THE INFLUENCE OF DISCHARGE ON RECREATIONAL VALUES INCLUDING CROWDING AND CONGESTION AND SAFETY IN GRAND CANYON NATIONAL PARK

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DRAFT

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Abstract

The Colorado River corridor is not only a dynamic riparian ecosystem, it is a place that renders unforgettable recreational experiences for over 20,000 individuals each year. It has been found that visitors to the Grand Canyon generally have a very satisfactory experience regardless of crowds, facilities or services. To many, the Grand Canyon, particularly a Colorado River trip through the Grand Canyon, is a "once in a lifetime" experience.

The questions about the effects of discharge from the Glen Canyon Dam on recreational values have been considered since GCES Phase I. These questions addressed economic values related to recreational experiences, safety, and fishing attributes. The studies revealed that certain flow regimes affect different values, but across all variables, Colorado River users reported high satisfaction levels.

The 1991 River Contact Study considered the effects of constant versus fluctuating flows on river contact levels and congestion at popular attraction sites. The data showed that on-river contacts were greatest for trips launching on weekend days that typically travel at a faster rate per day. The constant 5,000 cfs flows that took place during selected weekends contributed to increased travel time, but did not show a significant relationship between contacts and flow. Attraction site congestion was greatest for trips with similar schedules that launched on the same or consecutive days. Certain flow regimes, particularly constant low flows affect time spent at attraction sites. However, there was no significant correlation between discharge and attraction site congestion. Overall, the findings of the River Contact Study showed that discharge had no significant effect on crowding and congestion along the river corridor.

The Observed and Reported Boating Accident study conducted during GCES Phase I had limited data for flows less than 8,000 cfs. The findings of the 1990-91 study showed that low flows contribute to certain types of accidents. The results showed that hitting rocks, damaging equipment and walking around rapids were significantly related to low flows. This information supports the GCES I findings; that based on accident rates at various flows, the highest risk of accidents is during flood flows, followed by low flows, medium and high flows.

The commercial and noncommercial trip leaders surveyed during the study period, reported that certain trip attributes are affected by the constant low flows. The amount of time spent travelling on the river during the low constant flows had the most notable impact on a trip itinerary. The consensus amongst the commercial trip leaders was that regardless of flow, skill and knowledge of guides had the greatest influence on the passenger's experience.

Introduction

Overview

This study was instituted as a part of the Glen Canyon Environmental Studies (GCES) to compare the effects of various operational alternatives for the release of water from Glen Canyon Dam. The focus of the study was on several research flows to make inferences about the effects of discharge patterns on river recreation on the Colorado River. The principal questions were whether or not constant and fluctuating flows affect crowding and congestion on the river, and how flows less than 8,000 cubic feet per second (cfs) affect boating accident rates.

Each year, over 22,000 individuals travel through the Grand Canyon on the Colorado River. Visitors travel on commercial or noncommercial river trips which are offered on a variety of watercraft powered by oars, paddles or motors, and vary in length and duration. Major drainages and side canyons along the 225 mile river corridor in Grand Canyon National Park provide recreational activities off-river including hiking and swimming. These destination or "attraction" sites are regular stops for nearly every river trip that passes through the canyon.

The impacts of recreational use are most evident at major rapids and attraction sites. Multiple trailing, proliferation of campsites, and disturbance of cultural features are results of repeated use, especially at attraction sites. Crowding and congestion have resulted in certain reaches of the river corridor as trips "set up" for planned visits to popular sites such as Redwall Cavern, Little Colorado River, Deer Creek Falls and Havasu Creek. Past research and monitoring programs have indicated that distribution of use (i.e. launch schedules) and trip length have shown a significant relationship to contact levels along the river corridor. This study reports on the relationship of river flow to contact levels.

The whitewater rapids of the Grand Canyon are world renown recreational resources. The rapids of the Colorado River, like other rivers, take on certain characteristics as the volume changes. At higher volumes, the waves grow larger and increase certain risks, including upset. At lower volumes, the rapids present different risks as rocks become exposed and holes are formed. Based on public input, river flows, particularly low flows, present greater concern for safety while negotiating rapids. The investigation of accident rate at major rapids during low flows addresses this concern.

Background

The 1989 Colorado River Management Plan established an integrated monitoring program to assess conditions of the natural, cultural and experiential resources along the river. The management objectives for river contacts defined in the Plan were based on the findings of sociological research (Shelby and Nielsen, 1976, Shelby and Harris, 1981). The Colorado River Research Program, implemented in 1975, included the report, "Use Levels and Crowding in the Grand Canyon", which revealed that use levels affect the character of the Grand Canyon experience in terms of river and attraction site encounters (Shelby and Nielsen, 1976). A subsequent study was done in 1980 to compare contact data with the 1976 results, and to help establish a baseline for comparing river contact data in the future (Shelby and Harris, 1981).

As a result of the 1989 Plan, programs were implemented to monitor the effects of use levels on the visitor experience using crowding and contacts as indicators. The monitoring program adapted the methods used during the 1976 and 1980 studies. The River Contact Survey, conducted as part of the Glen Canyon Environmental Studies Phase II recreational studies, incorporates the Colorado River Management Plan objectives, with applications for comparing contact levels during constant and fluctuating flows.

The report, "The Effect of Flows in the Colorado River on Reported and Observed Boating Accidents in Grand Canyon" (Brown and Hahn, 1987), provided the basis for conducting additional research on the effects of flow on boating accidents. That study involved making observations at rapids and investigating National Park Service Case Incident files, and evaluated accident rates during low, medium, high and flood flows. The information on low flows, however was limited due to the exceptionally high releases during the GCES I study period. Based upon the recommendation of this research, the program was continued during the GCES research flow periods between June 1990 and July 1991.

In order to provide a more reliable empirical estimate of accident rates at low and flood flows, the researchers recommended that additional observations be made during flow periods below 8,000 cfs and above 33,000 cfs. The 1990 - 91 GCES II research flow periods did not include flows greater than 33,000 cfs, but did include several periods of 5,000 cfs constant flows and one 8,000 cfs constant flow period. This report will present the results of observations made during the constant low flow periods.

Grand Canyon users, particulary commercial river guides, can provide a wealth of information and perspective on how dam operations can affect the quality of their trips. During the observation and research periods, guides were interviewed by investigators to gain first hand knowledge on how different flow regimes affect the river trip.

Objectives

The overall objective of this study was to assess the influence of discharge on recreational values and boating accidents in Grand Canyon National Park. Specifically, three objectives were identified:

1. Determine the effects of river discharge on river contact levels and the amount of time spent on the river.

   a. Determine the effects of river discharge on contact levels between constant and fluctuating flows.

   b. Determine the difference in the amount of time spent on the river between constant and fluctuating flows.

2. Determine the effects of river discharge levels on whitewater boating accidents.

   a. Determine the effects of low flows (9,000 cfs or less) on boating accidents.

   b: Compare accident rates at low flows (9,000 cfs or less) to rates determined for low, medium, high and flood flows during GCES I.

3. Determine the effects of low flows on river trips based on first hand experience.

Hypotheses Tested:

1. HO: Discharge levels have no influence on contact levels during river trips.

2. HO: Discharge levels have no influence on accident rates at rapids.

3. HO: Discharge levels have no influence on river trip attributes.

The objectives of this study are based on alternatives to the above hypotheses. They are designed to collect the necessary data to determine if 1) river flow levels affect contact levels through rate of travel; and 2) some rapids have an increased risk of accidents due to exposed rocks and other hydrologic features at flows less than 9,000 cubic feet per second (cfs).

Methods

River Contact Survey

This study utilized the methodology of the ongoing contact and crowding river monitoring program (OMB #1024-0051) and focused on comparing contact level during several research flow periods to accommodate GCES Phase II research. The methodology follows that of the River Contact Survey (Shelby and Nielsen, 1976), which was conducted as part of the Colorado River Research Program. The River Contact Survey was designed to determine contact levels while travelling on the river, at attraction sites and while at campsites. The survey instrument (see Appendix A) was modified only slightly to include recording of contacts with NPS patrol, administrative and research trips.

The survey packet was made up of four components:

1) Daily River Contacts: This form was used to record the type, number, and duration of contacts while travelling on the river. "On river contacts" refer to contacts made during river travel and include contacts with other trips which are also travelling (river-river), on shore at lunch or rest stops (river-shore), or vice versa while the recorder is on shore (shore-river). The number of people, number of boats and duration of contacts was recorded for each trip.

2) Attraction Site Stops: A form was used to record when the stop occurred, duration of visit, and type and number of contacts made at each attraction site. Past monitoring programs showed that the greatest number of contacts are made at attraction sites, and river contacts are highest in association with those reaches just above or below the attraction site.

3) Campsite Contacts: The form used recorded location and proximity of camps within sight or sound of another group. In certain reaches campsites are considered "critical" in terms of size, location and availability (Kearsely and Warren, 1991).

4) Trip Schedule: A separate form used to record all stops made by the trip each day including the duration and activity. Stops are generally made for lunch, attraction site visitation, rest and shade, scouting rapids, and camp. From the trip schedule, we were able to differentiate between on-river and off-river time.

The River Contact Survey was designed to be administered by trained observer participants on commercial river trips. Volunteers were recruited by the Division of Resources Management at Grand Canyon National Park to administer the surveys. The volunteer participant observers were trained to recognize various contact activities and record all pertinent data in a concise and discrete manner. In order to assure consistency in the program, an attempt was made to have a minimum number of different participant observers collect data on several trips.

Prior to the implementation of the study, specific trips were selected to accommodate data collection at each research flow. The commercial river outfitters were contacted by the Principal Investigator to schedule volunteers to collect data on the river trips. Data could only be collected on commercial river trips if space was available. The trips sampled for the River Contact Study are listed in Appendix B.

The results of the River Contact Study are based on data collected from 28 river trips. The sample represents 245 trip days during the study period. Data were collected during seven research flow periods, this was done to contrast contact levels for each discharge. Data collection took place during the research "E" (wide range) flow in September 1990, the "D" (wide range) and 15,000 constant flows in May 1991, and the "F" and "G" (high minimum, wide range) flows in July 1991. Because the 5,000 constant flows lasted only three days, researchers also collected information on trips that included this discharge and others. In addition, data was collected during periods of "normal summer operations" as a control for comparison with the F and G flow during the high density use period. The research flow periods in which trips were sampled are described in Table 1.

Daily Contact Rate and Time on River. The contact levels and time spent on river were compared for each flow regime during the research period. Contact levels were determined by calculating the number of contacts per hour per trip at each flow. This was done to ascertain the contact rate per hour for each trip to compare the dependent trip variables as well as the independent variables of daily contacts. Based on the information recorded on the Trip Schedule, the actual travel time on river was determined for each day. The daily contact rate and travel time were the response variables measured on each trip under constant versus fluctuating flows.

Two nonparametric Analysis of Variance procedures were used to test for significant differences in the response variables for each flow regime. The Kruskal-Wallis one way analysis of ranks (H value) was used to test for differences in contact rate and travel time at all flows for all trip types. Friedman's nonparametric randomized block analysis of variance (f value) was used to test for significant differences in contact rate and travel time between flows for trips experiencing both constant and fluctuating flows.

Table 1: GCES Research Flow Periods during which the River Contact Study took place.

DISCHARGE	DESCRIPTION	DATES	#SAMPLE DAYS
E Flow	3000-26200 cfs; high fluctuation, low minimum, ramping: high increase, high decrease	9/17-27/90	30
D Flow	3000-26200 cfs: high fluctuation, low minimum, ramping: low increase, high decrease	5/5-16/91	17
15,000 constant	15000 cfs constant for 11 days	5/20-30/91	44
Normal Summer	Normal summer operations; range varies depending on day; 3000-30000 cfs, no restrictions on ramping	6/3-27/91	65
G Flow	10000-33200 cfs; high fluctuation, high minimum, ramping: high increase, high decrease	7/1-11/91	32
F Flow	10000-33200 cfs; high fluctuation, high minimum, ramping: high increase, low decrease	7/15-25/91	30
5,000 constant	5,000 cfs constant for 3 days; scheduled on selected weekends throughout research period	9/14-16/90, 5/3-5, 5/17-19, 5/30-6/2, 6/28-30, 7/12-14, 7/26-28/91	27

Attraction Site Contacts. Using the Attraction Site Stops component of the River Contact Survey, the number and duration of attraction site visits and number of contacts was determined for all trips sampled. Unlike daily contact rate and mean travel time, contact levels at attraction sites could not be quantified on a daily basis. Although visitation and contact levels vary by site, the results are calculated for total attraction site contacts for the entire trip. The amount of data limits the analysis to comparisons between trips experiencing 1) constant flows, 2) fluctuating flows and, 3) both constant and fluctuating flows.

The Kruskal-Wallis one way analysis was used to test for differences in in contact levels, time spent at attraction sites, and number of sites visited between flow types.

Assumptions and Limitations of the Study. The collection of data on river contacts was dependent upon the opportunity for researchers to experience a variety of river trips to record the necessary information. We found that in some cases, outfitters were reluctant to allow another individual outside of the crew and passengers, to accompany the commercial trips. Most outfitters however, accommodated requests for the purpose of this project. On the other hand, it was not always possible to place researchers on the requested or alternative trips because the trips were at maximum capacity.

The research flows were primarily designed for the purpose of evaluating sediment transport and erosion processes along the Colorado River corridor, and thus scheduled according to those research needs. The data collection for this study had to fit into the existing research flow schedules. The various research flow regimes were not designed to accommodate a study that requires a wide window of flow regimes (i.e. constant) from which comparisons between the effects on daily trip itineraries can be evaluated. The results of this study are therefore circumscribed by the ability to place researchers on river trips, and number of days of constant flows to make comparisons.

Boating Accident Study

Observed Boating Accidents. As a result of the recommendation made by Brown and Hahn following GCES Phase I, the Observed Boating Accident study was continued to obtain more information on boating accidents during low flows. Data collected for the earlier study covered periods of both steady and fluctuating flows in 1985 and 1986. The data collection for that study took place during periods of steady flow, (no changes greater than 10,000 cfs) in a 24 hour period, and ranged from 24,000 to 29,000 cfs and 30,000 to 32,000 cfs), and fluctuating flows (ranging from 5,000 to 27,000 cfs).

During the data collection periods in 1985 and 1986, flows were substantially higher than normal, thereby limiting the amount of data collected during low flows (8,000 cfs or less). In addition to the observations, phone interviews were conducted with river users who ran trips during the flood flow periods (>32,000 cfs) to obtain data for that particular flow period. The information obtained during the Phase I study was compared to the low flow data collected between June 1990 and July 1991.

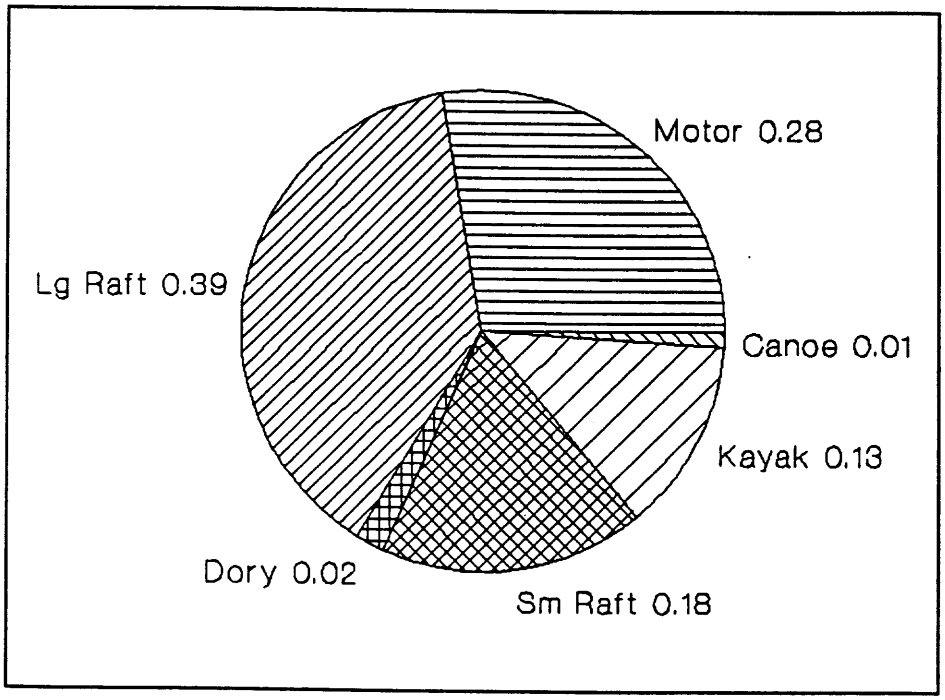
Observations were made by NPS personnel and volunteers during constant low flow periods at six major rapids in Grand Canyon. Observations were made at rapids where the highest rate of incidents are known to occur: House Rock (RM 16.9), Hance (RM 76.8), Horn Creek (RM 90.2), Granite (RM 93.5), Crystal (RM 98.1) and Lava Falls (RM 179.5) Rapids. During the Phase I study, observations were also made at Upset, 24.5 Mile and Duebendorff rapids. These rapids were not included in the recent program due to logistical obstacles.

The sample sizes were determined in the baseline study to assure that the sample provides adequate data for examining the relationship between accidents and flows. The recommended sample size for the low flow observations was 100 boats per rapid. For most rapids, this sample size was met or exceeded, except at Granite and Lava Falls, where the proportion of incidents is smallest. The known difficulty of negotiating these rapids is also easier during lower flows. Table 2 shows the distribution of samples by location, and Figure 1 shows the distribution of observations across boat types. The 1987 low flow results are based on observations of 100 boats for all sites. The 1991 results will reflect observations of 660 boats for all sites during constant low flows, primarily 5,000 cfs.

Table 2: Distribution of Boating Accident Observations during Constant Low Flows.

RAPID (River Mile)	NUMBER OF TRIPS	NUMBER OF BOATS
House Rock (16.9)	45	152
Hance (76.8)	48	142
Horn Creek (90.2)	36	110
Granite (93.5)	19	55
Crystal (98.1)	29	117
Lava Falls (179.5)	28	84

Figure 1: Distribution of Observations by Boat Type (n = 660)



Using a structured checklist, observers recorded characteristics and outcome of the run for each boat. The trip observation variables for both the Brown and Hahn (1987) and recent study were described as follows:

1. Time and date of run.
2. Type of boat: motor rig, large raft, small raft, kayak, canoes & inflatables, dories.
3. Type of trip; private or commercial.
4. Starting point for route taken through rapid (left, right or middle).
5. Whether the party scouted the rapid (and length of scouting time).

Whether any of the following happened to the party:

6. Lost control of an oar; refers primarily to boaters in rafts and dories losing grip of an oar.
7. Flipped; for kayaks, coded only if the boater came out of the boat. For all others refers to overturning.
8. Struck a rock.
9. Persons overboard.
10. Length of time persons were in the water: the maximum amount of time any person from a boat spent in the water.
11. Most serious injury: broken into categories of Slight, Incapacitating (requiring evacuation), Life-Threatening, and Fatality.
12. Equipment lost or damaged: covers both equipment lost from a boat and damages.
13. Number of boats who walked people around rapid.
14. Boat portaged or lined through rapid: included all boats carried around or through a rapid or lined through empty.

The analysis of data collected during the 1990-91 GCES II research flow periods for determining the relationship of accident rate to flows follows the methodology of the original study with modifications based of the availabilibity of statistical programs. The primary method of analysis for the GCES I study was the hierarchical analysis of variance (ANOVA) which allowed for a purer test of the relationship between river flow and each of the accident variables. Since all data during the GCES II was done during the low flow category (3 - 9,000 cfs), an Analysis of Variance process was used to compare the rate of each accident variable to the flow level.

As illustrated in Table 6, the proportion of boats hitting rocks was slightly less for the 1990-91 study than determined in the original study. However, the rate for hitting rocks remains the greatest at low flows. Based on the data collected for the original study, the proportion of boats having passengers walk around rapids was lowest for the low flow category. The data collected during the recent low flow study period, however, showed that the proportion of boats having passengers walk around rapids was highest for flows around 5,000 cfs (.13), as compared to medium (.12), high (.08) or flood (.11) flows shown in the original study.

During flows less than 8,000 cfs, motorized rafts incur the highest rate of incidence across all variables except losing control of oar. Thirteen percent of the trips observed walked passengers around rapids. The largest proportion passengers walking around rapids were on motor boats, however the largest proportion of boats walking passengers were small rafts. Motorized boats also experienced a higher rate of equipment damage (mainly to the motors) as compared to small rafts. There were no observations of equipment damage to large rafts, dories or kayaks during this study period.

Table 7: Observed Boating Accidents: Accident Rate by Boat Type during Low Flow Study Period, 1990-1991.

	Motor	Lg Raft	Sm Raft	Kayak	Canoe	Dory
Lost Control of Oar	.00	.05	.11	.00	.00	.00
Boat Struck Rock	.15	.08	.16	.00	.00	.00
Boat Flipped	.00	.00	.00	.003	.00	.00
Equipment Damage	.04	.00	.02	.00	.00	.00
Passengers Walked[2]	.08	.08	.26	.01	.75	.00
Lined or Portaged	.00	.00	.00	.01	.75	.00

[2] The proportion represents the **number of boats** from which passengers walked around the rapids. The numbers of actual passengers walking around rapids is greatest for motor boats, which have an average passenger capacity of 16, compared to an average capacity of 5 for oar boats. Walking and portaging are considered the same action for single-person crafts such as kayaks and canoes, thereby showing the same proportions for each action.

In comparing accident rates for commercial and private trips, it was found that private trips using smaller rafts had a higher rate of walking around rapids and equipment damage than commercial trips using large rafts.

The highest rate of any variable occurred at Hance Rapid (see Figure 2). Figure 3 shows the rate of incidence for Hance Rapid during the 5,000 cfs constant flow periods. Hitting rocks had the highest rate for motor rigs, as did walking and equipment damage. Because it is so rocky, Hance becomes more difficult to avoid rocks and holes during low flows, especially for large (up to 40′) motorized craft.

Walking passengers around the rapid was done to avoid risk of injury or swim to passengers, or damage to boats and equipment including motors and oars. Although it was not included on the observer checklist, boats sometimes became "stuck" or "wrapped" on rocks during the low flows. This incident was noted on the checklist under the "Other" category. Three incidents were noted at Hance where large motorized boats with crew only wrapped on the large rocks at the bottom of Hance Rapid for up to 60 minutes. In all cases, the boats were freed with the assistance of other craft and ropes to shore. In two of the three situations, other trips were forced to stay above the rapid because they could not make a safe run due to the additional obstacle blocking safe passage. This caused delays in trip schedules for a total of ten trips. The NPS also responded to five incidents at Hance during the 5,000 constant period where motorized boats became wrapped and required the Search and Rescue operation to free the boats and evacuate people (Ken Phillips - Search and Rescue Coordinator, personal communication).

Brown and Hahn developed a "Composite Index of Risk" which provided an accurate indication of the relative risk of running the river at various flow levels. The index was developed by creating a composite variable which reflected the risk of all types of accidents that cause personal injury or equipment damage. Based on the data from the GCES I study, the following composite index values were obtained for each flow category: Low = .18, Medium = .14, High = .11, Flood = .22. The higher values signify a higher rate of accidents overall.

Because of the limited observations during low flows, it could not be applied for flows less than 8,000 cfs. The rating also included Accident Records analysis and judgement of commercial guides. The results of the 1990 - 1991 observed accident study supports the index rating of .18 for low flows, and includes flows less than 5,000 cfs. Using this index as a basis for the relative risk of running rapids at different flow levels, High flows are safest, followed by Medium, Low and then Flood.

Figure 2: Accident Rates for all Rapids

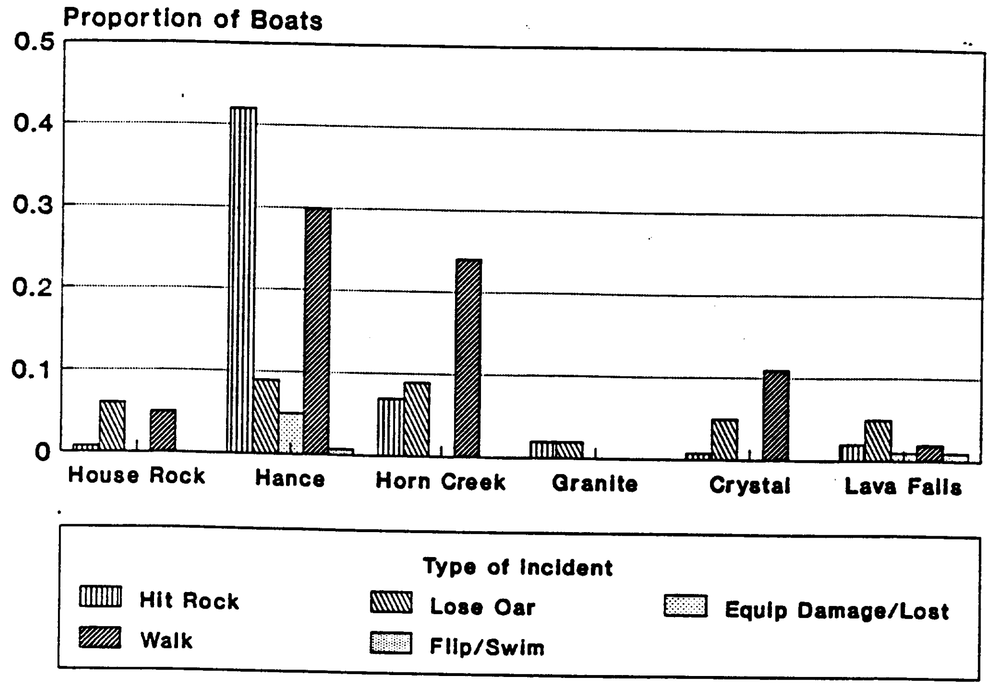
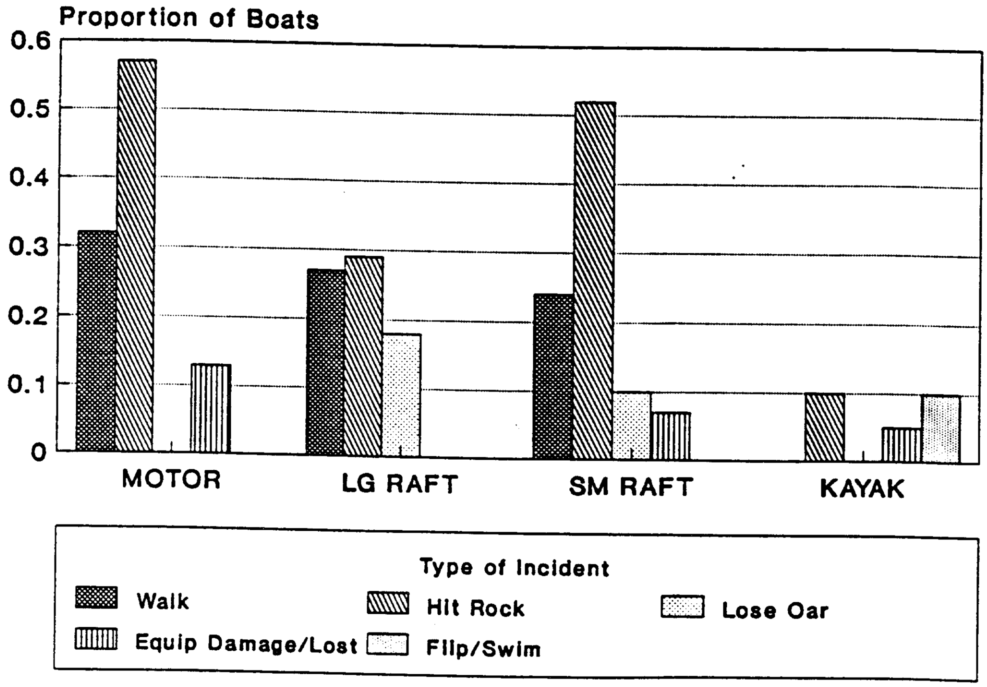


Figure 3: Accident Rates at Hance Rapid



Reported Accidents. Chi-Square analysis of the recorded versus expected accident distributions for the June 1990 - July 1991 study period showed no significant relationship between accident occurrence and flow range ($X^2 = 2.89$, $p>.05$). Table 8 summarizes variables used for analysis.

Table 8: Reported Boating Accidents: Percent of total Grand Canyon boating accidents vs. percent of total boat-hours in each flow range category, and recorded vs. expected Grand Canyon boating accidents by flow range for June 1990 - July 1991.

	Flow Range		
	Low (< 9,000)	Medium (9 - 15,999)	High (16 - 31,500)
Percent of total Grand Canyon accidents	52.38	28.57	19.05
Percent of total boat-hours in each flow range	57.51	15.53	26.96
Recorded Accidents	11.00	6.00	4.00
Expected Accidents	12.08	3.26	5.66

Although it was not shown to be statistically significant, the highest proportion of total accidents occurred during flows less than 9,000 cfs, which also had the highest percentage of boat-hours. In looking at the distribution of accidents during low flows, the Chi-Square Test was also done to compare accidents at flows 5,000 cfs or less to those above 5,000 cfs. Although seven of the eleven river incidents recorded during the low flow range each occurred during a three-day 5,000 cfs constant research period, the difference in accidents occuring during flows less than 9,000 but greater than 5,000 cfs, was not significant ($X^2 = 2.93$, $p >.05$).

Based on the information from the Case Incident Records for June 1990 to July 1991, the actual accident rate across all flows and all rapids was .43% (or .0043 boats per day having an accident); and the accident rate for flows less than 9,000 cfs was .22%.

Trip Leader Survey

The results of the Trip Leader Survey were based on interviews with 93 commercial or private trip leaders at nine locations. The interviews were conducted by surveyors who were also conducting attraction site monitoring or making accident observations at rapids during the constant low flow (5,000 cfs) research periods. Although the surveys were administered in the same manner by all interviewers, the location of the survey may have an effect on responses. For example, individuals surveyed at House Rock Rapid (mile 16.8) may not have experienced low flows yet on the trip, because it was often the first day of the trip. Since trips further downstream had more of an opportunity to experience low flows, those surveys provided the most information. The largest proportion of interviews (>.70) were conducted at Crystal, Deer Creek Falls and Havasu, where trips would have been on the river for several days and had the opportunity to experience low flows. The results were tabulated across all locations for all trip types. Table 9 shows the proportion of surveys conducted by location. The proportion of surveys by trip type is representative of the actual use level of each trip type.

Table 9 : Trip Leader/Guide Surveys by Location (n = 93)

LOCATION	PROPORTION
House Rock Rapid	.02
Little Colorado River	.14
Hance Rapid	.03
Horn Creek Rapid	.01
Granite Rapid	.03
Crystal Rapid	.21
Deer Creek Falls	.34
Havasu Creek	.18
Lava Falls Rapid	.02

Significantly more trip leaders stated that low flows interfere with the daily trip itinerary ($X^2 = 21.8$, $p < .05$). Out of the total 93 surveyed, 69 indicated that the low flows affected the daily itinerary, and 24 said that it did not. Responses between motor and oar trips were not significantly different ($X^2 = .003$, $p > .05$). When asked how the trip itinerary was affected, significantly more trip leaders stated that low flows resulted in increased travel time, i.e. motoring or rowing ($X^2 = 26.8$, $p < .05$). Significantly more trip leaders felt that walking around rapids during the low flows did not affect the trip itinerary ($X^2 = 20.1$, $p < .05$). All respondents indicated that dealing with injuries did not affect the itinerary. Although more trip leaders said that scouting rapids during low flows affected the daily itinerary, the higher number was not significant ($X^2 = 1.8$, $p > .05$).

Of the stated factors influencing the daily trip itinerary, only dealing with equipment damage showed significantly different responses for motor versus oar trips ($X^2 = 15.9$, $p < .05$). Of oar trips, significantly more respondents indicated that dealing with with equipment damage did not affect the trip ($X^2 = 32.1$, $p < .05$). Of the motor trips, the number of responses stating that dealing with equipment damage affects the trip itinerary, was not significantly different from the number of responses stating that it does not have an effect

(X^2 = .76, p >.05). Figures 4a and 4b illustrate the proportion of responses and effects of low flows on the daily trip itinerary based on the survey responses.

Of the Trip Leaders who responded to questions regarding trip quality, roughly one third indicated that constant low flows "detract from" the experience, and another third indicated that constant low flows "contribute to" the experience. As compared to motor trips, significantly more oar trip leaders indicated that low flows "contribute to" the quality of the experience for the passengers (X^2 = 9.2, p <.05). The last third indicated that low flows both "contribute to" and "detract from" the quality of the experience for the passengers.

Of those who indicated that low flows detract from the experience, a majority said 1) that rapids were less exciting, 2) more time was spent on river, with less time for hikes, and 3) that rapids were more dangerous. On the other hand, others indicated that 1) larger camping beaches, 2) better fishing, 3) the technical nature of rapids, and, 4) educational opportunity for passengers to see effects of flows, contributed to the experience during the constant low flows.

Approximately half of the trip leaders said they either skipped planned hikes or spent less time at attraction sites in order to make the necessary mileage to stay on schedule. In many cases, time was spent on river to "beat" the low water in order to run certain rapids at higher water.

Over one third of the respondents attributed the constant low flows to increased crowding and congestion. Some indicated that they made more stops than usual to wait for higher flows, thereby slowing down the trip above certain reaches. Many trip leaders said that they encountered more congestion above Hance Rapids and above Phantom during the constant low flows as compared to other flows.

Figure 4a: Proportion of Trip Leader Responses

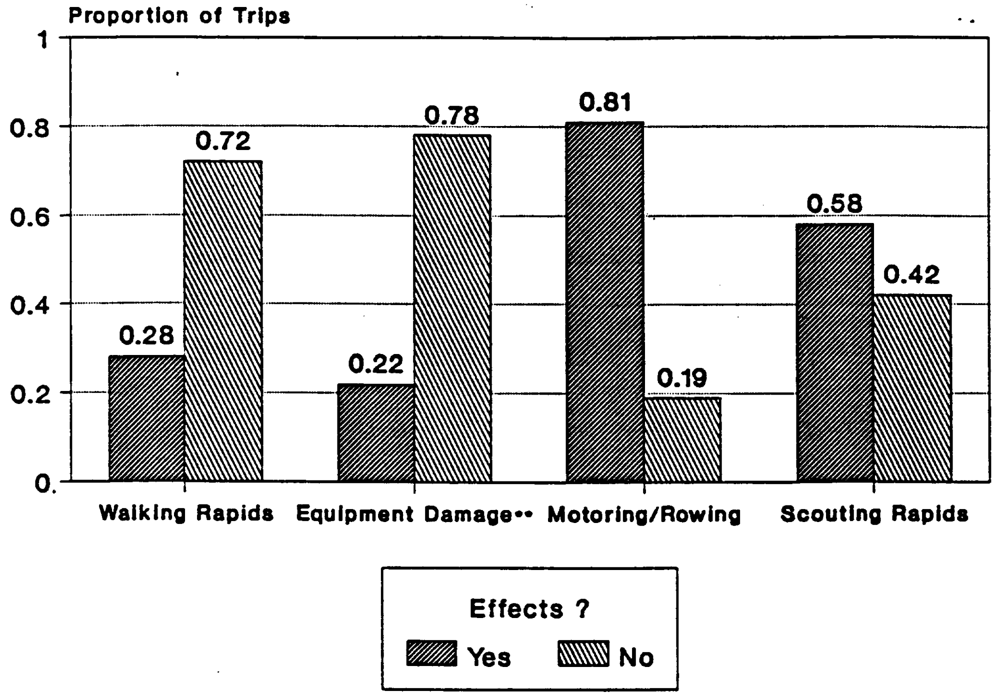
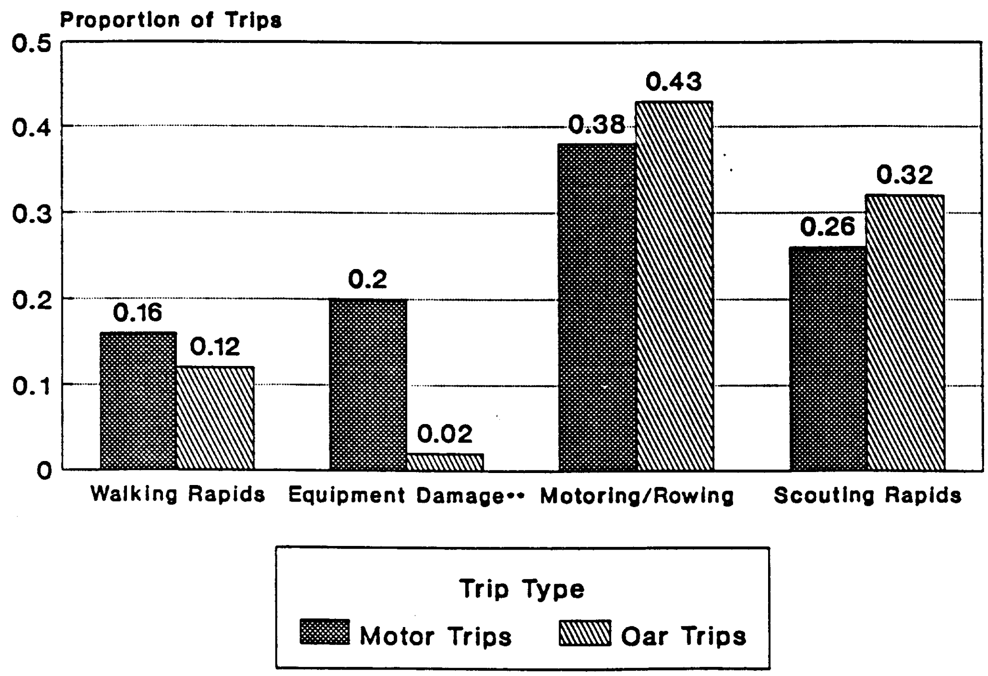


Figure 4b: Proportion of Effects by Trip Type



**p > .05

n = 69 reporting effects

Discussion of Results

River Contact Survey

As addressed in the 1989 Colorado River Management Plan, management objectives for contact levels and crowding at popular destination or "attraction sites" along the Colorado River have been defined by the Limits of Acceptable Change. Recent monitoring programs have indicated that these limits are being exceeded under certain conditions (Jalbert, 1989 and 1990). It has been found that a number of factors influence contact levels and congestion along the Colorado River corridor (Shelby and Nielsen, 1976, and Jalbert 1989 and 1990.) The day of launch, the number of trips launching on the same day, the type (motors or oars) of trips launching, and the length of the trips launching on the same day, contribute to increased on-river contacts and congestion at attraction sites.

In summary, the results of the River Contact survey showed no significant relationship of discharge to river contact levels and attraction site congestion. The data, however indicates certain trends. First, that flows dictate the rate of daily travel, and are especially affected in terms of contacts when travel rate is slow during constant low (5,000 cfs) flows. During the high fluctuating periods such as the research F and G flows, as well as the normal summer operations, motor trips launching on days that follow periods of constant low flows come in contact with oar trips at attraction sites that they normally do not contact during a "routine" trip schedule. It may therefore be inferred that the periods of constant low flows (5,000 cfs) have indirectly contributed to increased on-river contacts and attraction site congestion.

Secondly, the mean daily time spent on river tends to be greater for trips during fluctuating flows, as compared to constant flows (including the 5,000 cfs). The results indicate a difference in mean travel time within various fluctuating flow regimes. For example, as shown in Table 3, the mean travel time for oar trips during the high fluctuation, low minimum 3 - 26,000 cfs ("E or "D") flows versus the high fluctuation, high minimum 10 - 33,200 cfs ("F" or "G") flow, show a difference of 2.41 hours. More data would be required, however to substantiate any significance, especially for the variation within the range of fluctuating flows.

The influence of discharge is secondary to the effects of the launch schedule management on contact levels and crowding. Professional guides work within the constraints of the trip length to provide visitors with a quality experience that includes off-river time. Adjustments in the daily trip itinerary are made based in part, on flows to provide a variety of activities including attraction site stops. In general, the medium to high flows (10 - 26,000 cfs allow for greater flexibility in the daily trip itinerary. Lower flows (less than 10,000 cfs), on the other hand, decreases flexibility in the daily itinerary, sometimes resulting in shorter and fewer attraction site stops (Bishop, et. al., 1986).

Observed and Reported Accidents

The combined results of observed and reported accidents at low flows substantiates the findings of the GCES I studies. First, certain types of incidents are significantly related to low flows, and secondly, personal injury is not necessarily related to low flows. Although the rate for personal injury requiring evacuation as reported by boaters and NPS officials shows a trend toward higher rate of occurrence during flows less than 9,000 cfs, this was not shown to be statistically significant.

Although the question of accident rates at constant versus fluctuating was not addressed directly in this report, the results indicate certain trends which managers need to be consider. For the GCES II study, all of the observed accidents occurred during the 5,000 cfs constant flow period, and 34% of the reported accidents occurred during the same periods. Once again, the Chi-Square analysis of the reported accidents indicated that this was not significant, however it showed a trend towards an increase in accidents as flows less than 9,000 cfs decrease.

Brown and Hahn reported on the effects of fluctuating flows versus "steady flows". It is important to note that "steady flows" were defined as no changes greater than 10,000 cfs in a 24 hours period, and that these flow were also in the high flow category (17 - 31,000 cfs). The fluctuating flow analysis showed that the only variable significantly related to flow regime (steady versus fluctuating) was lining or portaging boats. Since all observations for the GCES II study were made during constant periods of 5,000 cfs (few at 8,000 cfs), it may be inferred that the constant low flows, have a relationship to accident rate.

Boaters may also manage risk by avoiding it. Walking passengers and lining or portaging boats are actions taken to avoid the risk of accidents in rapids. As pointed out in the Brown and Hahn study, these actions "reflect the boater's perceived level of risk in running the rapid and serve as secondary indicators of objective risk". As a result, one may infer that the rate of accident variables is lower due to the manner in which trip leaders chose to manage the situation, that is, by walking passengers around the rapids.

One can expect that during low flows rocks become more exposed, thereby increasing the chances of hitting them. The chances decrease as river level rises, and rocks are submerged. Exposed rocks are also a direct cause of equipment damage. Although the data does not reflect a significant rate for equipment damage, all observers at Hance noted that they heard "loud cracks" from some motor boats when they hit the bottom hole at Hance, and "guessed" that the motor was damaged. The boats went out of sight shortly below the rapids, and it could not be confirmed that damage was done to motors, and therefore not recorded on the checklist. Information received during interviews with guides, and NPS accident reports, however, support the observers' speculation that motor damage occurred at Hance during the 5,000 cfs flow.

Based on the information from NPS records, the relationship between accidents and low flows has been most notable in the past two years. Nine river incidents requiring Search and Rescue operations that include evacuation, boat and equipment rescue or both, occurred during a 5,000 cfs flow period. As noted above, five of these incidents occurred at Hance rapids involving motor rigs. It is also important to note that the majority of the low water incidents occurred during the constant low flow period, which in itself may have been a factor. In other words, trip leaders may prefer to run Hance at a higher water level to avoid risk of accidents, however, the trip schedule may not allow for adjustments during certain (i.e. constant low) flow periods.

<u>Trip Leader Survey</u>

The survey served as an opportunity to learn directly from the trip leaders specific attributes and influences of flows, particularly constant low flows on individual river trips.

The information from the Trip Leader Survey substantiated some of the findings of the River Contact and Observed Boating Accident studies. As found in the results of the boating accidents study, the rate for walking around rapids is higher at low flows (.13) than at medium (.12) and high (.08) flows. The survey indicates that the highest proportion of the respondents felt that walking around rapids did not affect the daily trip itinerary. Of those that felt it did, walking passengers around rapids affects motor trip itineraries as compared to oar trips. Normally trips avoid walking passengers around rapids. During the constant low flow periods, some rapids (particularly Hance), were more difficult to navigate because of the exposed rocks. Although it became more "technical" due to the exposure of rocks (increased obstacles), small boats were much more likely to navigate the rapids without incident than were motor boats. Walking the passengers around rapids decreased the risk of injury to passengers and made the motorized boats lighter, and thus, more maneuverable increasing the chances of safe passage through the rapids.

As suggested by the results of the accident observations and River Contact study, more time is spent scouting during low flows compared to medium and high flows. According to the Trip Schedule data in the River Contact Survey, the time spent scouting is nearly twice as much for motor trips at constant low flows than at others. The survey showed that over half of the respondents reported that scouting rapids during the low flows did affect the trip itinerary, although not significantly. Commercial motor trips spent more time scouting during constant low flows compared to other flows. Typically, motor trips are more likely to run nearly all of the rapids during higher flows. During the constant 5,000 low flow period, 99% of the trips observed scouted Hance and Horn Creek. At higher flows, however, these rapids are not usually scouted by motor boatmen.

The variable that had the greatest influence on the daily trip itinerary for motor and oar trips was the time spent travelling (motoring or rowing) on the river. Comments indicated that late camp arrival and shorter attraction site visits were necessary adjustments in order to stay on schedule. Although the difference was insignificant, oar trips were more affected by time spent on the river as compared to motor trips. Motorized boat have a greater ability to "make-up" time to stay on schedule as compared to oar powered boats.

As reported for the observed accidents study, motorized boats experienced more damage to equipment than all other boat types. Although most of the respondents indicated that repairing equipment damage did not affect the itinerary, ninety percent of those that did were motor trip leaders. Once again, Hance Rapids at 5,000 cfs was the greatest contributor to motor prop damage.

When judging the quality of the experience during the constant low flow periods, responses were evenly split between those who felt it contributed to quality and those who felt it detracted from the quality of the trip experience. Most commercial trip leaders will attest that their skills and experience contribute most to the type of the experience the visitor has, regardless of the river flow. The private trip leaders were more "dissappointed" at the low flow periods, because certain expectations were not met; specifically, the "big ride" in rapids.

Conclusions

The data collected for the River Contact Survey included trip days that experienced a variety of flows, including constant 15,000 and 5,000 cfs flows. Under normal dam operations (i.e. high fluctuations), trips have made adjustments as much as possible to meet the explicit trip schedules. The constant 5,000 cfs research flows were a dramatic change in the normal flow regimes, which presented an added challenge to river users to meet schedules dictated by trip lengths. It was quickly learned that the 5,000 cfs constant low flows did not provide the flexibility for trips that higher flows do.

The distribution of days during constant and fluctuating flows was not even. Aside from the periodical three day 5,000 constant flow, the GCES research flow schedule included a limited number of days of constant flows (11) during the Primary Use Season (May - September). Based on the sample, the results show no effect of discharge on contact levels. It is believed that a more even distribution of constant and fluctuating flow days would assure a higher level of confidence in the results. However, research and monitoring programs support the conclusion that contacts and congestion are most affected by current launch schedule management.

The results of the observations made at House Rock, Hance, Horn Creek, Granite, Crystal and Lava Falls Rapids substantiate the results of the GCES I baseline study on the effects of flows on observed boating accidents. Based on accidents rates, flood flows present the greatest risk, followed by low flows, then medium, and then high flows. The rate of incidence for walking around rapids and hitting rocks is highest at low flows compared to other flows. The rapid that showed a direct relationship between accidents and low flows was Hance.

Based on the NPS Case Incident Records, the data analyzed for the 1990 - 1991 research periods suggests that low flows (8,000 cfs or less) are a contributing factor to reported river accidents; however, they are not the controlling factor. Hance Rapids was the only rapid that showed a direct relationship between reported accidents and low flows.

The information from the Trip Leader Survey substantiates some of the findings of the River Contact Survey and Accident Observations Study. For trips with constant low flows, more time is spent travelling on the river and less time is spent hiking. Walking around rapids and dealing with equipment damage were incidents that occurred more during low flows and affected the daily trip itinerary. Some trip leaders also indicated that passenger expectations were not met in terms of big rapid rides.

These dominant characteristics of the low flows namely increased river travel time, walking around rapids, the type of rapid ride and safety are directly related to the flow sensitive attributes reported in the GCES I User Preference survey (Bishop et. al., 1986). According to this study, trip participants associated beach availability, not walking around rapids, side hikes and layovers, naturalness of setting, and safety with a quality experience.

In conclusion, the findings of this study 1) concur with the null hypothesis that discharge levels have no significant influence on contact levels during river trips and at attraction sites; 2) support the GCES I accident study findings that low flows produce higher accident rates than medium or high flows; and, 3) it appears that some recreation values diminish and safety concerns increase as a result of constant low flow periods.

ATTRACTION SITE STOPS

Trip__________

	Site Number	1	2	3	4	5	6	7	8
Name									
	Day of Trip								
	Time Stopped								
	Length of Stop (Hours)								
Trip Type	1)OAR 2)MOTOR 3)BOTH								
Trip Type	1)PRIVATE 2)COMMERCIAL 3)BOTH 4)HPS of RESEARCH 5)ALL								
Size of Contact	Total # Groups								
Size of Contact	Total # Boats								
Size of Contact	Total # People								
Passengers: Nature	1) Ignored 2) Wave Only 3) Verbal 4) Chat 5) Conversation								
Passengers: Reaction	1) Negative 2) Neutral 3) Positive								
Boatman	Nature as above								
Boatman	Reaction as above								

COLO	Motor	7/13-14/91 7/15-20/91	5,000 constant F
CAEX	Oar	7/18-23/91	F
GRCD	Oar	7/26-28/91 7/25,29-31/91 8/1-9/91	5,000 constant F Interim Flows
Total: **28 Trips**	**16 Motor** **12 Oar**	**256 Trip Days**	

Interviewer: ______________________ Date: ____________________

Location: ______________________ Time: ____________________

Observer Checklist

Party Description

Boat Types ______________________ Colors ____________________

#Boats ______________________ Markings ____________________

Estimate of Flow Level ______________________________________

Trip Experience Description

Did Party Scout Rapid? ______________________________________

Did Party Line Any Boats? ______________________________________

Did Any Members Walk? ______________________________________

What Run Was Taken (L,M,R)? ______________________________

****

	Boat 1	Boat 2	Boat 3	Boat 4	Kayaks
Flipped	______	______	______	______	______
Struck Rock	______	______	______	______	______
Person Out (time in H2O)	______	______	______	______	______
Lost Control of Oar	______	______	______	______	______
Lost Oar	______	______	______	______	______
Equip. Lost (damaged)	______	______	______	______	______
Injury	______	______	______	______	______

Other Problems ______________________________

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Notes: