	1.00	325	0.98
119.0	R	nc	Onenineteen–mile	3	3	MIPS	1964	0.21	1789	0.91	1381	0.77	413	0.30
119.2	R	nc	No Name	1	2	MIPS	1553	0.11	951	0.61	350	0.37	170	0.49
119.8	L	nc	Onetwenty mile	3	3	MIPS	2341	0.94	2341	1.00	2265	0.97	2196	0.97
120.0	R	nc	Upper Blacktail	2	2	MIPS	384	0.96	384	1.00	384	1.00	369	0.96
122.2	R	nc	Onetwentytwo mile	3	3	MIPS	4406	0.29	3828	0.87	2403	0.63	1259	0.52

Mile	Side	Reach	Name	HWsize	LWsize	MIPS	5K	5–25K	8K	5–8K	15K	8–15K	25K	15–25K
122.7	L	nc	Upper Forester	3	3	MIPS	1326	0.67	1235	0.93	1199	0.97	895	0.75
125.4	L	nc	Below Fossil	3	3	MIPS	1774	0.26	1774	1.00	1217	0.69	464	0.38
125.5	L	nc	No Name	3	3	MIPS	645	0.93	645	1.00	645	1.00	599	0.93
126.2	R	nc	Randy's Rock	2	3	MIPS	1648	0.34	1648	1.00	957	0.58	563	0.59
131.1	R	c	Below Bedrock	1	2	MIPS	1652	0.53	1616	0.98	1170	0.72	875	0.75
131.8	R	c	Galloway	3	3	HM	183	0.97	183	1.00	183	1.00	177	0.97
132.0	R	c	Stone Creek	2	3	HM	2995	0.27	2805	0.94	1991	0.71	797	0.40
133.0	L	c	Onethirtythree mile	3	3	HM	1268	0.27	1113	0.88	485	0.44	341	0.70
133.5	R	c	Racetrack	2	2	MIPS	477	0.70	477	1.00	424	0.89	333	0.79
133.8	R	c	Upper Tapeats	3	3	HM	717	0.96	717	1.00	717	1.00	689	0.96
133.9	R	c	Lower Tapeats	2	2	HM	441	1.00	441	1.00	441	1.00	441	1.00
134.6	L	c	Owl Eyes	3	3	MIPS	2694	0.26	2445	0.91	1275	0.52	697	0.55
136.0	L	c	Junebug	2	2	HM	177	0.76	177	1.00	177	1.00	135	0.76
136.2	L	c	Opp. Deer Creek	2	3	HM	599	0.68	599	1.00	544	0.91	406	0.75
136.3	L	c	Below Deer Creek	2	3	MIPS	1716	0.91	1716	1.00	1586	0.92	1570	0.99
136.8	L	c	Poncho's Kitchen	3	3	MIPS	953	1.00	953	1.00	953	1.00	953	1.00
136.9	L	c	Football Field	2	3	MIPS	2417	0.05	2244	0.93	1673	0.75	109	0.07
137.0	L	c	Backeddy	3	3	HM	629	0.79	586	0.93	579	0.99	499	0.86
137.9	L	c	Doris	2	3	HM	594	0.91	594	1.00	594	1.00	540	0.91
138.2	L	c	Doris	2	2	HM	464	1.00	464	1.00	464	1.00	464	1.00
138.4	L	c	Above Fishtail	2	2	HM	314	1.00	314	1.00	314	1.00	314	1.00
139.0	R	c	Fishtail	3	3	HM	916	0.44	707	0.77	707	1.00	400	0.57
139.8	L	c	Oneforty–mile	2	2	HM	438	0.74	438	1.00	427	0.97	322	0.75
143.3	L	c	Above Kanab	2	2	HM	141	1.00	141	1.00	141	1.00	141	1.00
145.1	L	c	Above Olo	1	2	MIPS	496	0.22	439	0.89	312	0.71	108	0.35
145.6	L	c	Olo Canyon	0	2	MIPS	797	0.03	729	0.91	289	0.40	21	0.07
147.9	R	c	Opp. Matkat	2	2	MIPS	386	1.00	386	1.00	386	1.00	386	1.00
148.4	L	c	Lower MatKat	1	2	MIPS	225	0.58	225	1.00	131	0.58	131	1.00
148.5	L	c	Below Matkat	0	1	HM	132	0.64	111	0.84	111	1.00	85	0.77
150.3	L	c	Upset Hotel	2	2	HM	300	0.88	300	1.00	289	0.96	264	0.91
151.3	R	c	Upper Ledges	0	2	HM	93	0.58	93	1.00	93	1.00	54	0.58
151.5	R	c	Ledges	3	3	HM	559	1.00	559	1.00	559	1.00	559	1.00
153.5	R	c	Sinyala	1	1	HM	122	0.80	122	1.00	98	0.80	98	1.00
155.7	R	c	Last Chance	2	2	HM	715	0.22	620	0.87	372	0.60	157	0.42
157.7	R	c	First Chance	2	2	HM	558	0.86	558	1.00	490	0.88	479	0.98
158.5	R	c	Second Chance	2	2	HM	320	1.00	320	1.00	320	1.00	320	1.00
160.0	L	c	Onesixty–mile	1	2	HM	246	0.36	246	1.00	246	1.00	88	0.36

Mile	Side	Reach	Name	HWsize	LWsize	MIPS	5K	5–25K	8K	5–8K	15K	8–15K	25K	15–25K
160.7	R	c	Onesixtyone mile	0	2	MIPS	1767	0.11	1574	0.89	1073	0.68	188	0.18
164.5	R	nc	Tuckup Canyon	3	3	MIPS	2110	0.86	2110	1.00	2110	1.00	1806	0.86
166.6	L	nc	Lower National	3	3	MIPS	2161	0.89	2161	1.00	2024	0.94	1914	0.95
168.0	R	nc	Fern Glen	3	3	MIPS	5796	0.40	5099	0.88	2322	0.46	2322	1.00
171.6	L	nc	Lower Mohawk	3	3	MIPS	1312	1.00	1312	1.00	1312	1.00	1312	1.00
174.3	R	nc	Upper Cove	2	2	MIPS	572	0.87	572	1.00	549	0.96	500	0.91
174.4	R	nc	Lower Cove	3	3	MIPS	2446	0.78	2446	1.00	2446	1.00	1906	0.78
177.7	L	nc	Vulcan's Anvil	2	2	MIPS	493	0.97	493	1.00	493	1.00	480	0.97
184.5	L	nc	No Name	2	3	MIPS	2135	0.25	1995	0.93	563	0.28	543	0.96
188.0	R	nc	Upper Whitmore	3	3	MIPS	2037	1.00	2037	1.00	2037	1.00	2037	1.00
188.2	R	nc	Lower Whitmore	2	2	MIPS	974	1.00	974	1.00	974	1.00	974	1.00
202.0	R	nc	Two–o–two mile	3	3	MIPS	2553	0.39	2553	1.00	1438	0.56	985	0.68
206.6	R	nc	Indian Canyon	1	1	HM	100	0.77	100	1.00	95	0.95	77	0.81
211.7	R	nc	Fall Canyon	1	1	MIPS	606	0.91	606	1.00	606	1.00	552	0.91
212.9	L	nc	Pumpkin Springs	3	3	MIPS	1444	0.37	1150	0.80	820	0.71	535	0.65
219.8	L	nc	Upper Twotwenty	3	3	MIPS	1704	0.82			1403		1403	1.00
219.9	R	nc	Middle Twotwenty	3	3	MIPS	2007	1.00	2007	1.00	2007	1.00	2007	1.00
220.0	R	nc	Lower Twotwenty	2	2	MIPS	421	0.76	421	1.00	410	0.97	318	0.78
222.0	L	nc	Twotwentytwo–mile	3	3	MIPS	839	0.84			708		708	1.00

Key:
Reach: reach types used in 1991 inventory: c=critical, nc=non–critical
HWsize: size class of site when flows are greater than 15K cfs
LWsize: size class of site when flows are 15K cfs or less
1: sm small (1–12 persons)
2: medium (13–24 persons)
3: large (25–36+ persons)
MIPS: indicates whether measured primarily by MIPS or hand–measured (HM)
5K,8K,15K,25K indicates area in square meters at a particular flow level where K refers to thousands of cubic feet per second
5–25K,5–8K,8–15K,15–25K: indicates the percentage of camp area remaining when flows are increased from 5–25K, 5–8K, 8–15K, 15–25K