COLORADO RIVER INVESTIGATIONS VII

July - August, 1988

By
Students and Staff of Geology 538-626
Northern Arizona University

Under the Supervision of

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Submitted to
Mr. Richard W. Marks, Superintendent
Grand Canyon National Park
Grand Canyon, Arizona

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INTRODUCTION

This report presents results of a five-week, six-semester-hour course (GLG 538-626) for graduate students on the geology, hydrology, and biology of the Grand Canyon. The course was offered through Northern Arizona University in collaboration with the National Park Service, Grand Canyon National Park. Conducted during July and August, 1988, this program involved two weeks of laboratory classes and short field trips as an introduction to the natural history of northern Arizona, and culminated in an 11-day river trip through Grand Canyon. Each student worked on a research project under the supervision of either Stanley S. Beus or Steven W. Carothers, Department of Geology, Northern Arizona University. The river trip was followed by four days of intense class work to summarize the results of the field investigations and prepare this report. Some project data required additional analysis during the following semester.

The research project reports here submitted were prepared either entirely, or in part, by the student investigators in the course. Some final editing has been done, and the report is herewith submitted to Superintendent Richard W. Marks of Grand Canyon National Park. The data collected and the conclusions presented contribute to several ongoing studies and questions or problems of concern to the National Park Service in management of Grand Canyon as both a natural history laboratory and a recreational experience for those who visit.

CHAPTER I

TOPOGRAPHIC CHANGES ON SELECTED BEACHES IN THE GRAND CANYON, 1987-1988

Dianne Connelly, Muriel Gravina, Larry Kendall
David Loucks, Vernon Perry, Sharon Spiegel

INTRODUCTION

On July 27, 1988, a research team of six began an eleven-day continuation study of campsite beaches along the Colorado River in the Grand Canyon. The Colorado River beaches are one of the most important elements of the recreational value of the Grand Canyon National Park. There is serious cause for concern for these beaches, which have been altered considerably since the 1963 addition of the Glen Canyon Dam on the Colorado River. This study was implemented to determine the direction, degree and speed of this alteration. Results of this study will assist management agencies of the Grand Canyon National Park to understand the positive and/or negative impact of the changes being wrought on the Colorado River beaches as a result of the control of river flow by the Glen Canyon Dam.

The study involved a transit survey along previously fixed profile lines from established benchmarks. The research team surveyed 37 profiles on 18 beaches (Table I-1). This year, two new benchmarks were set at Pancho's Kitchen, L136.6, with two cross sections. The Ledges beach, L151.6, was not surveyed this year because all that remained was exposed rock. Lower Nankoweap, R53.0, and Mouth of the Little Colorado, R61.8, were not surveyed this year due to time restraints.

OBJECTIVES

The flows of the Colorado River regulated by the Glen Canyon Dam will cause topographic changes on the surface of selected beaches throughout the river corridor in Grand Canyon National Park as compared to previously recorded measurements. This study is designed to measure and monitor these changes on an annual basis.

METHODS

(See Addendum I-1 for detailed description of procedures and list of recommended materials and equipment.)

Previously established benchmarks were located (one to five per beach) and two new benchmarks were set at Pancho's Kitchen, L136.6. Instrument stations were set (as per historical data) from which horizontal sight rod readings were taken, based on topography, following historical profiles.

Recordings of this cross sectional data were used to generate new beach profiles which were then compared and contrasted with past profiles.

RESULTS

Since 1987, beaches have essentially remained the same or lost sediment (See Table I-2; Figs. I-1 to I-41). On two beaches, local channeling in one area produced a slight gain in another.

Comparison of inner beaches:
- 25.7% lost sediment since 1987
- 65.7% remanied the same
- 8.6% showed a slight gain

Comparison of outer beaches
- 37.1% lost sediment
- 48.6% showed no change
- 14.3% showed a slight gain.

Comparison with original survey - Inner Beaches
- 33.3% lost
- 33.3% no change
- 33.3% gained

Comparison with original survey - Outer beaches
- 74.4% lost sediment
- 7.4% no change
- 22.2% gained

CONCLUSION

Glen Canyon Dam closed in 1963 and sediment, originally deposited during annual floods on Grand Canyon beaches, was trapped behind the dam. Since that time the beach sands have shown loss due to erosion.

Most of the over 200 beaches in the Grand Canyon gained sand in 1983 after an unexpected high-water spill. Since 1983, these same beaches have been gradually eroding.

Beaches in this year's survey essentially remained the same or lost sediment. Slight gains on inner beaches could be due to blowing dunes. Gains and losses on the outer beaches are caused by the river and/or flash flooding. On balance these processes have taken away more than they have put back on most beaches being monitored.

A comparison of each beach with its original survey is difficult, since some surveys were conducted during 1975 whereas others were not begun until after the 1983 floods. A summary of gain or loss of sand on the beaches surveyed this year is given in figures I-42 and I-43).

Table I-1. Beach Profiles Surveyed.

River Mile	Beach Name	1974	1975	1980	1982	1983	1984	1985	1986	1987	1988
L18.2	Upper 18 Mile Wash		2			2	2	2	2	2	1
L19.3	19 Mile Wash (gone)		2	1		2		2	2		
L34.7	Nautiloid Canyon	2	2			2	2	2	2	2	2
R53.0	Lower Nankoweap	3	3	1		1	3	2	1	2	
R58.1	Awatubi						1		1	1	1
R61.8	Mouth of the Little Colorado	1		1		1	1	1	2	1	
L65.5	Tanner Mine	2		2		2	2	2	2		
R72.2	Unkar Indian Village (gone)	1	1	3		2	1				
L75.5	Nevills Rapid (new 1984)						2	2	2	2	1
L81.1	Grapevine	2		2		2	1	2	2	2	2
L87.1	Lower Suspension Bridge		2	1				1			
L93.2	Upper Granite Rapid	2		1		2	2	2	2	2	2
R109.4	109 Mile (gone)	2				1	2				
R112.2	Waltenberg Canyon (gone)	1		1		1	1				
R120.1	Blacktail Canyon	2		2	1	2	2	2	2	2	2
R122.0	122 Mile Beach (new 1985)							2	2	2	2
R122.8	Forster Canyon (new 1983)					3	3	3	3	2	3
L124.4	Upper 124 1/2 Canyon (gone)	2			1	1					
R131.0	Bedrock Rapid	2		2		2	2	2	2	2	2
L136.6	Pancho's Kitchen (new 1988)										2
L151.6	The Ledges (gone)	2	2			1	2	2		1	
L166.5	Upper National		2	1		1	2	2		2	2
L166.6	Lower National (new 1985)							2	5	5	5
R180.9	Lower Lava Falls	2		2		2	2	2	2	2	2
L190.2	190 Mile		1	1			1	1	1	1	1
L193.9	194 Mile Beach (new 1987)									3	3
L208.8	Granite Park	2	2	2	1	2	2	2	2	2	2
R220.0	220 Mile Beach (new 1985)							2	2	2	2

1974, 1975 data from Howard (1975)
1980 data from Dolan (1981)
1982 data from Beus and others (1982)
1983 data from Beus and others (1984)
1984 data from Beus and others (1985)
1985 data from Beus and others (1986)
1986 data from Beus and others (1987)
1987 data from Beus and others (1988)
1988 data from this report

Table I-2. Summary of loss or gain of beach sand.

		1988-1987		1988-Original Survey	
Beach	Profile	Inner	Outer	Inner	Outer
L18.2	CS1	-5.0	+1.0	-3.0	+3.0
L34.7	CS1	0.0	-0.5	+5.0	+4.0
	CS2	0.0	0.0		
R58.1	CS1	+2.0	+2.0	0.0	-2.0
L75.5	CS1	0.0	0.0	+2.5	+2.0
L81.1	CS1	+1.0	+1.0	+2.0	+3.0
	CS2	0.0	0.0	+4.0	+1.0
L93.2	CS1	+0.5	+0.5	+3.0	-3.0
	CS2	0.0	+0.5	-3.0	-3.0
R120.1	CS1	0.0	0.0	+2.0	-3.0
	CS2	0.0	0.0	+6.0	-1.0
R122.0	CS1	-0.5	0.0	-3.0	-2.0
	CS2	-1.5	0.0	-2.0	-4.0
R122.8	CS1	0.0	0.0	+1.5	+2.0
	CS2	0.0	-2.0	0.0	-1.0
	CS3	-2.0	-6.0		
R131.0	CS1	0.0	0.0	0.0	0.0
	CS2	0.0	0.0	0.0	-1.5
L136.6	CS1	new survey			
	CS2	new survey			
L166.5	CS1	-2.0	-1.0	-4.0	-3.0
	CS2	-2.0	-2.0	-6.0	-4.0
L166.6	CS1	0.0	-1.0	-1.0	-1.0
	CS2	0.0	-1.0	0.0	-4.0
	CS3	0.0	-2.0		
	CS4	0.0	0.0		
	CS5	0.0	-2.0 (gully)		
R180.9	CS1	0.0	0.0	0.0	0.0
	CS2	-2.0 (gully)	0.0	0.0	-3.0
L190.2	CS1	0.0	0.0	-2.0	-1.0
L193.9	CS1	0.0	0.0		
	CS2	0.0	0.0		
	CS3	0.0	-1.5		
L208.8	CS1	-1.5	-0.5	-5.0	-4.0
	CS2	0.0	0.0	+4.5	-2.0
R220.0	CS1	0.0	-2.0	0.0	-3.0
	CS2	-1.0	-3.0	0.0	-3.0

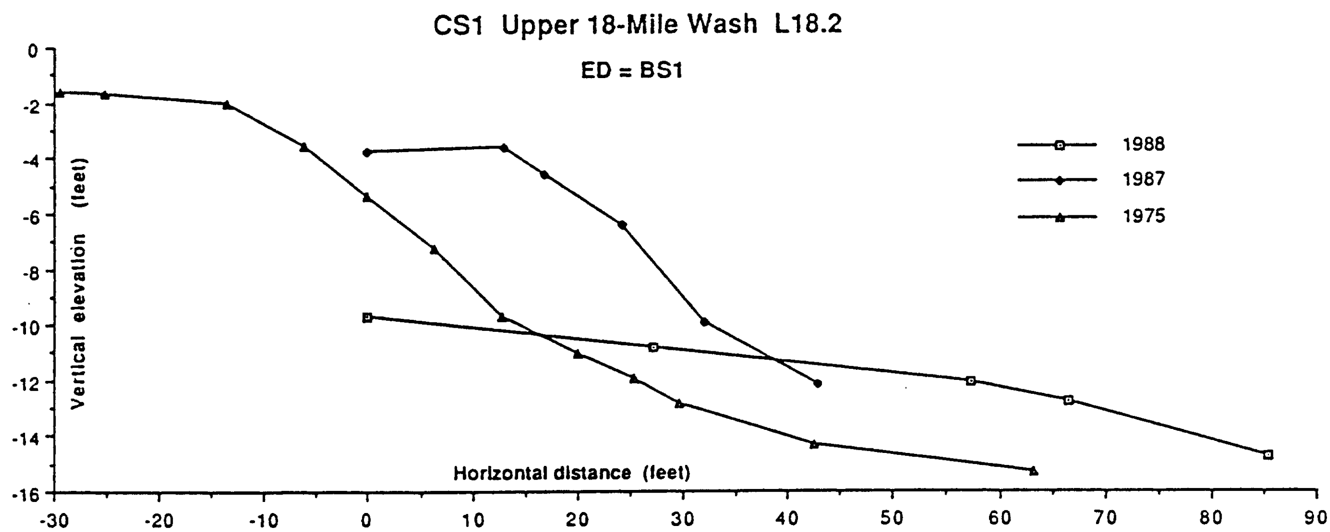
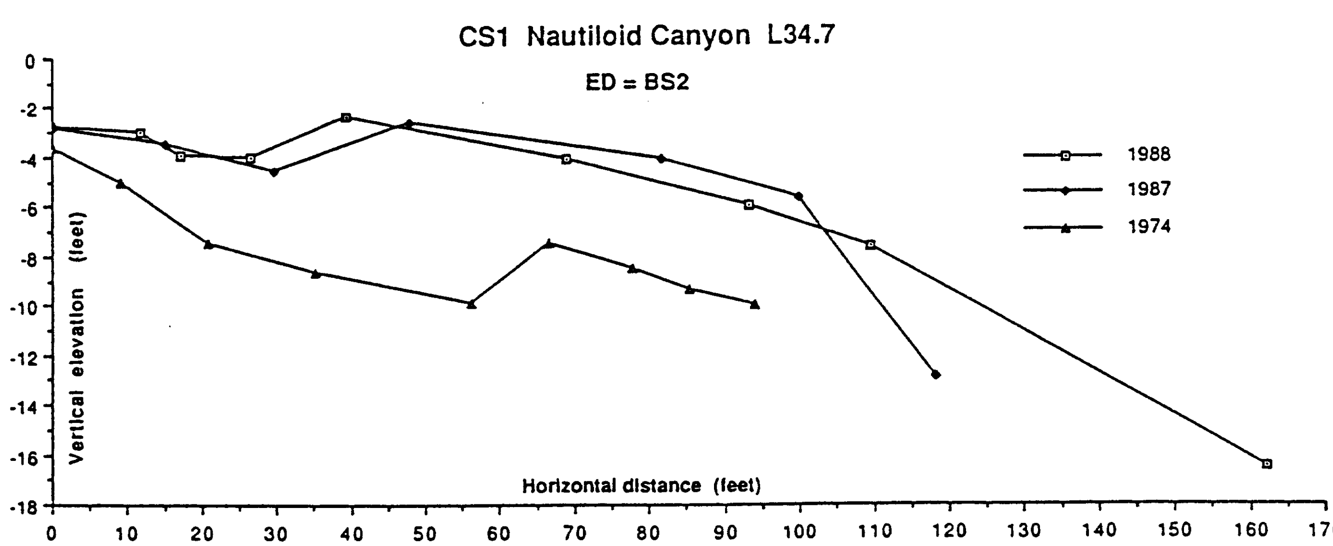


Figure I-1



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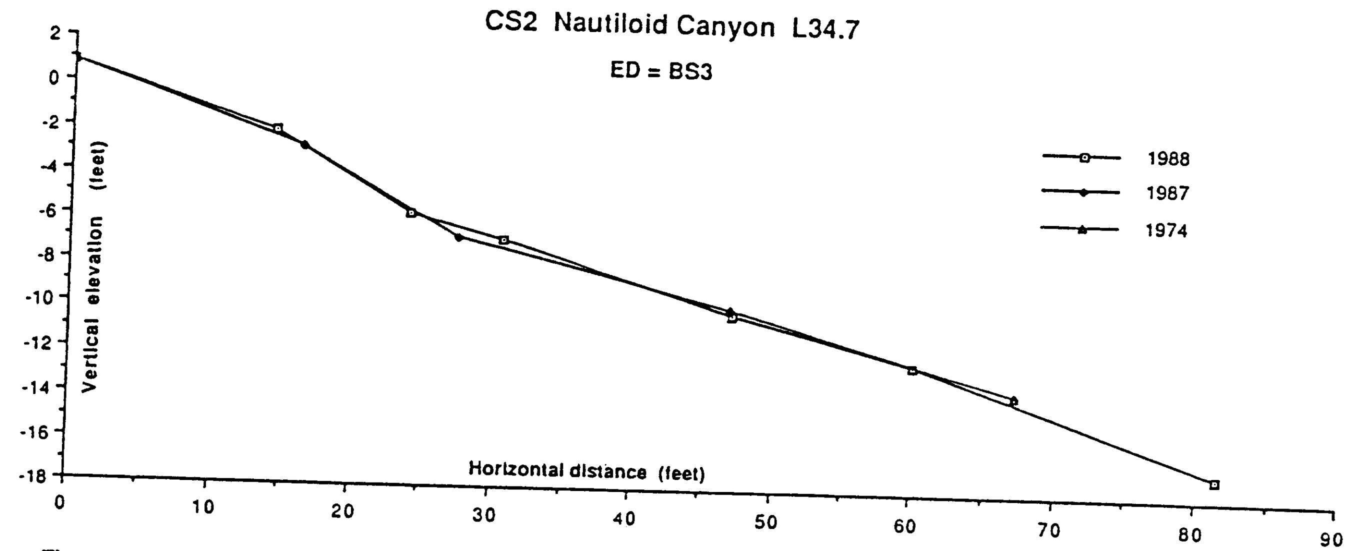

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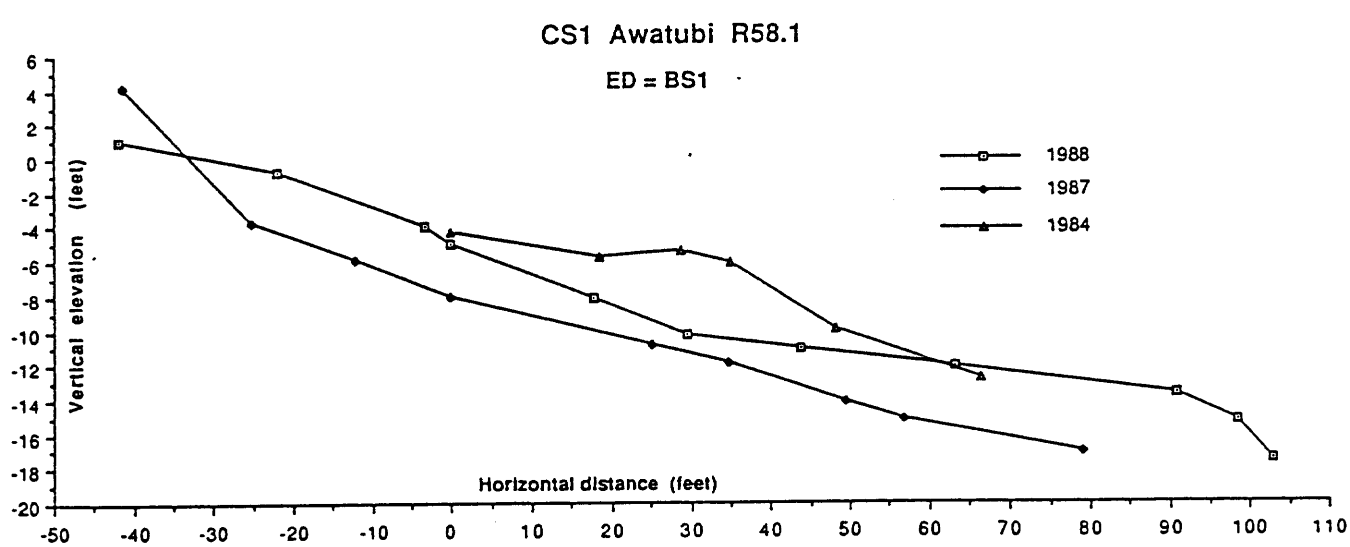

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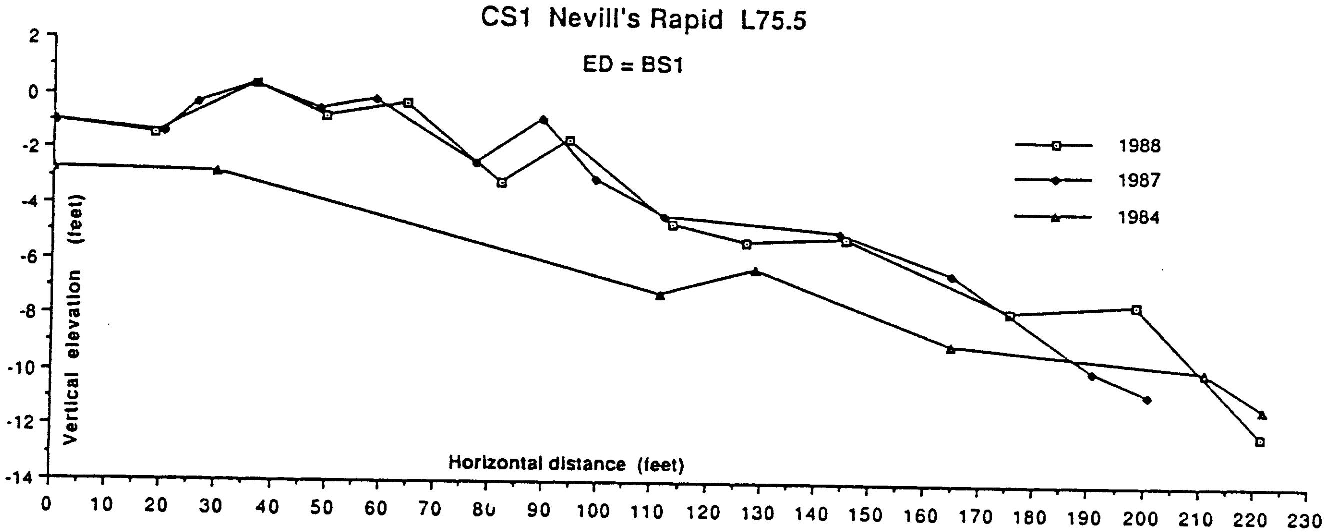

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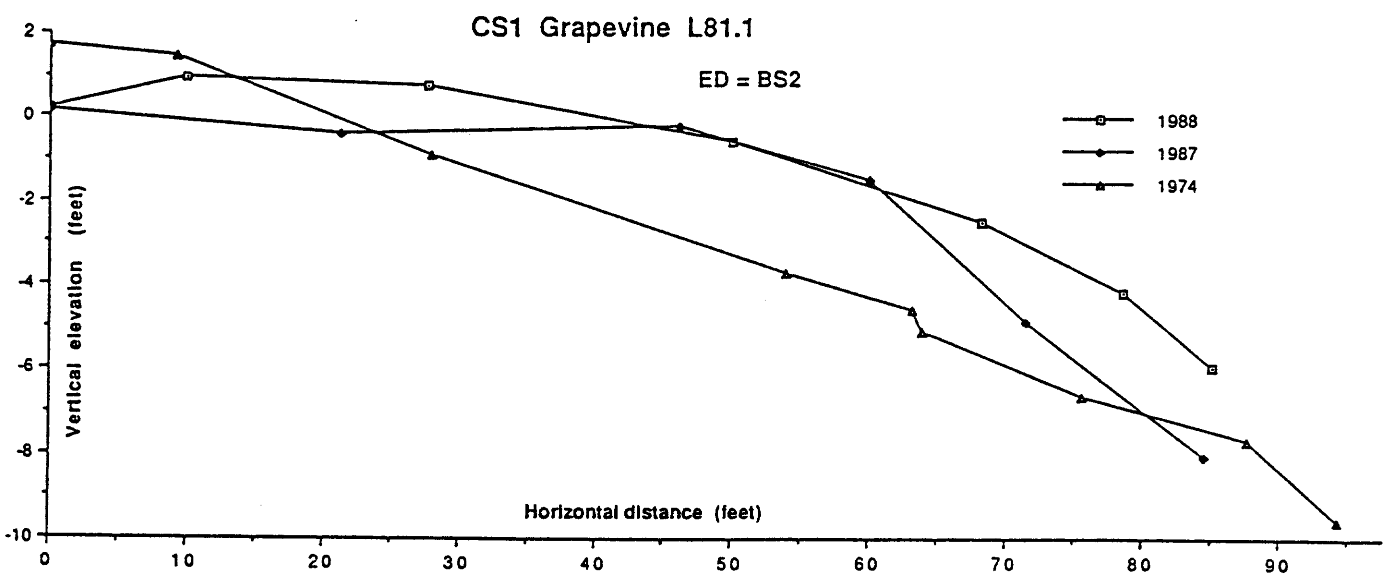

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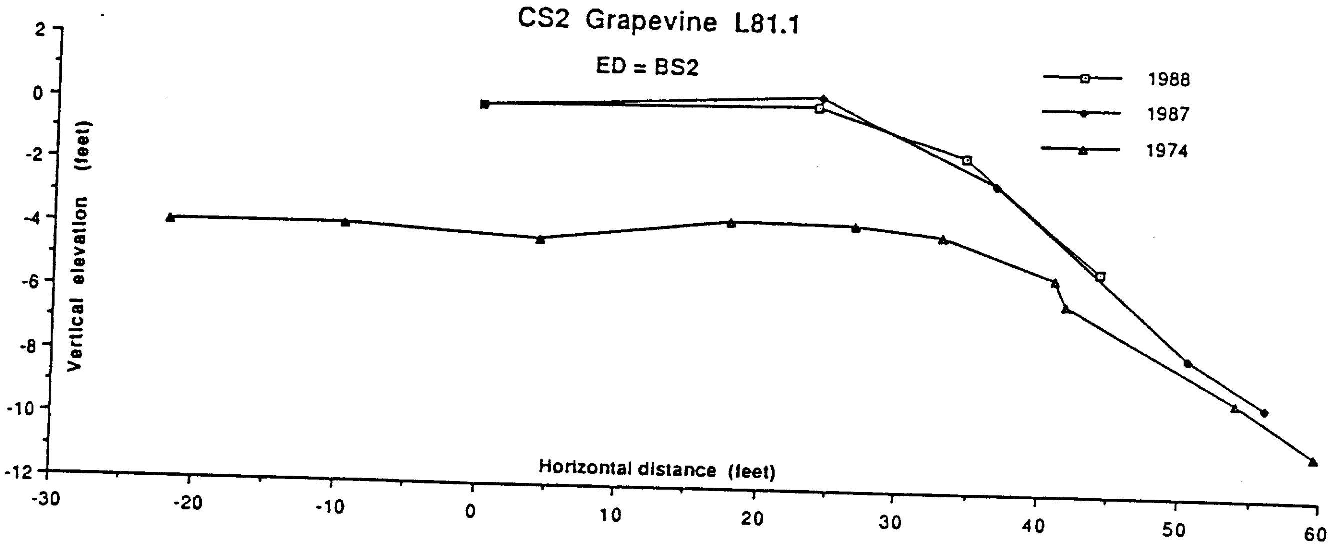

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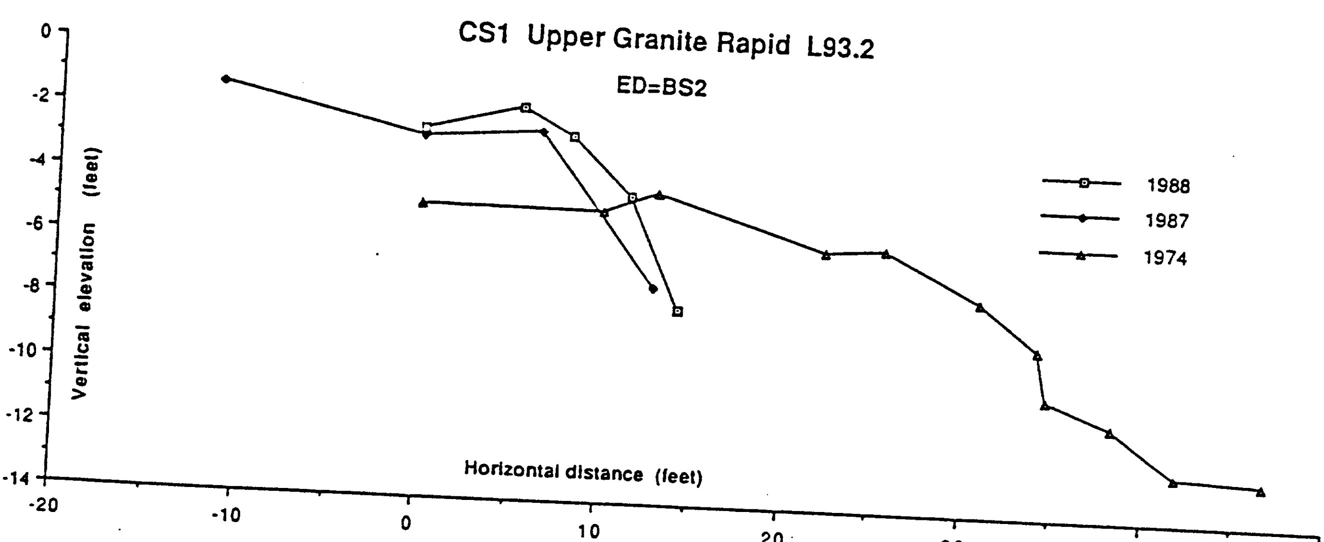

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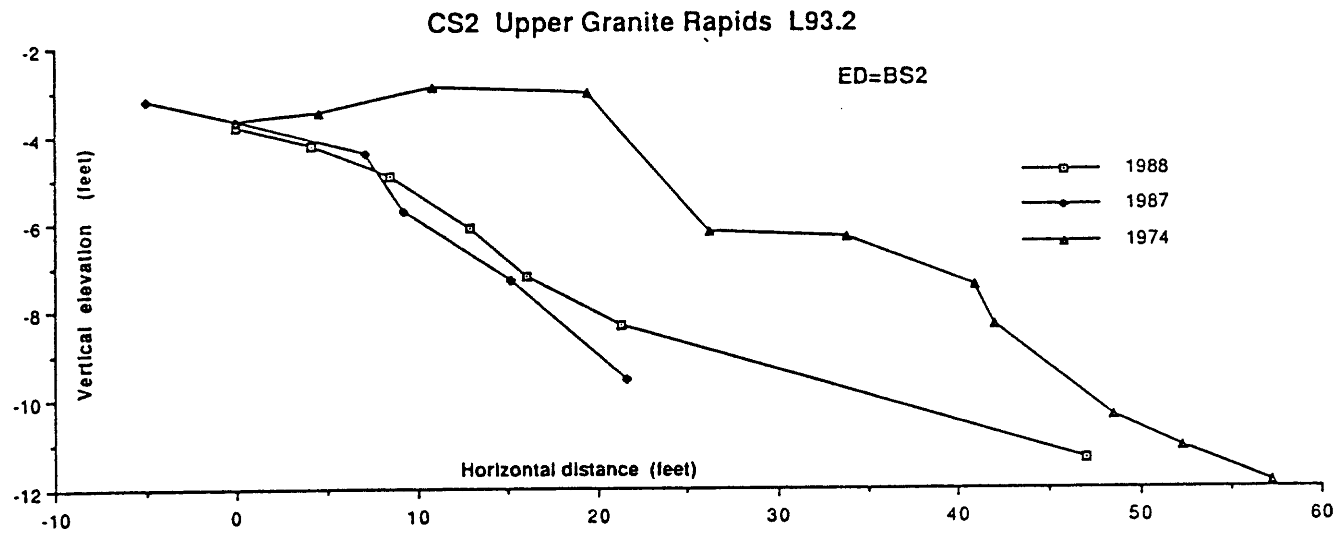

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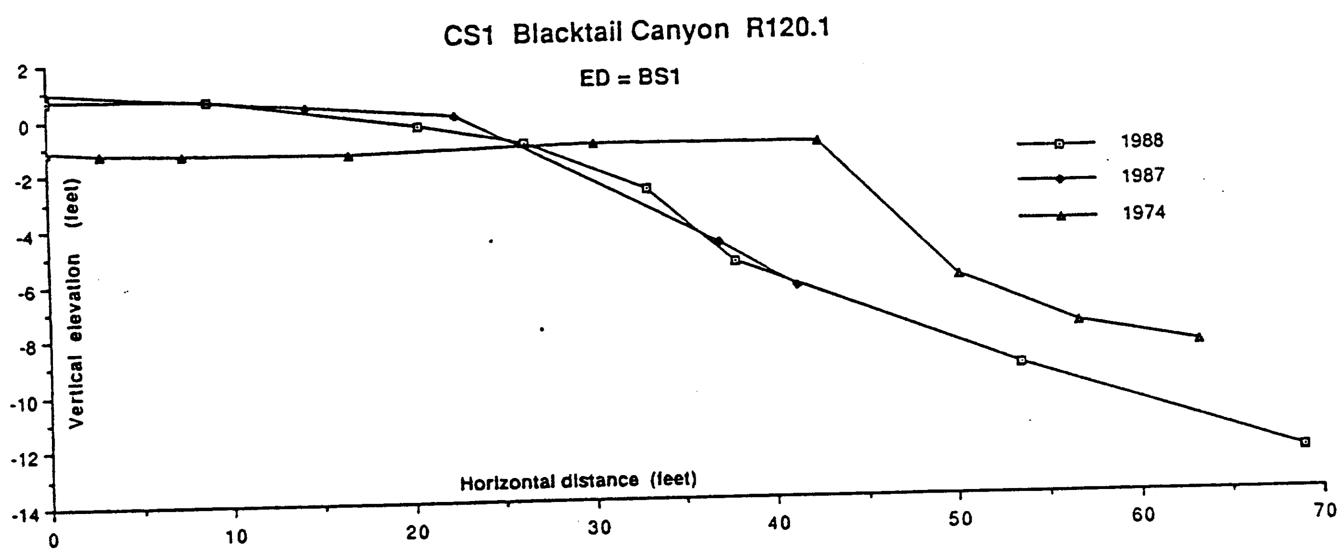

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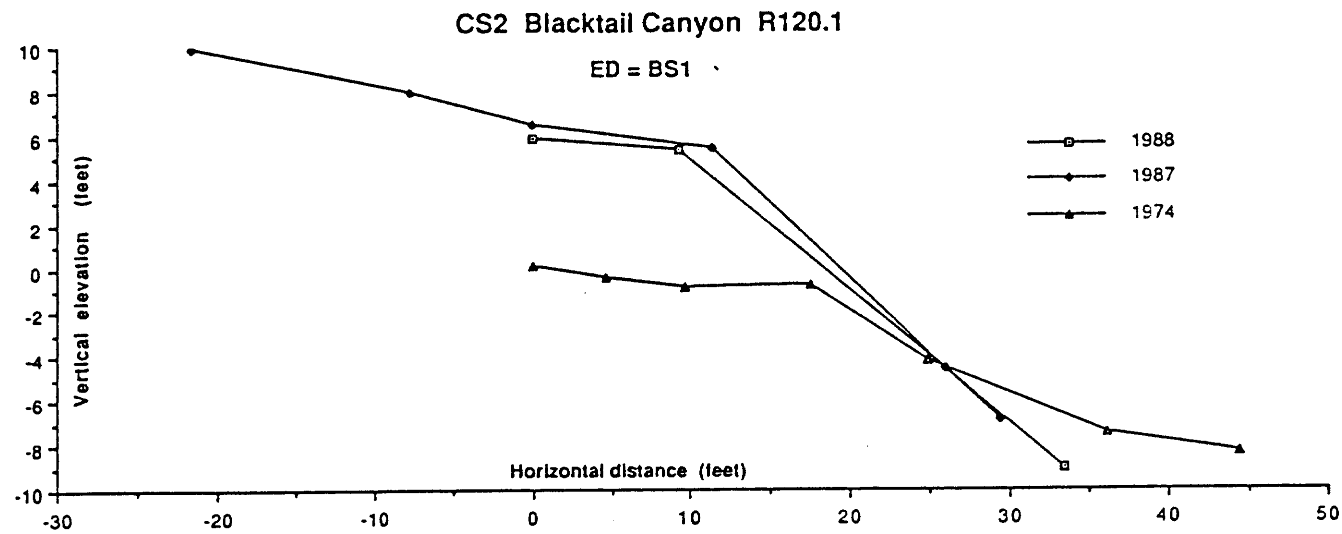

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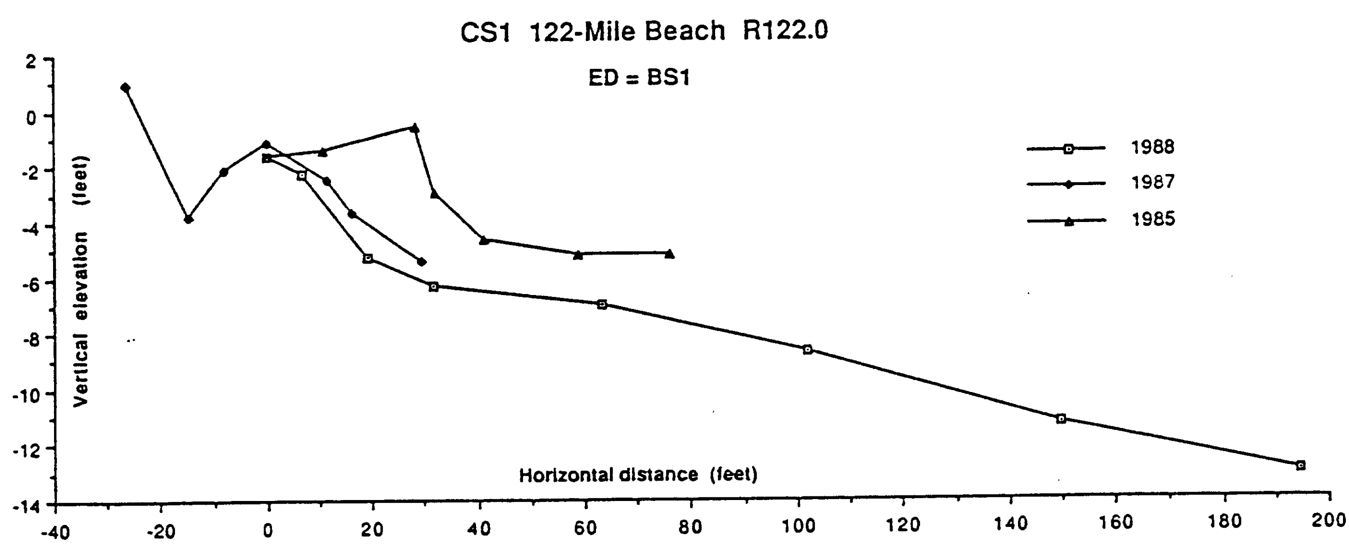

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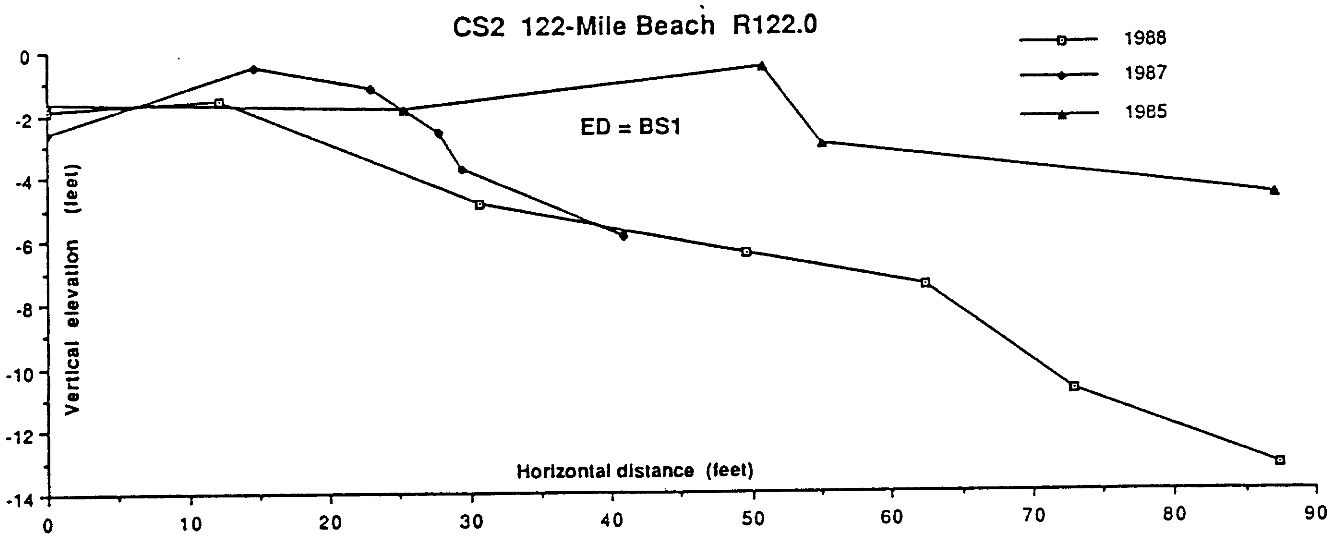

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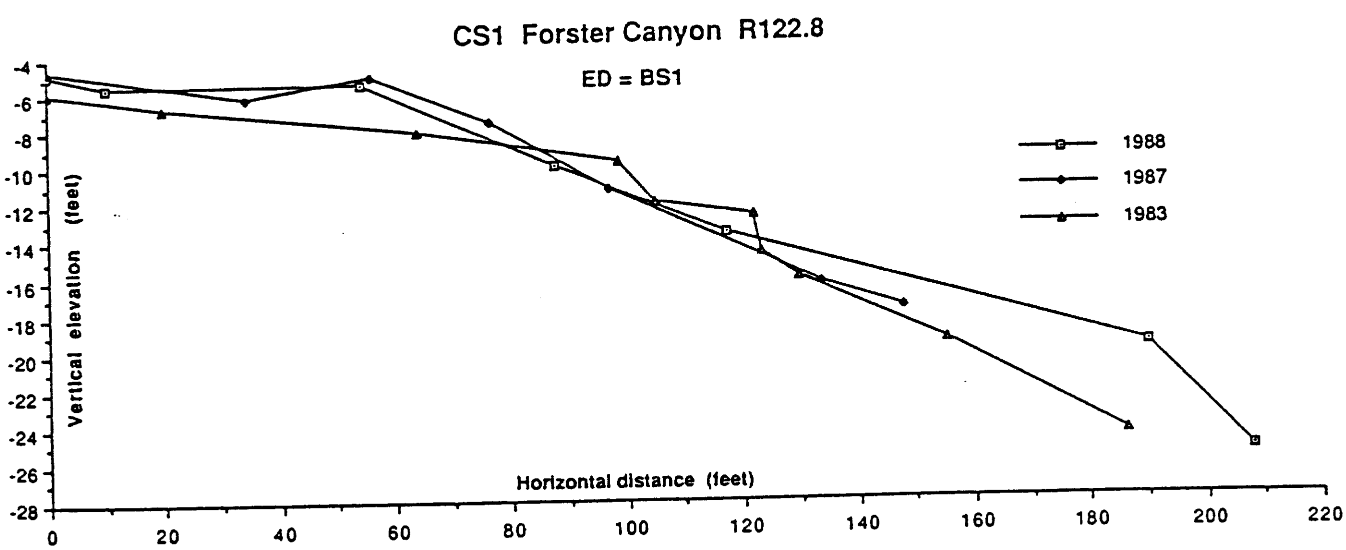

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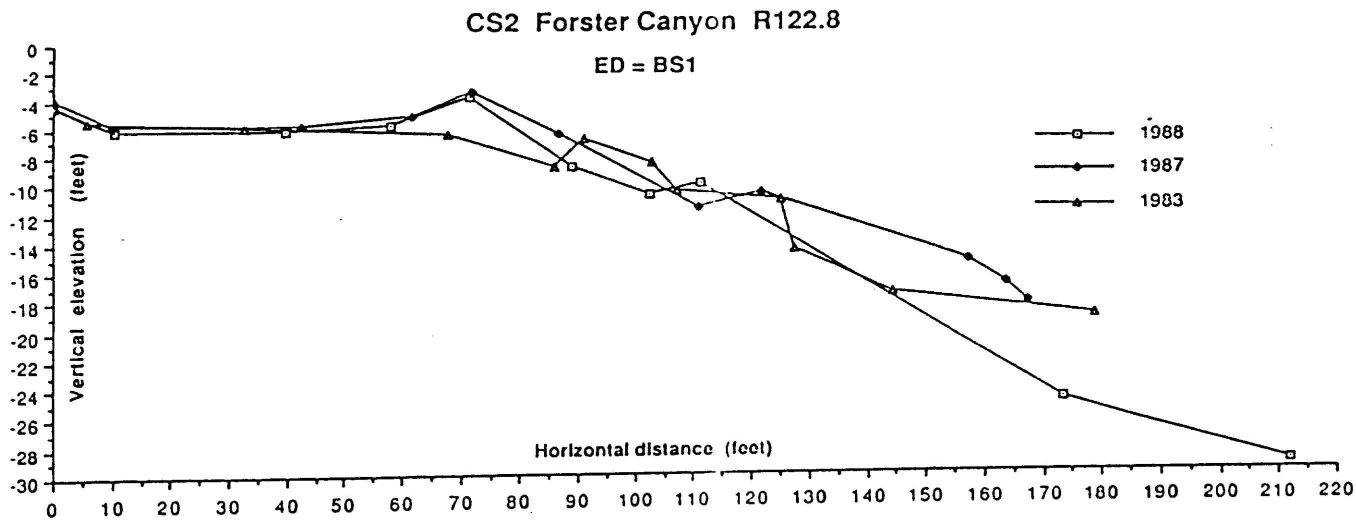

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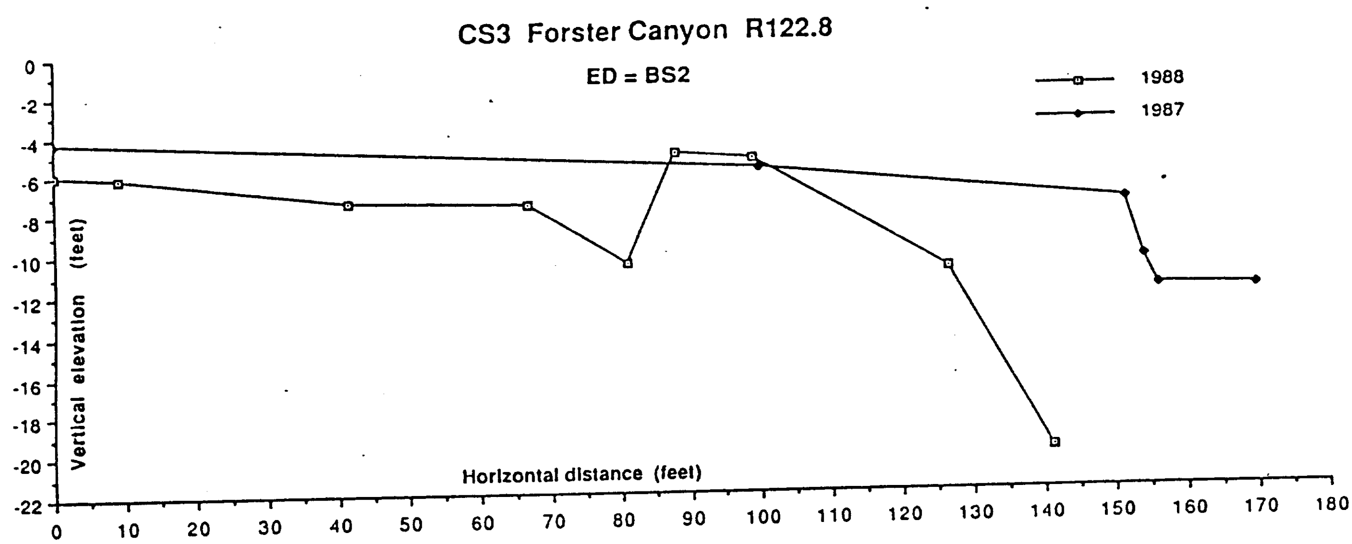

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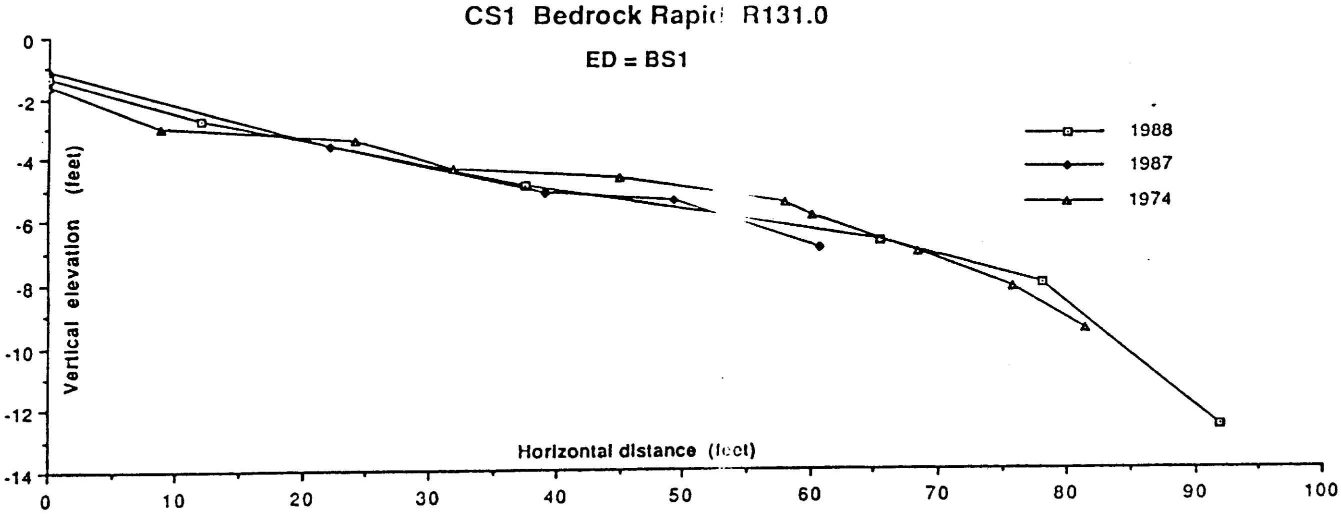

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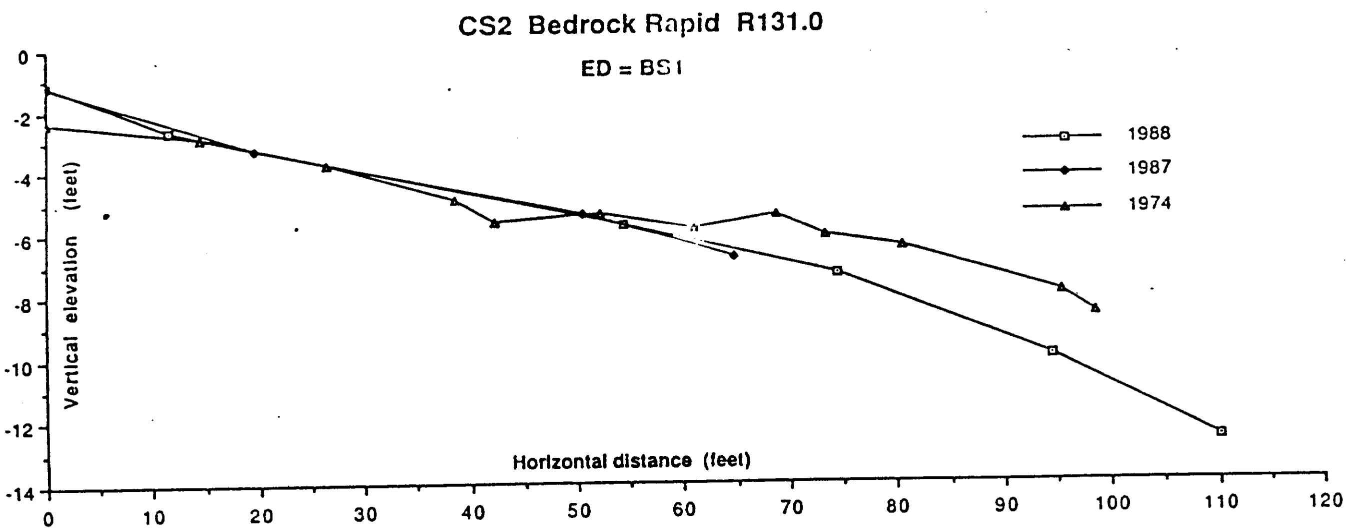

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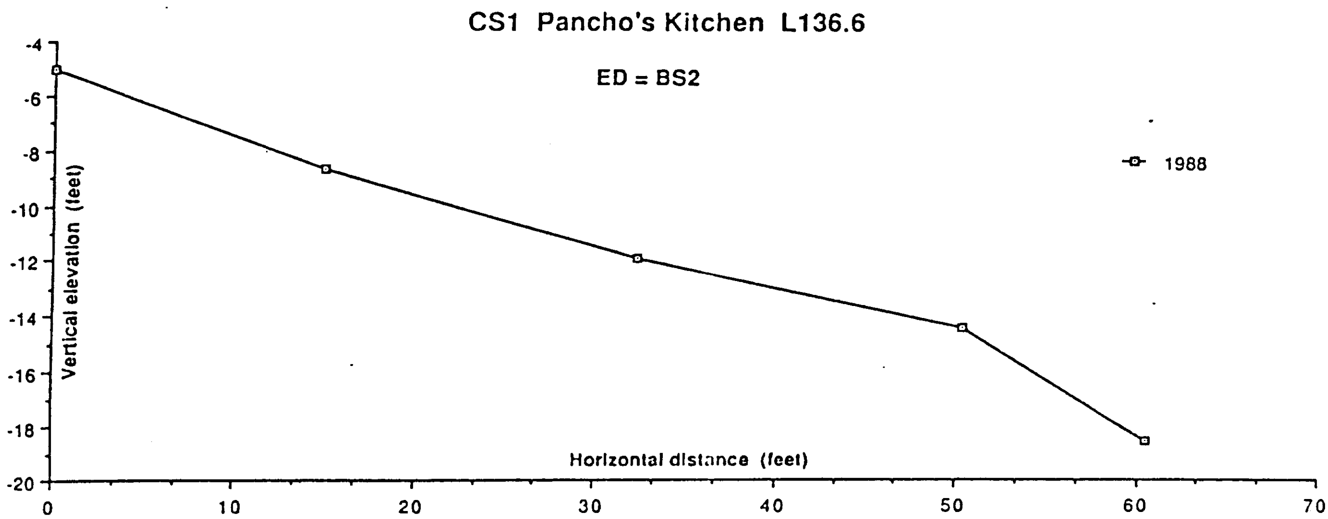

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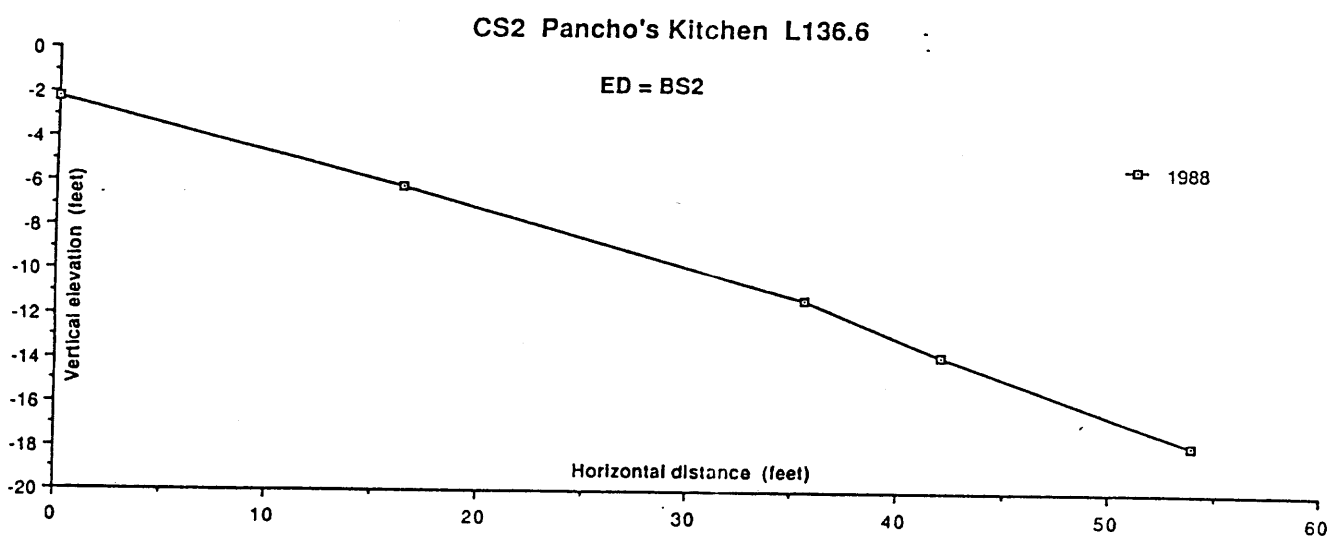


Figure I-20

BEACH PROFILE LOCATION SHEET

?

Site Panchos Kitchen   Mile Post 136.6

Date established 8/2/86

AFTER A LIGHTNING FILLED NIGHT

Base station #1 NAIL IN CRACK IN TAPEATE SS. 6' ABOVE SAND UNDER OVERHANG   Photo yes
Perm. mark NAIL   33

.77' from Nail to overhang above

Base station #2 LIME STONE ROCK   Photo Yes
Perm. mark X CHIPPED IN GREY LIMESTONE

Base Station #3 NONE   Photo ______
Perm. mark ______

223°
230° 53'
73

Elevation datum BS2   Photo # ______

Length of base line #1 152.3 Ft from BS1 TO BS2
Base line orientation N74W from BS2

Length of base line # 2 ______ from ______
Base line orientation ______ from ______

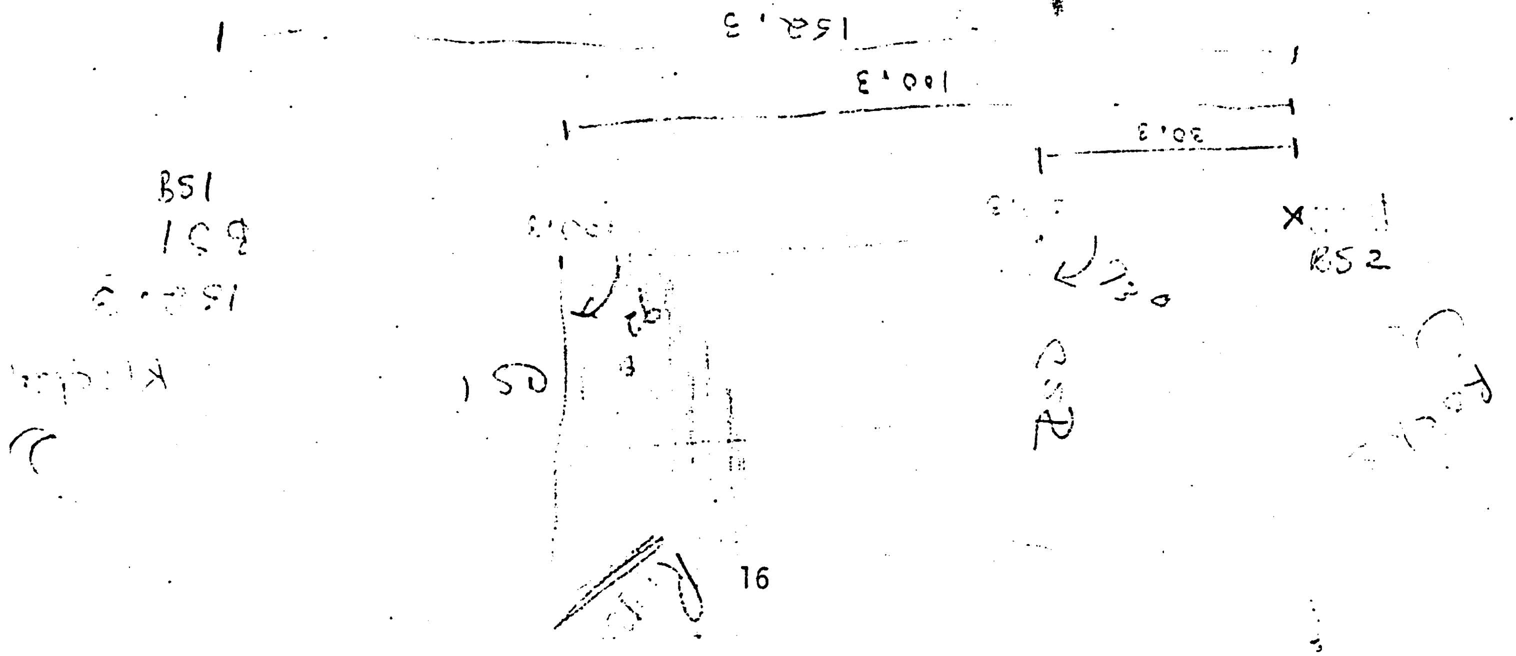
Length of base line #3 ______ from ______
Base line orientation ______ from ______

Cross section #1: ______ from CS1 to BS2
at an angle of 12 (counter) clockwise from direction of BS2

Cross section #2: ______ from BS2 TO ...
at an angle of 93° (counter) clockwise from direction of BS2

Cross section #3: ______ from ______
at an angle of ______ (counter) clockwise from direction of ______

Comments



CROSS-SECTION DATA SHEET

MILE: 136.6

CAMPGROUND NAME: Pon Hos Kitchen

CROSS-SECTION NO.

SURVEY DATE: 8/2/88

ORIGINAL SURVEY? yes

RESURVEY NO.

Tue. 8/2/88 9:30

FROM	TO	ROD READING (feet)	SLOPE DISTANCE (ft/in)	VERTICAL ANGLE (deg)	HORIZONTAL DISTANCE	COMMENTS Low Water
CS2	BS2	2.54				HI
CS2	CS2	4.75				
CS2	1	8.75			16.4	
CS2	2	13.92			35.5	TOP of CUTBANK
CS2	3	16.42			42.0	Hi WATER LINE
	4	20.36			53.9	Water edge
CS2	BS1	000		−1°20'	122.0	
CS1	BS2	000		+0°30'	100.3	42 47 92"
CS1	CS1	4.20				HI
CS1	1	7.80			14.9	
CS1	2	11.03			32.4	
	3	13.52			50.3	Top of Cutbank
	4	17.67			60.5	Water edge

42.47
49.11
91.60
92°

COMMENTS:

LS

Figure I-21. BS 1 at Ponchos Kitchen. L 136-6.

Figure I-22. BS 2 at Ponchos Kitchen. L 136.6.

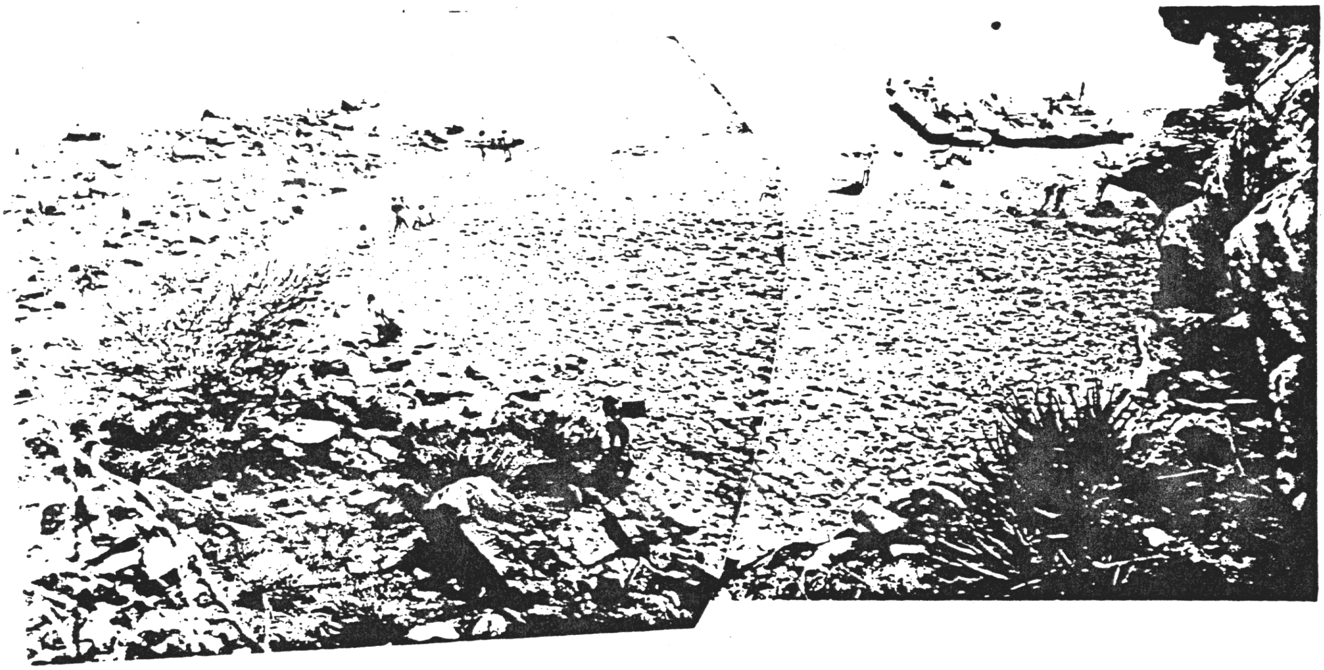


Figure I-23. Beach at Ponchos Kitchen

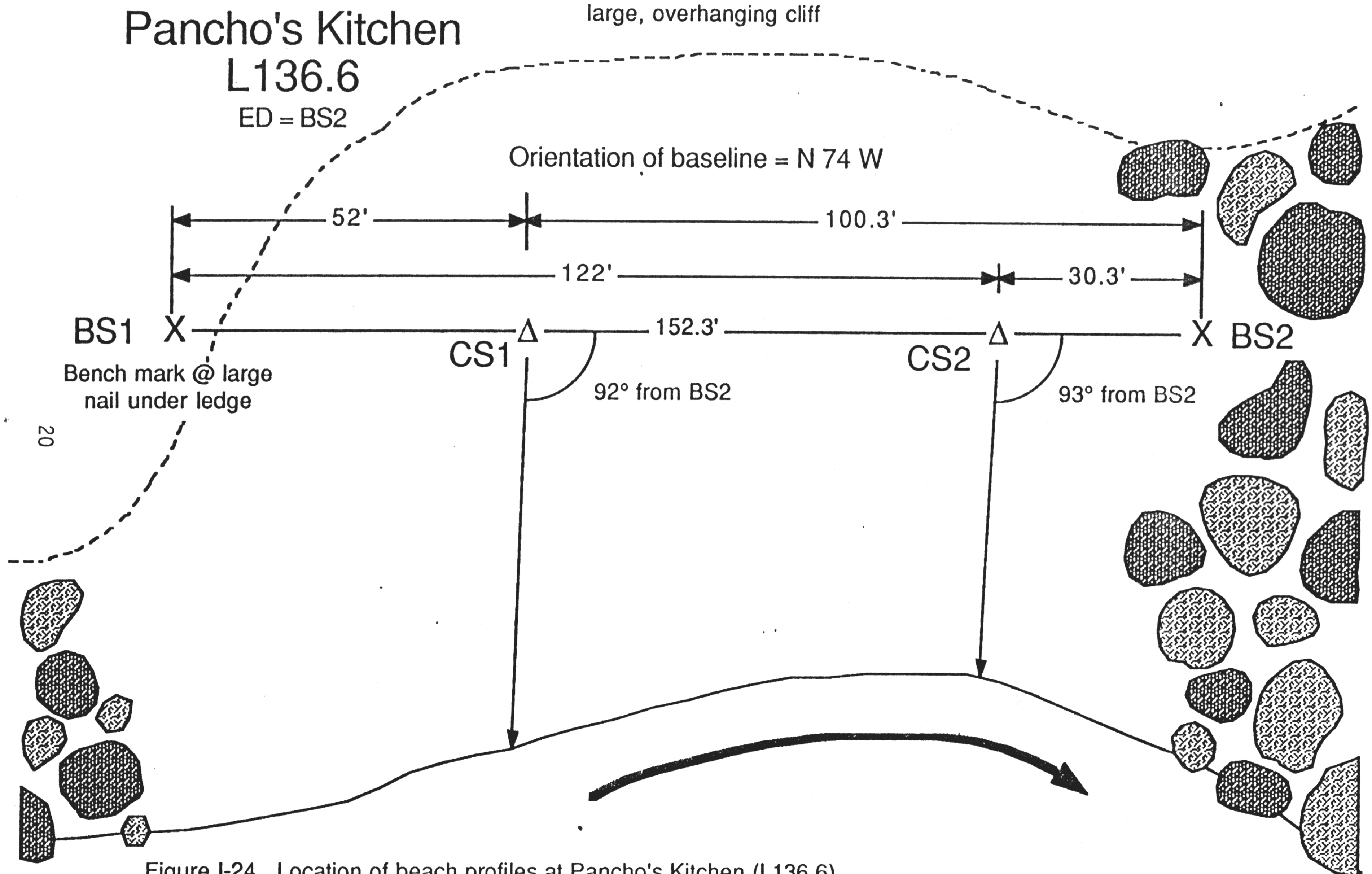
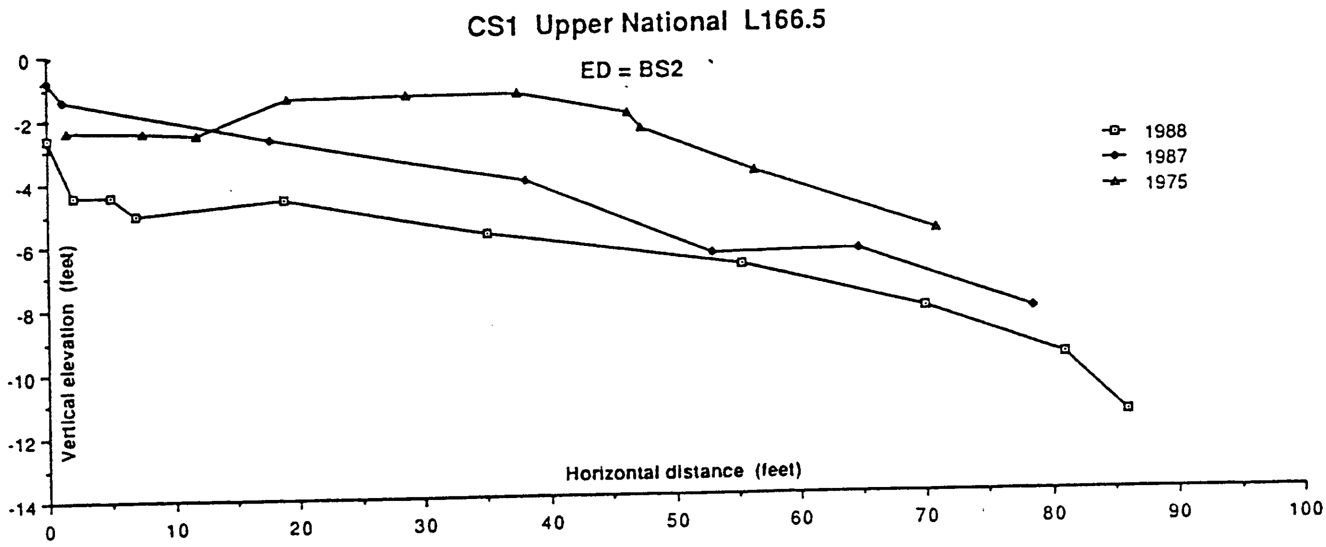


Figure I-24. Location of beach profiles at Pancho's Kitchen (L136.6)



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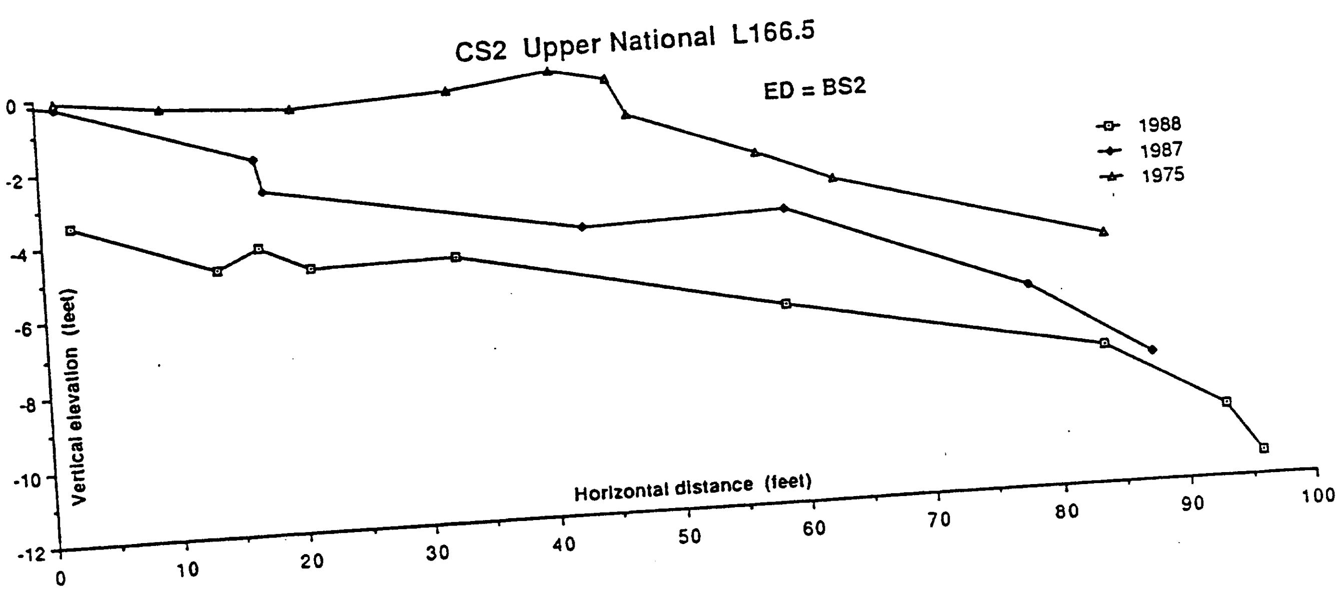

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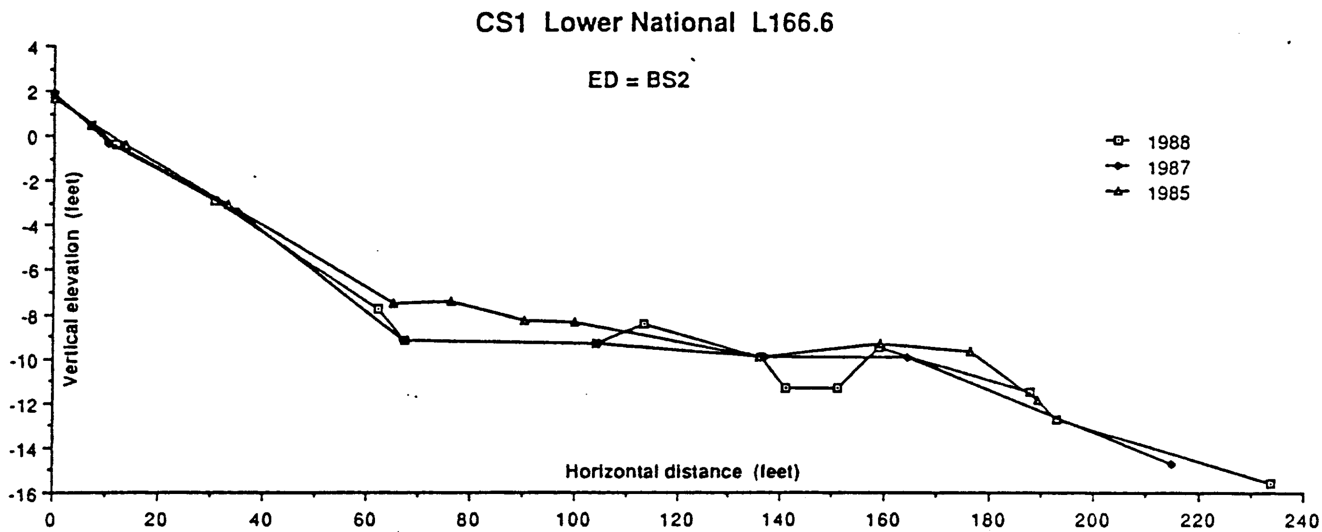

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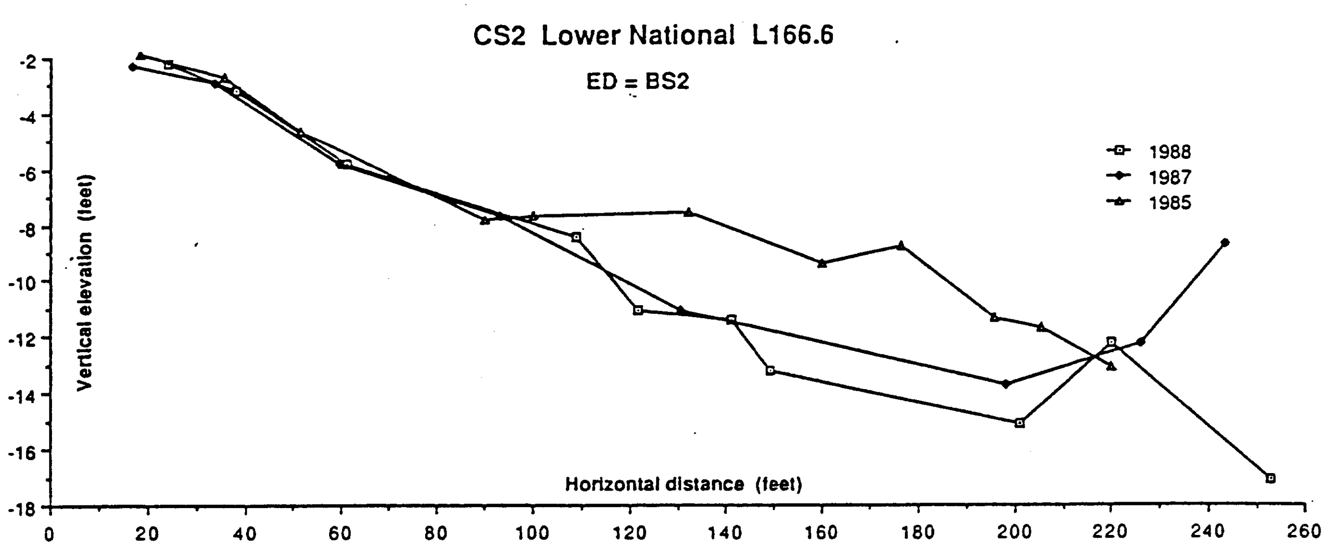

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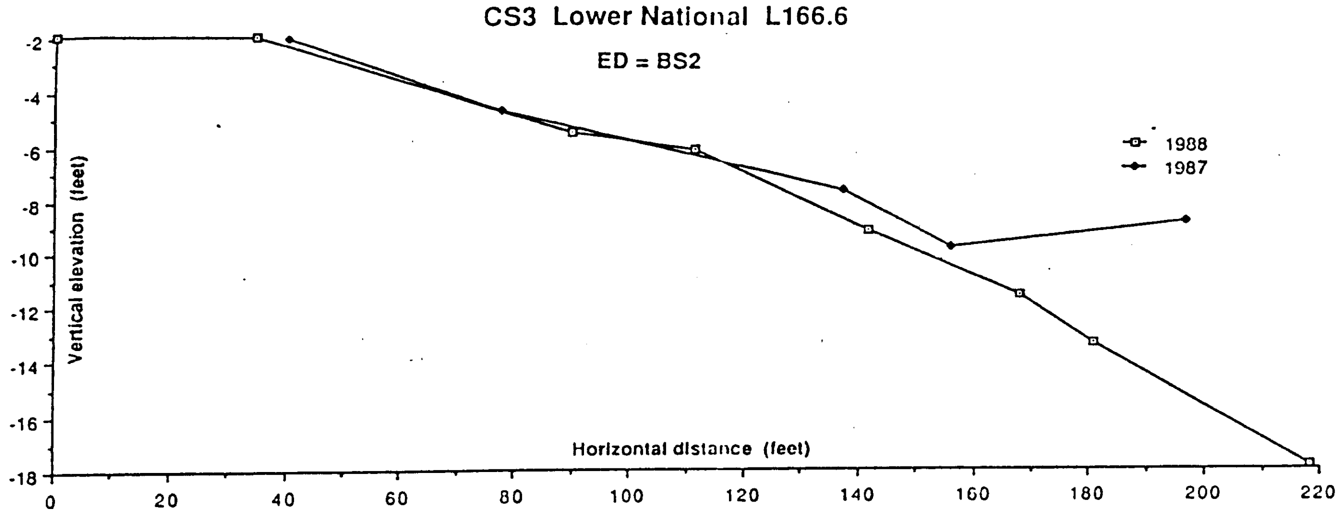

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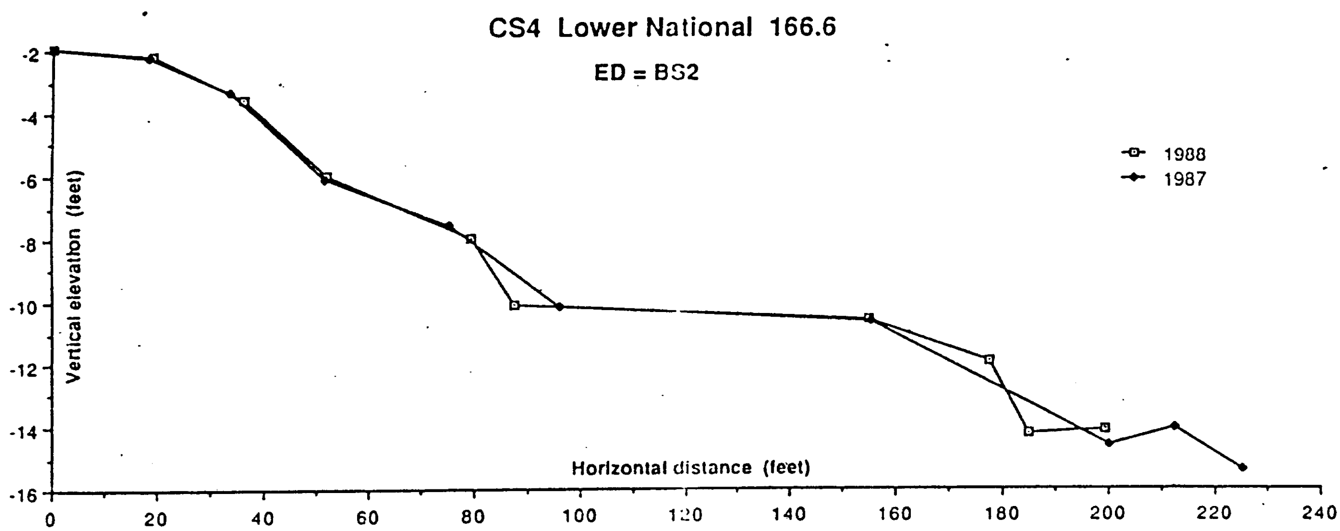

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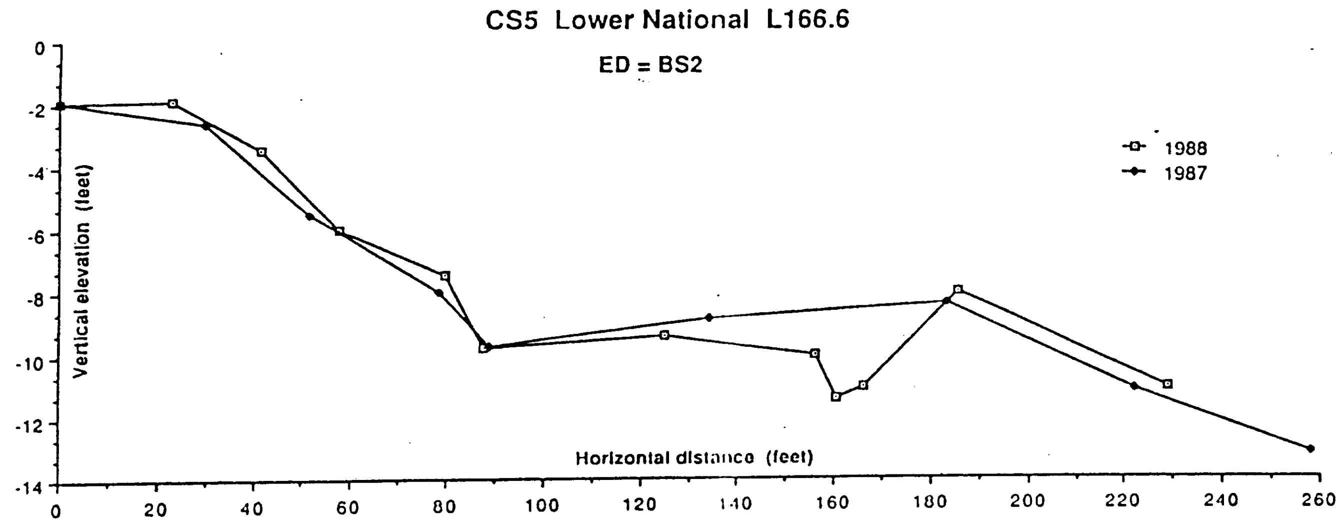

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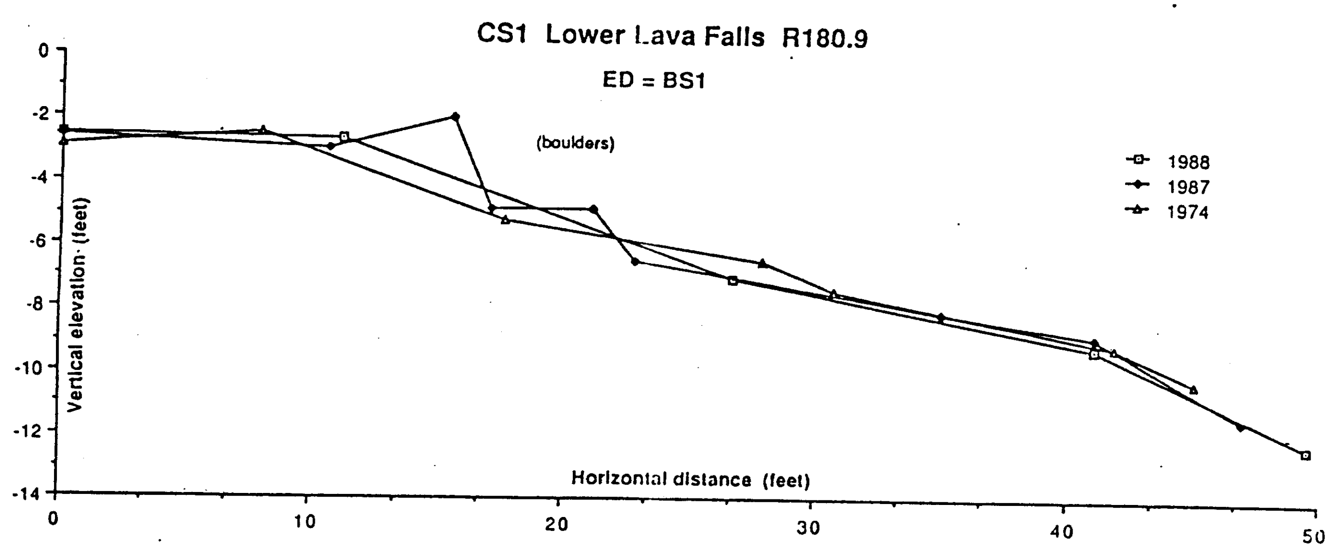

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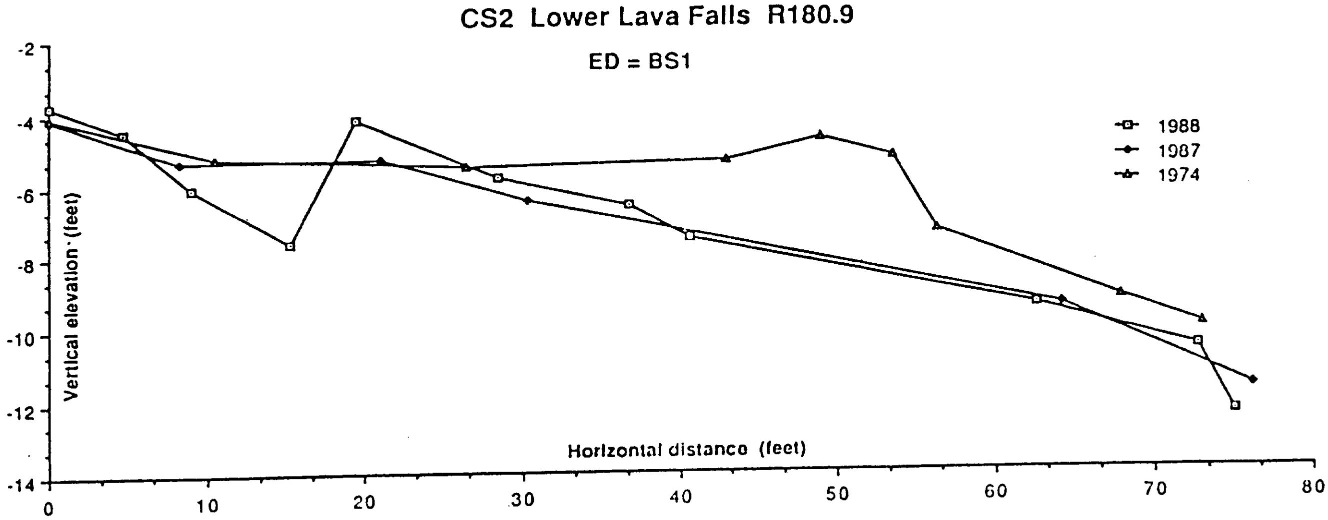

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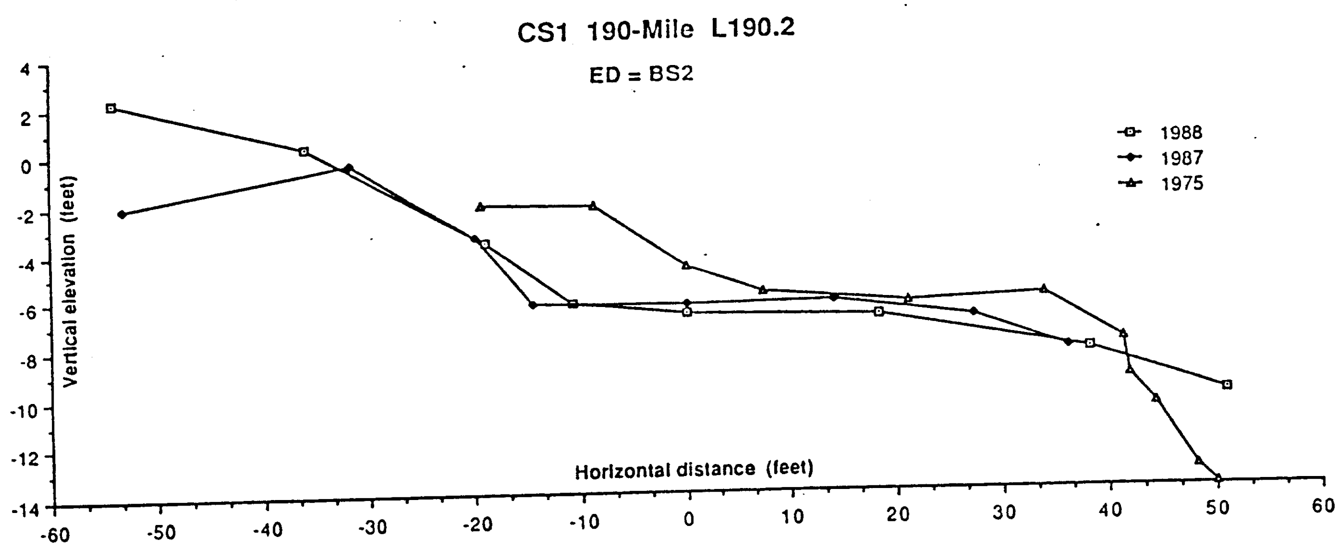

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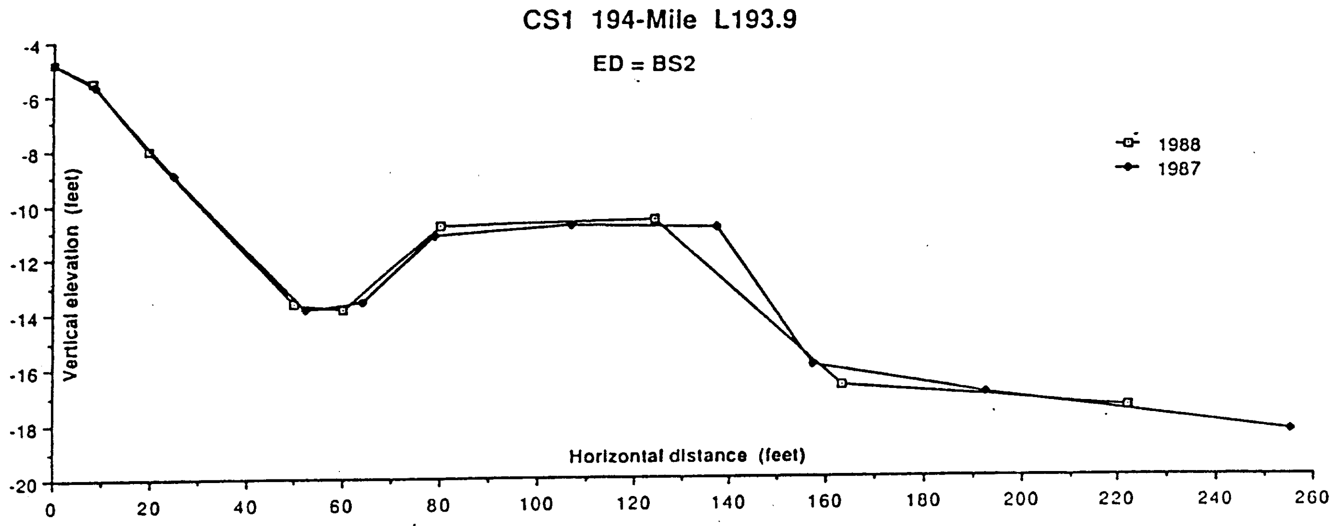

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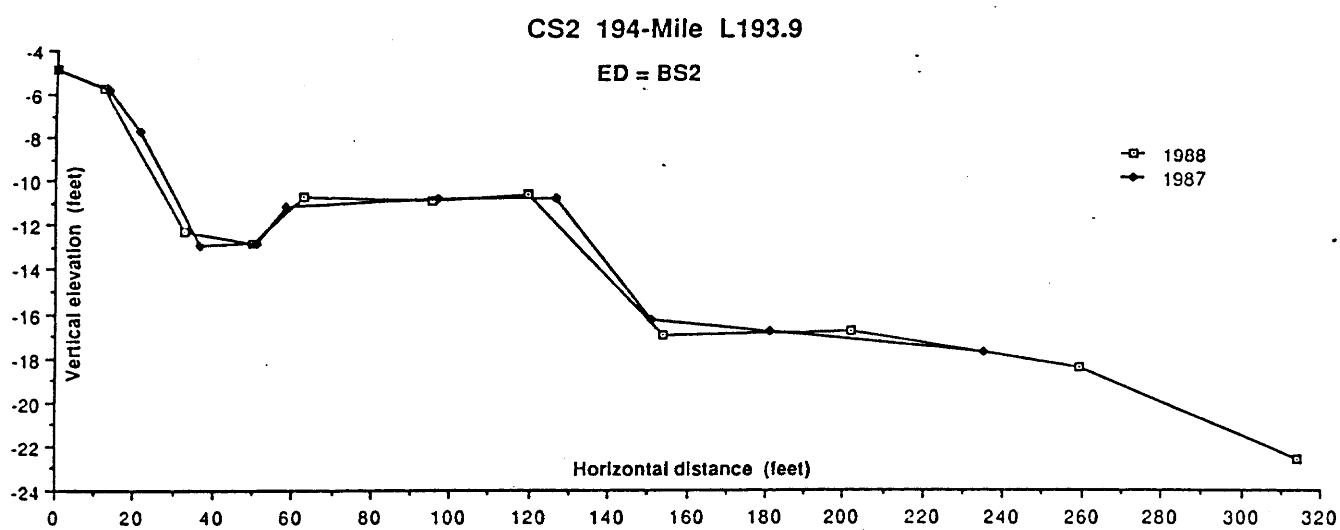
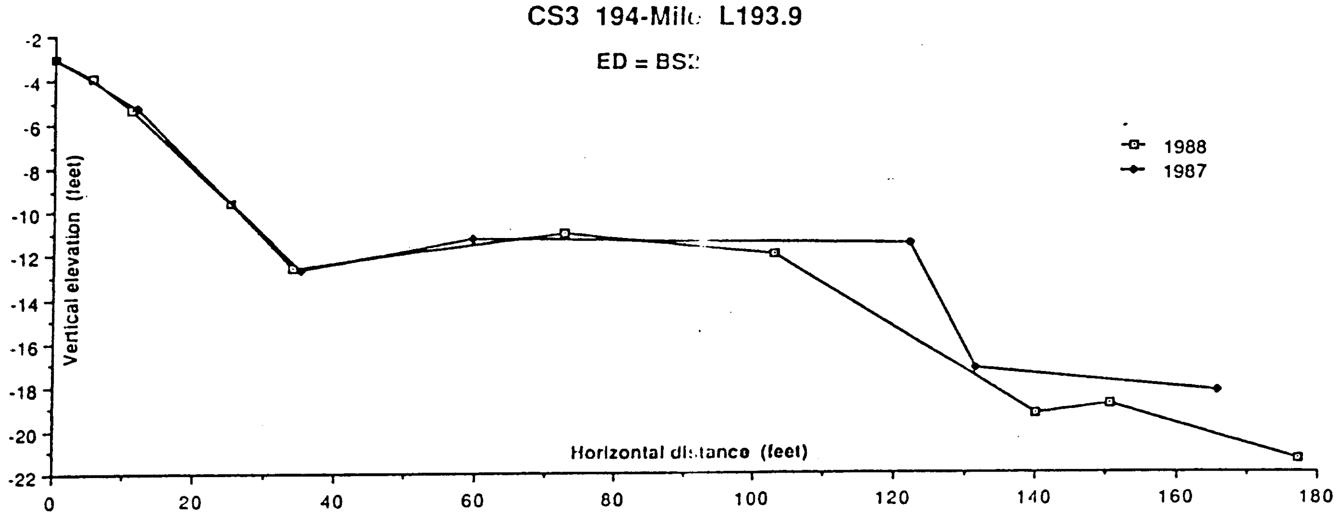


Figure I-36



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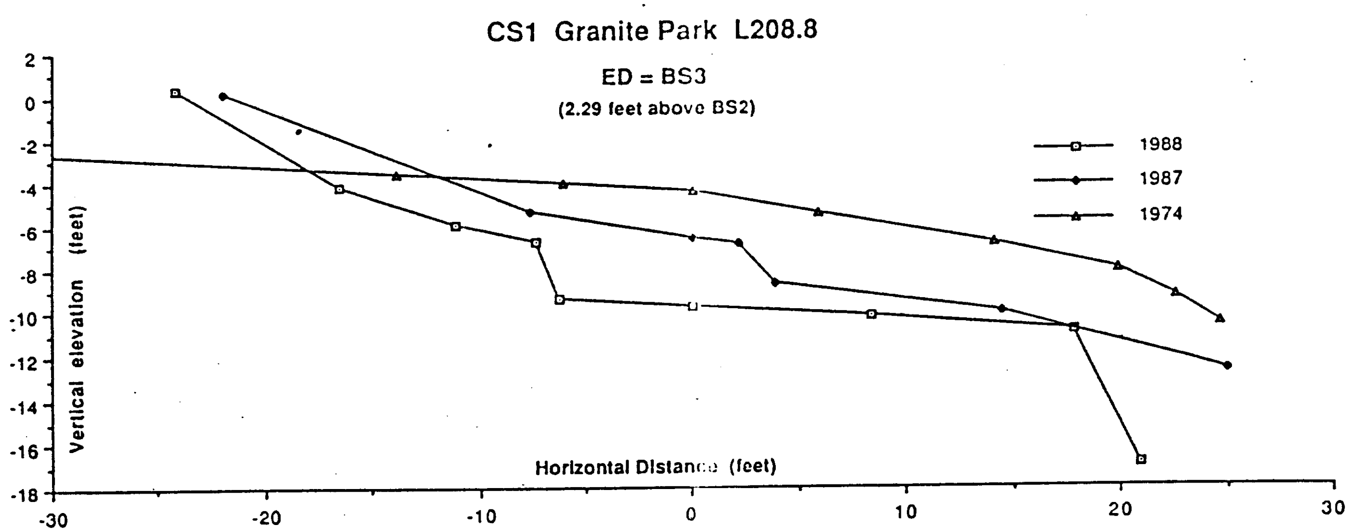


Figure I-38

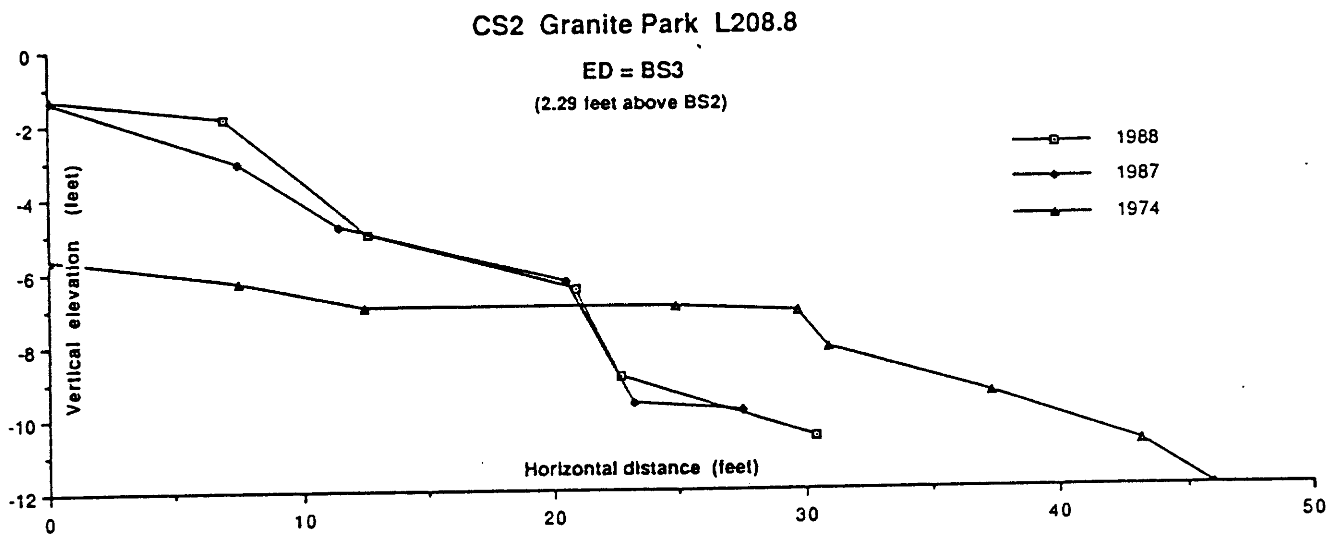


Figure I-39

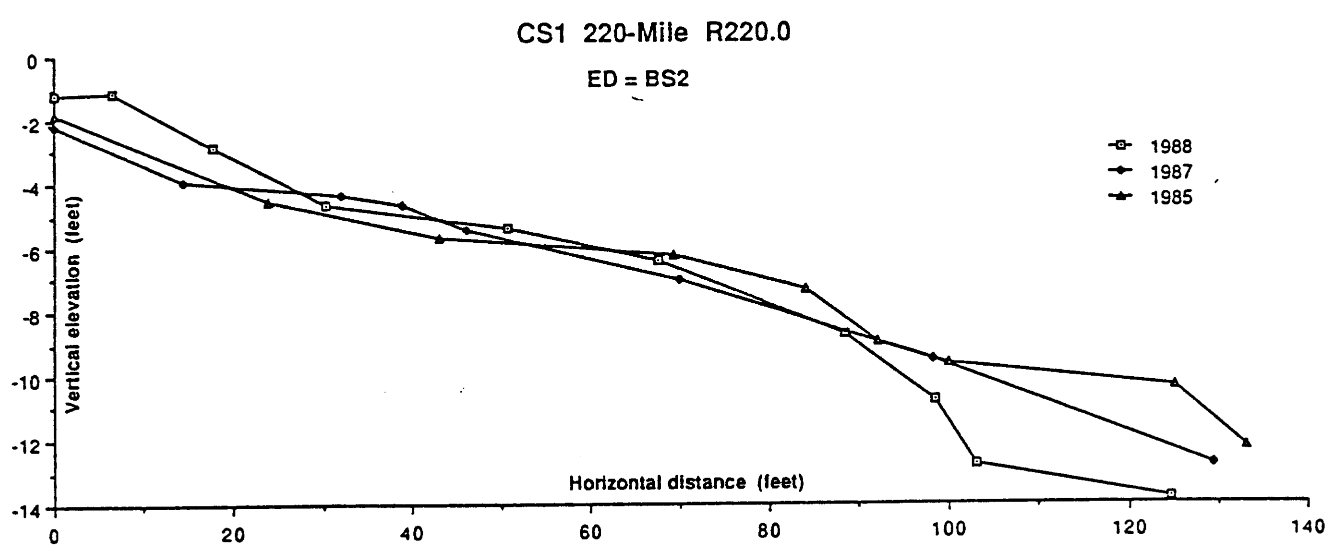


Figure I-40

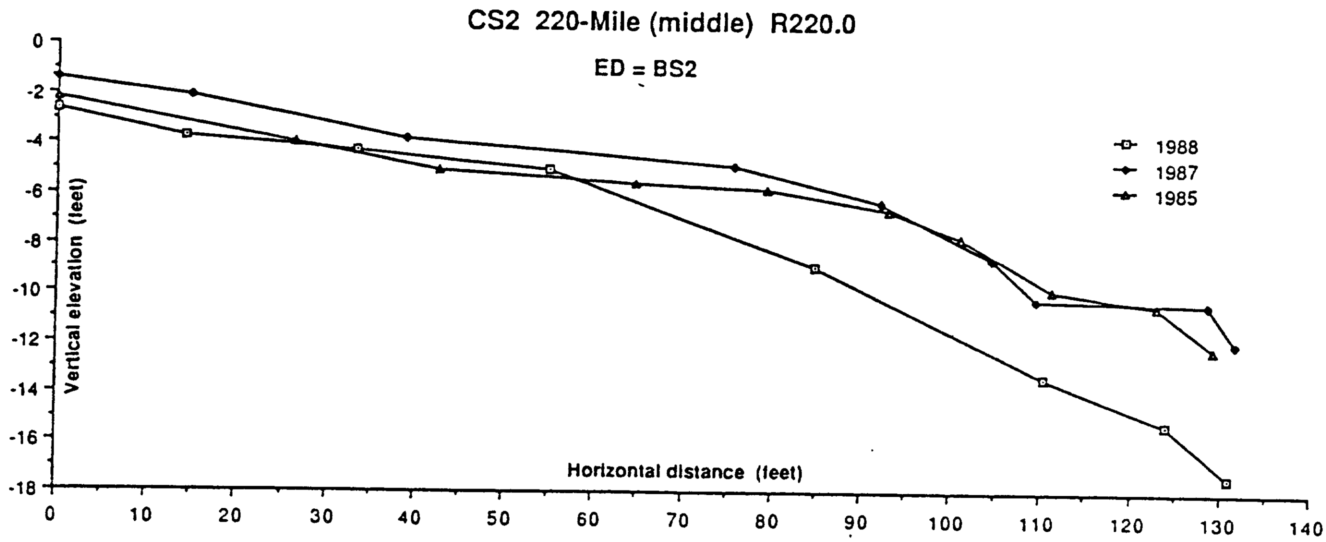
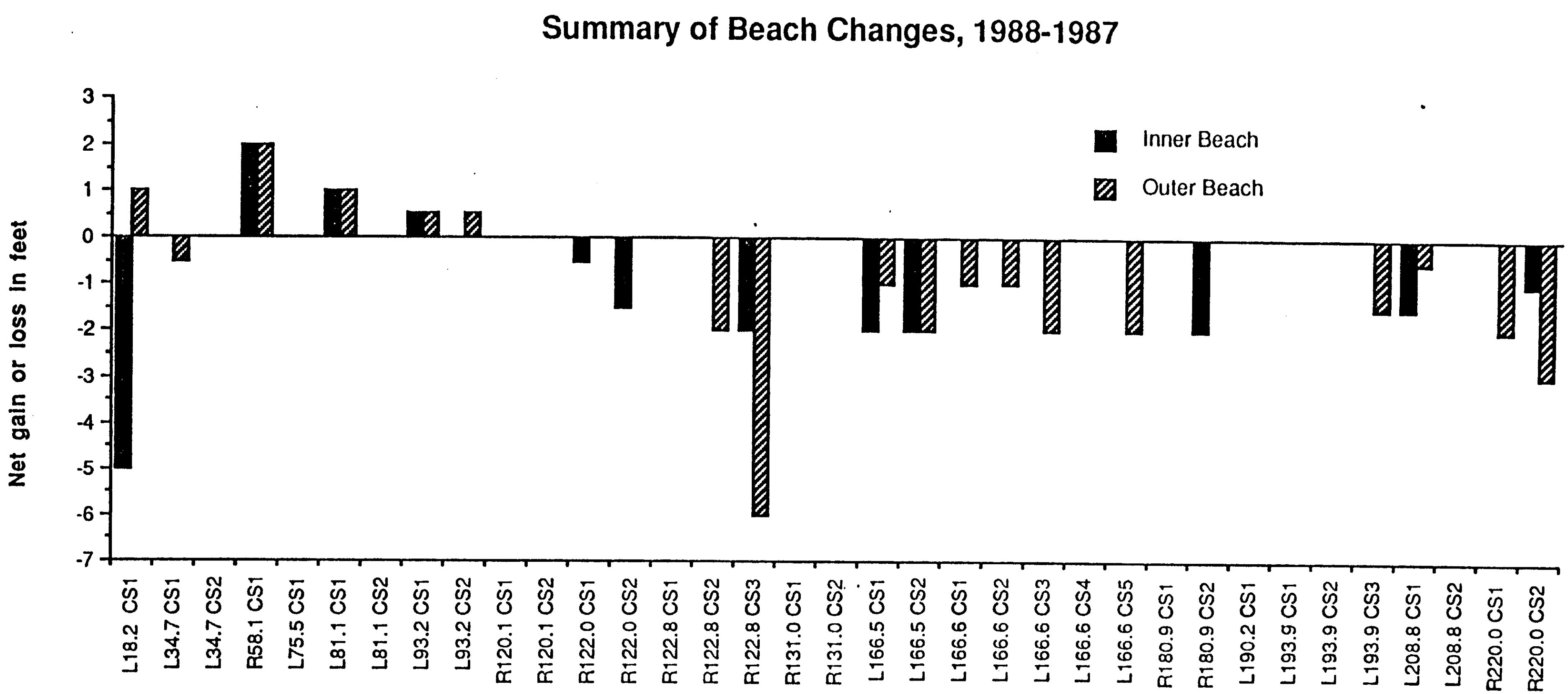

CS2 220-Mile (middle) R220.0
ED = BS2
1988
1987
1985
Vertical elevation (feet)
Horizontal distance (feet)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

Figure I-41



Summary of Beach Changes, 1988-1987
Inner Beach
Outer Beach
Net gain or loss in feet
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
L18.2 CS1
L34.7 CS1
L34.7 CS2
R58.1 CS1
L75.5 CS1
L81.1 CS1
L81.1 CS2
L93.2 CS1
L93.2 CS2
R120.1 CS1
R120.1 CS2
R122.0 CS1
R122.0 CS2
R122.8 CS1
R122.8 CS2
R122.8 CS3
R131.0 CS1
R131.0 CS2
L166.5 CS1
L166.5 CS2
L166.6 CS1
L166.6 CS2
L166.6 CS3
L166.6 CS4
L166.6 CS5
R180.9 CS1
R180.9 CS2
L190.2 CS1
L193.9 CS1
L193.9 CS2
L193.9 CS3
L208.8 CS1
L208.8 CS2
R220.0 CS1
R220.0 CS2

Figure I-42

Summary of Beach Changes Since Original Survey - 1988

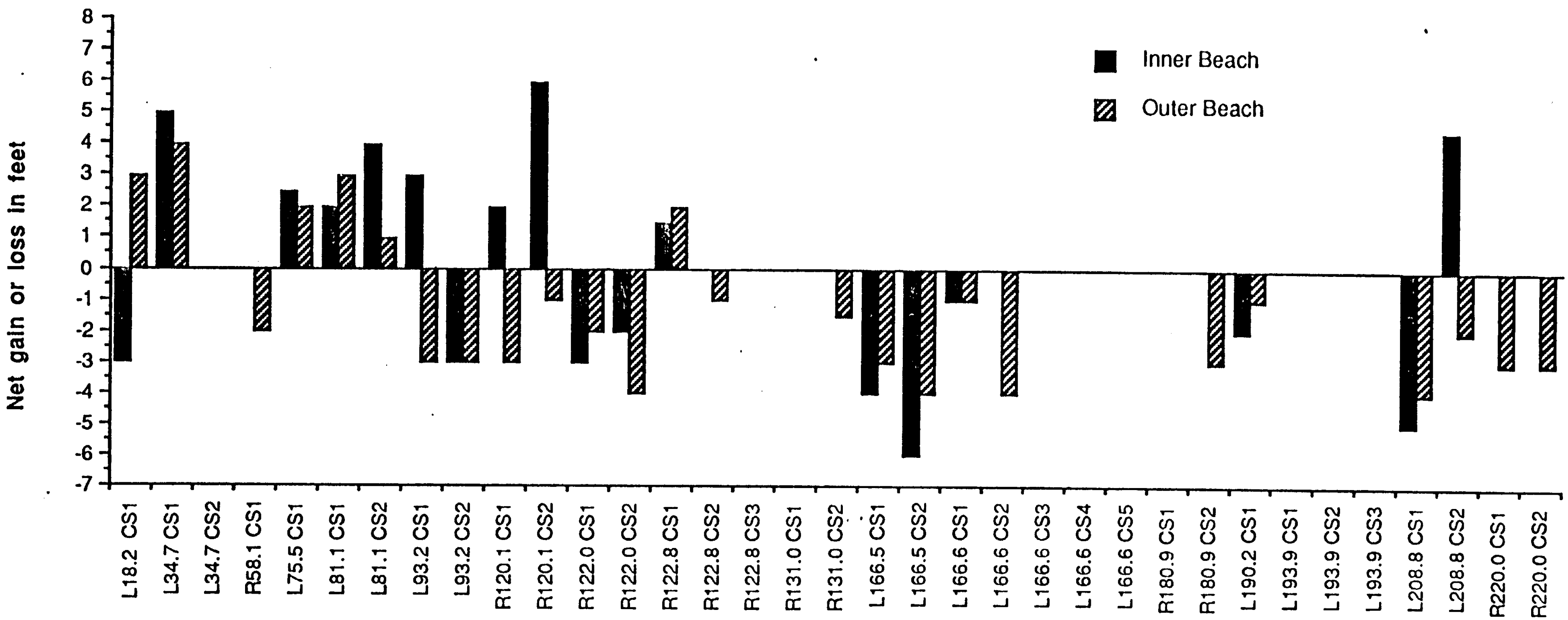


Figure I-43

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CHAPTER II

HUMAN IMPACT ON THE BEACHES OF THE COLORADO RIVER IN GRAND CANYON

Ramona Waddle, Pat Garber, Fran Fulton, Melissa Ferguson

INTRODUCTION

Within the past 20 years two major and distinctly interrelated natural resource management problems have arisen along the river corridor of the Colorado River in Grand Canyon National Park. Specifically, the problems relate to: 1) the extensive environmental changes that have taken place in the hydrological characteristics of the river as a result of Glen Canyon Dam, and 2) the dramatic increase in recreational use of the systems by river runners.

Although located 15 miles upstream of the national park boundary, Glen Canyon Dam changed the very nature of the Colorado River in Grand Canyon almost as soon as construction began in the mid 1950s. Post-dam changes in water flow, temperature, and sediment discharge have all combined, often synergistically, to alter the Grand Canyon river ecosystem. On one side of Glen Canyon Dam, the wildly variable and raging Colorado River has been buried beneath the deep waters of Lake Powell; on the other side, the river we still call the Colorado is now released through turbines and gates as a predictable, computer-regulated, icy cold, sediment-free, and partially tamed river. To further complicate the matter, the "new" dam-controlled Colorado River in Grand Canyon has recently proven to be one of the most popular white-water recreation areas in the world, with a strict National Park Service permit system regulating and allocating both private and commercial use of the 225 miles of Colorado River from Lees Ferry to Diamond Creek (GCNP 1981). The high waters and ensuing floods of 1983 unexpectedly disrupted the stabilizing patterns of water flow established during the past 20 years.

Given the above considerations, the present challenges to developing an adequate system for resources management along the river corridor of Grand Canyon National Park include: a) determining the eventual ecological "steady state" of the dam-altered river in terms of sediment erosion and deposition, vegetation and animal community composition, and overall ecosystem stability; b) determining and evaluating the impacts of river recreationists on the changing aquatic and terrestrial systems; and c) mitigating such recreational impacts to the extent that natural park values are not compromised.

As mandated by "The Planning Process of the National Park Service in 1975," a Colorado River Management Plan (GCNP 1981) was drafted to guide short- and long-term management of the riverine and riparian areas of Grand Canyon National Park. Subsequently, a monitoring program was initiated to analyze and quantify human impacts and to determine how changes in management policies influence present resource trends. This monitoring program was designed to gather base line data and show the impact (adverse and otherwise) of visitor numbers and use patterns on the riparian environment.

Heavy recreational use in other parks has caused changes in plant species composition and vegetation density and diversity (Johnson et al. 1977). Preliminary data from Grand Canyon (Aitchison et al. 1979) indicated that similar changes or impacts were taking place on the principal 100 plus campsites of the river corridor. All of these campsites are on alluvial terraces (sand and silt/sand composition) that were deposited during pre-dam flood discharges. In the 20 years prior to 1983, vegetation previously scoured from the beaches on an annual basis proliferated, while human related debris incorporated into beach sands during normal camping activities accumulated. With no natural purging of recreation related debris (organic as well as inorganic) there existed the potential for popular beaches to fill "cat box style" with any number of forms of human waste products. Additional problems of a similar vein have recently been observed in backcountry campsites where recreational use is clearly in excess of the natural purging capacity of the system.

In an effort to clean up the beaches, the Colorado River Management Plan requires that all wood and charcoal carried into the Canyon by river recreationists be burned in fire pans and the ashes be carried out. Gas stoves are now required for most cooking purposes. Regulations also require all river users to haul out solid human wastes.

The 1983 floods cleaned the beaches, resorted the sand, and gave the system a fresh start. Along with this cleansing, new beaches formed and others disappeared. The 1983 study established important base line data for future investigations. These data are the control for this study.

Early in 1976, 25 Colorado River campsites in Grand Canyon were selected for the purpose of monitoring levels of recreational impact. In 1980-81, nine additional beaches in the 15 miles of Glen Canyon below Glen Canyon Dam were evaluated for levels of human impact. Since 1976, the original Grand Canyon sites have been monitored and re-evaluated several times (Carothers et al. 1984). In 1982, human impact data for 35 beach sites in Glen and Grand Canyons were presented and compared with the results of previous sampling efforts.

In 1983, human impact data for 22 Grand Canyon beach sites, included 17 of the beaches evaluated in 1982 and five new beaches, were compared to the 1982 data. Eleven of the original beaches were no longer comparable in 1983 and were dropped from the study. In 1984, two previously studied beaches were not included: however, seven new beaches were added. The beaches which were deleted or added in the 1985, 1986, and 1987 studies are indicated in the tables.

OBJECTIVES

The objectives of this 1988 study are 1) to collect data on the degree of sand discoloration and the incidence of charcoal and human litter present on Colorado River beaches in the Grand Canyon, and 2) to compare those data with the findings from similar studies conducted in 1984, 1985, 1986, and 1987 to determine the human impact on the beaches in the years following the flood. It was hypothesized that human use in these years had resulted in a significant increase in sand discoloration and in charcoal and litter on the beaches.

METHODS

1. A 40-meter transect line was run through the principal use area of the beach along the same upstream-downstream line established in previous years. If the beach had been so altered by the river as to change patterns of use, a new transect line was established and documented. If a 40-meter transect line could not be established, the longest possible line was run and the distance recorded.

2. Black and white photographs of the transect, including the metric tape and river mile marker, were taken from upstream and downstream directions. The river mile number was written on a chalkboard and positioned in the sand for inclusion in the photograph.

3. Ten $1m^2$ plots were laid out equidistant from each other in an alternating pattern along the transect line.

4. Each $1m^2$ plot was inspected by hand sifting through the surface sand, and pieces of charcoal of 1 cm or over and all pieces of human litter found in the plot were counted, recorded, and removed. A dry sand sample from the surface of each plot was collected in a whirl pack. If damp sand was unavoidable, it was collected to be dried out later. Each sample was labeled with the beach name, the river mile, and the plot number. Plots were numbered 1-10, beginning upstream.

5. Sand samples, charcoal and human litter, were also collected at the sand/water interface and from the terrace above the beach at the old high water line.

6. Each sand sample was sifted through a 150 micron stainless steel mesh apparatus until the amount of sifted material completely covered the bottom of the apparatus.

7. A piece of No. 7 course grade filter paper was place in the lid, hatched side up, and the sifted material shaken against the filter paper 75 times.

8. The filter paper was removed with tweezers, and stored in a labeled petri dish. The apparatus was then cleaned by swirling sand around inside the containers and discarding the sand.

9. When all of the samples from a transect were shaken, the discoloration on the filter paper was evaluated with a Colorguard II Reflectometer and recorded on a data sheet.

> The Colorguard II Reflectometer is an instrument operating with an optical system, photocell amplifier, digital read-out and portable power system, and is used to make reflective measurements. Hence, with a digital read-out display, reflected light can be measured from any source. The reflectometer was used to obtain reflective values from the filter paper discs which were discolored with filtrate from the sand samples. The reflectometer was standardized

prior to each series of readings against a white standard and a gray standard to calibrate the instrument.

10. Means and standard deviations of the reflectometer readings from the ten transect samples were calculated for each beach. These were then tabulated with the 1984, 1985, 1986, and 1987 data.

RESULTS

Twenty-four beaches were sampled in 1988. The levels of sand discoloration as measured by reflectometer readings are presented in Table II-1. For purpose of comparison, this data is presented with equivalent figures from 1984, 1985, 1986, and 1987. Due to available time, erosion, and/or change in vegetation, three beaches were deleted from the study. Three beaches were added to the study, and the transect line on at least one beach was changed.

In comparing the 1988 and 1987 sand analyses, all but three beaches showed an increase in discoloration. In comparing the 1988 data to those of 1984, five beaches showed a decrease in sand discoloration, ten showed an increase in discoloration, and three showed no significant difference.

Table II-2 is a summary of a t-test for level of significant differences between 1984 and 1988 sand discoloration measurements for Grand Canyon beaches. The comparisons indicate that there has been a significant increase in sand discoloration for this period of time.

Results of the charcoal and human litter accumulation are summarized in Table II-3 for the years 1984-1988. In comparing the 1987-1988 data, nine of the twenty beaches compared showed an increase in incidence of charcoal, and five showed an increase in the amount of human litter. A comparison of the 1988 results with the 1984 results showed an increase of charcoal on 14 of 18 beaches, while the human litter data remained constant with six beaches showing an increase, six a decrease, and six showing no change.

CONCLUSIONS

The Colorado River beaches in 1988 appear to have suffered a deterioration in cleanliness compared to previous years. The results of the sand discoloration tests show a slow but steady deterioration from 1984 through 1988. Approximately half the beaches compared showed a significant difference in sand discoloration between 1987 and 1988.

The study indicates that the levels of charcoal and human litter found on the beaches are steadily increasing. The levels of charcoal found are considerably greater than the amount of human litter found for 1988. These data indicate that the increasing levels of charcoal may be responsible for the increased sand discoloration. It is worth noting that for the five years compared, the results have been consistent and significant.

The results of this study support the initial hypothesis that Grand Canyon camping beaches have shown an increase in both sand discoloration and the incidence of charcoal and human litter since the 1983 flood scoured them clean.

RECOMMENDATIONS

In order to better monitor the human impact on the sand discoloration levels, we recommend that some seldom used beaches be included in the study as a control. Perhaps factors other than human use are influencing the data. We also recommend that future investigators consider relocating some transect lines. The pattern of beach use has changed as the beach profiles and water levels have changed. The present transect lines no longer always cross the most heavily impacted portions of the beaches.

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Table II-1. Results of sand discoloration analysis of beach campsites in Grand Canyon, 1984-1988 (means only).

Site No.	Campsite Name	River Mile	Sand Discoloration (Standard Deviation) 1984 (S.D.)	1985 (S.D.)	1986 (S.D.)	1987 (S.D.)	1988 (S.D.)
1	Badger Rapid	8.0	69.69 (2.52)	70.55 (1.82)	59.65 (5.59)	69.03 (3.95)	68.76 (2.86)
2	20 Mile	20.0	68.78 (3.14)	64.29 (3.07)	67.47 (4.54)	69.20 (2.19)	
3	Shinumo Wash	29.0	69.10 (3.16)	68.62 (3.03)	68.24 (5.14)	72.57 (1.95)	67.42 (3.22)
4	Anasazi Bridge	43.5	70.55 (1.83)	71.13 (1.80)	71.61 (1.79)	72.72 (2.24)	
5	Lower Nankoweap	53.0	64.91 (3.16)	69.33 (2.66)	66.67 (3.51)	71.36 (1.85)	65.67 (2.73)
6	Awatubi	58.1	64.48 (5.73)	66.97 (3.31)	64.96 (4.21)	70.90 (2.46)	69.61 (3.47)
7	Lava Canyon (Chuar)	65.5	65.91 (4.05)	68.56 (3.81)	67.24 (2.87)	beach gone	
8	Unkar (gone)	72.2	67.70 (2.28)				
9	Nevills Rapid	75.5	66.80 (4.87)	72.21 (1.35)	70.94 (2.98)	69.77 (3.12)	67.68 (3.20)
10	Hance Rapid	76.5	66.87 (5.14)	63.82 (2.92)	65.00 (4.12)	69.12 (3.56)	
11	Grapevine	81.1	67.62 (2.18)	67.39 (2.95)	69.38 (3.95)	71.25 (1.04)	67.98 (1.42)
12	Granite Rapid	93.2	68.48 (3.28)	62.35 (3.50)	68.55 (2.06)	67.52 (1.40)	58.66 (3.47)
13	Lower Bass Camp	108.5	63.38 (5.69)	64.46 (1.69)	67.87 (3.71)	70.31 (3.46)	63.0 (2.56)
14	114 Mile	114.0	69.22 (2.06)	63.77 (2.39)	71.44 (2.30)	deleted	
15	122 Mile	122.0	71.16 (2.15)	68.55 (2.65)	71.44 (2.30)	beach gone	69.47 (2.28)
16	Forster	122.8	68.65 (5.16)	69.74 (0.74)	73.27 (1.93)	67.98 (1.43)	66.54 (4.04)
17	Bedrock	131.0	70.54 (3.40)	68.20 (2.02)	71.50 (1.64)	69.49 (1.68)	68.19 (2.55)
18	Dubendorff	132.0	70.22 (2.51)	69.63 (2.35)	69.62 (1.76)	71.07 (2.51)	71.83 (1.50)
19	Deer Creek	136.0		65.46 (1.38)	66.68 (2.16)	65.43 (2.30)	68.43 (3.70)
20	Pancho's Kitchen	137.0	65.90 (3.79)	67.20 (3.81)	69.43 (3.04)	69.32 (2.00)	66.35 (2.32)
21	Upper National	166.5	68.95 (3.00)	73.31 (0.98)	beach gone	beach gone	
22	Lower National Canyon	166.6	63.59 (3.00)	67.10 (2.42)	69.23 (1.66)	65.62 (2.17)	66.21 (2.09)
23	Upper Lava	179.0					71.73 (1.70)
24	Lower Lava Falls	180.0		67.74 (1.65)	67.63 (2.92)	72.87 (3.17)	69.43 (1.56)
25	186 Mile	186.0	72.06 (1.50)	70.95 (2.18)	69.54 (1.23)	71.43 (1.11)	64.65 (1.51)
26	Helicopter Pad	187.2					63.53 (2.07)
27	194 Mile	194					66.69 (1.56)
28	195 Mile	195.0				71.91 (1.71)	
29	Parashant	198.5	63.94 (4.77)	68.39 (2.68)	beach gone	beach gone	
30	Indian Canyon	207.0			71.09 (1.52)	72.18 (2.11)	69.17 (2.85)
31	Granite Park	208.8	68.93 (2.17)	69.88 (2.13)	69.97 (2.48)	69.56 (4.52)	69.04 (2.54)
32	Pumpkin Bowl	213.0	70.83 (1.75)	68.63 (2.41)	69.54 (1.81)	69.17 (2.60)	66.52 (2.25)
33	Trail Canyon	219.0	72.18 (1.45)	68.78 (3.38)	beach gone	beach gone	
34	220 Mile	220.0	67.71 ( )	66.93 (2.28)	68.67 (1.74)	69.18 (1.94)	64.97 (1.51)

Table II-2. t test for level of significance of differences between 1984 and 1988 sand discoloration measurements for Grand Canyon beaches. t test significance level is 2.101.

Campsite Number	Campsite Name	t Value 1984	1985	1986	1987	Significant Difference Compared 1984	1985	1986	1987
1	Badger Creek	-0.77	-1.67	4.59	-0.18	No	No	Yes	No
2	20 Mile								
3	Shinumo Wash	-1.18	-0.86	-0.43	-4.33	No	No	No	Yes
4	Anasazi Bridge								
5	Lower Nankoweap	0.58	-3.04	-0.71	-5.46	No	Yes	No	Yes
6	Awatubi	2.42	1.74	2.69	-0.96	Yes	No	Yes	No
7	Lava Canyon (Chuar 3)	the beach is gone							
8	Unkar	the beach is gone							
9	Nevills Rapid	0.48	-4.12	-2.36	-1.48	No	Yes	Yes	No
10	Hance Rapid								
11	Grapevine	0.44	0.57	-1.05	-5.87	No	No	No	Yes
12	Granite Rapid (Granite 4)	-6.50	-2.37	-7.74	-7.48	Yes	Yes	Yes	Yes
13	Lower Bass Camp	-0.19	-1.50	-3.42	-5.37	No	No	Yes	Yes
14	114 Mile	no data	delete - river protocol						
15	122 Mile	-1.71	0.83	-1.93		No	No	No	
16	Forster	-1.02	-2.46	-4.75	-1.06	No	Yes	Yes	No
17	Bedrock	-1.75	-0.01	-3.46	-1.35	No	No	Yes	No
18	Dubendorff	1.74	2.49	3.02	0.82	No	Yes	Yes	No
19	Deer Creek		2.38	1.29	2.18		Yes	No	Yes
20	Pancho's Kitchen	0.32	-0.60	-2.55	-3.07	No	No	Yes	Yes
21	Upper National Canyon		the beach is gone						
22	Lower National Canyon	2.27	-0.88	-3.58	0.62	Yes	No	Yes	No
23	Upper Lava Falls								
24	Lower Lava Falls		2.35	1.72	-3.08		Yes	No	Yes
25	186 Mile	-11.00	-7.51	-7.93	-11.43	Yes	Yes	Yes	Yes
26	Helicopter Pad								
27	194 Mile								
28	195 Mile		no data - new beach						
29	Parashant		the beach is gone						
30	Indian Canyon			-1.88	-2.68			No	Yes
31	Granite Park	0.10	-0.80	-0.83	-0.32	No	No	No	No
32	Pumpkin Bowl	-4.77	-2.02	-3.30	-2.43	Yes	No	Yes	Yes
33	Trail Canyon		the beach is gone						
34	220 Mile		-2.27	-5.07	-5.41		Yes	Yes	Yes

Table II-3. Results of charcoal and human litter accumulations analysis of beach campsites in Grand Canyon 1984-1988 (means only).

Beach No.	Campsite Name	River Mile	Charcoal cm/m2 1984	1985	1986	1987	1988	Human Litter m2 1984	1985	1986	1987	1988
1	Badger Rapid	8.0	2.5	0.2	0.2	10.4	5.7	0.2	0.0	0.3	0.4	0.2
2	20 Mile	20.0	0.0	0.3	0.0	0.2		0.2	0.2	0.0	0.0	
3	Shinumo Wash	29.0	0.0	0.0	0.0	0.6	0.7	0.1	1.0	0.1	0.5	0.1
4	Anasazi Bridge	43.5	0.0	0.0	0.2	0.2		0.0	0.0	0.0	0.1	
5	Lower Nankoweap	53.0	0.2	0.6	0.6	6.9	4.8	0.4	0.0	0.0	0.8	0.2
6	Awatubi	58.1	0.0	0.0	0.0	1.3	0.8	0.0	0.3	0.1	0.5	0.2
7	Lava Canyon (Chuar)	65.5	1.6	1.3	4.5	beach gone		0.3	0.0	0.2	beach gone	
8	Unkar	72.2	0.2	beach gone				0.1	beach gone			
9	Nevills Rapid	75.5	0.3	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.1	0.0
10	Hance Rapid	76.5	0.2	0.9	1.5	3.6		0.0	0.0	0.0	0.2	
11	Grapevine	81.1	0.0	0.0	0.0	0.5	0.6	0.0	0.0	0.0	0.0	0.2
12	Granite Rapid	93.2	0.0	0.0	0.0	2.1	0.8	0.0	0.0	0.4	0.2	0.6
13	Lower Bass Camp	108.5	1.5	0.4	0.5	3.8	3.5	2.2	0.0	0.5	0.6	0.3
14	114 Mile	114.0	0.2	0.0	0.1	delete		0.0	0.5	delete		
15	122 Mile	122.0	0.0	0.0	1.0		0.0	0.2	0.1	beach gone		0.0
16	Forester	122.8	0.0	0.0	0.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0
17	Bedrock	131.0	0.0	0.3	0.5	0.0	0.9	0.1	0.0	0.1	0.0	0.1
18	Dubendorff	132.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
19	Deer Creek	136.0		2.0	1.8	1.0	1.1		0.0	0.6	0.4	0.4
20	Poncho's Kitchen	137.0	0.0	0.1	1.3	0.8	0.0	0.4	0.1	0.8	0.4	0.0
21	Upper National Canyon	166.5	0.0	0.0	beach gone			0.2	0.2	beach gone		
22	Lower National Canyon	166.6	0.0	0.0	0.2	1.3	0.1	0.0	0.2	0.7	0.5	0.1
23	Upper Lava						0.0					0.3
24	Lower Lava Falls	179.0		0.7	1.6	3.7	0.5		0.0	0.9	0.0	0.1
25	186 Mile	186.0	0.2	0.6	0.8	0.0	0.1	0.0	0.0	0.0	0.0	0.4
26	Helicopter Pad						0.0					0.0
27	194						0.2					0.0
28	195											
29	Parashant	198.5	0.0	0.0	beach gone			0.2	0.3	beach gone		
30	Indian Canyon	207.0				0.0	0.0			0.0	0.1	0.1
31	Granite Park	208.8	0.1	0.0	1.2	1.9	0.8	0.1	0.0	0.1	0.1	0.3
32	Pumpkin Bowl	213.0	0.0	0.2	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0
33	Trail Canyon	219.0	0.1	0.0	beach gone			0.0	0.0	beach gone		
34	220 Mile	220.0	0.4	0.0	0.0	1.4	2.1	0.2	0.0	0.0	0.4	0.0

STATISTICAL METHODS FOR HUMAN IMPACT STUDY

The student must calculate for each data set (sand discoloration, charcoal contamination, and human litter) from each beach the following: a) the mean or average to determine the central tendency of the sample, b) the standard deviation to measure the degree of variability in the sample, and c) the t value to determine whether the difference between this year's results and a previous year's results is significant.

Notation

x = datum (single sample)

$\bar{x}$ = mean or average of data

n = number of samples

n-1 (or DF) = degree of difference (statistical device used to adjust for inherent bias in sampling)

s = standard deviation

Σ = sum

Procedure

For each data set:

Step 1. Calculate mean

$$\bar{x} = \frac{\Sigma x}{n}$$

Step 2. Calculate standard deviation

$$s = \sqrt{\frac{\Sigma x^2 - (\Sigma x)^2/n}{n - 1}}$$

Step 3. Calculate standard error

$$s\bar{x}_1 - \bar{x}_2 = \sqrt{\frac{s^2_1}{n_1} + \frac{s^2_2}{n_2}}$$

Step 4. Calculate t value

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s\bar{x}_1 - \bar{x}_2}$$

Step 5. Compare calculated t value to critical t value from table. Critical value is at axis of level of significance (.05) and degree of difference $(n - 1)_1 + (n - 1)_2$. If the calculated value is larger than the critical value, there is a significant difference between the means. If the calculated value is smaller than the critical value, there is not a significant difference between the means.

Badger Data Sheet
Sand Discoloration

Sample #	Sand Disc.	Squares	
1	73.6	5416.96	
2	66.4	4408.96	
3	72.5	5256.25	
4	68.4	4678.56	
5	70.0	4900.00	
6	66.0	4356.00	
7	70.3	4942.09	
8	64.9	4212.01	
9	68.7	4719.69	
10	66.8	4462.24	
sums	687.60	47352.76	472793.76 square of
mean	68.76		47279.38 square/10
St. Deviation	2.86		

Std. error	
a)1988-1987	1.54
b)1988-1986	1.98
c)1988-1985	1.07
d)1988-1984	1.20

t-value	
a)1988-1987	-.18
b)1988-1986	4.59
c)1988-1985	-1.67
d)1988-1984	-.77

Shinumo Wash
Sand Discoloration

Sample #	Sand Disc.	Squares	square of sum
1	70.50	4970.25	
2	68.90	4747.21	
3	66.60	4435.56	
4	71.20	5069.44	
5	68.20	4651.24	
6	68.30	4664.89	
7	63.10	3981.61	
8	70.80	5012.64	
9	64.00	4096.00	
10	62.60	3918.76	
sums	674.20	45547.60	454545.64
mean	67.42		45454.56
St. Deviation	3.22		

Std. error

a) 1988-1987	1.19
b) 1988-1986	1.92
c) 1988-1985	1.40
d) 1988-1984	1.43

t-value

a) 1988-1987	-4.33
b) 1988-1986	-.43
c) 1988-1985	-.86
d) 1988-1984	-1.18

Nankoweap
Sand Discoloration

Sample #	Sand Disc.	Squares	square of sum
1	65.00	4225.00	
2	68.10	4637.61	
3	68.80	4733.44	
4	63.80	4070.44	
5	64.40	4147.36	
6	65.60	4303.36	
7	60.00	3600.00	
8	69.30	4802.49	
9	66.20	4382.44	
10	65.50	4290.25	
sums	656.70	43192.39	431254.89
mean	65.67		43125.49
St. Deviation	2.73		

Std. error

a)1988-1987	1.04
b)1988-1986	1.41
c)1988-1985	1.20
d)1988-1984	1.32

t-value

a)1988-1987	-5.46
b)1988-1986	-.71
c)1988-1985	-3.04
d)1988-1984	.58

Awatubi
Sand Discoloration

Sample #	Sand Disc.	Squares	square of sum
1	74.60	5565.16	
2	68.00	4624.00	
3	66.20	4382.44	
4	67.20	4515.84	
5	72.20	5212.84	
6	73.60	5416.96	
7	63.60	4044.96	
8	69.70	4858.09	
9	71.80	5155.24	
10	69.20	4788.64	
sums	696.10	48564.17	484555.21
mean	69.61		48455.52

St. Deviation	3.47

Std. error

a)1988-1987	1.35
b)1988-1986	1.73
c)1988-1985	1.52
d)1988-1984	2.12

t-value

a)1988-1987	-.96
b)1988-1986	2.69
c)1988-1985	1.74
d)1988-1984	2.42

Nevills
Sand Discoloration

Sample #	Sand Disc.	Squares	square of sum
1	69.20	4788.64	
2	69.20	4788.64	
3	69.10	4774.81	
4	69.60	4844.16	
5	66.50	4422.25	
6	63.60	4044.96	
7	64.60	4173.16	
8	69.80	4872.04	
9	62.60	3918.76	
10	72.60	5270.76	
sums	676.80	45898.18	458058.24
mean	67.68		45805.82
St. Deviation	3.20		

Std. error

a) 1988-1987	1.41
b) 1988-1986	1.38
c) 1988-1985	1.10
d) 1988-1984	1.84

t-value

a) 1988-1987	-1.48
b) 1988-1986	-2.36
c) 1988-1985	-4.12
d) 1988-1984	.48

Grapevine
Sand Discoloration

Sample #	Sand Disc.	Squares	square of sum
1	66.70	4448.89	
2	67.90	4610.41	
3	70.50	4970.25	
4	67.70	4583.29	
5	66.90	4475.61	
6	70.00	4900.00	
7	65.80	4329.64	
8	68.00	4624.00	
9	68.00	4624.00	
10	68.30	4664.89	
sums	679.80	46230.98	462128.04
mean	67.98		46212.80
St. Deviation	1.42		

Std. error

a)1988-1987	.56
b)1988-1986	1.33
c)1988-1985	1.04
d)1988-1984	.82

t-value

a)1988-1987	-5.87
b)1988-1986	-1.05
c)1988-1985	.57
d)1988-1984	.44

Granite
Sand Discoloration

Sample #	Sand Disc.	Squares	square of sum
1	59.10	3492.81	
2	64.70	4186.09	
3	56.70	3214.89	
4	64.00	4096.00	
5	57.40	3294.76	
6	57.50	3306.25	
7	60.00	3600.00	
8	57.60	3317.76	
9	56.20	3158.44	
10	53.40	2851.56	
sums	586.60	34518.56	344099.56
mean	58.66		34409.96
St. Deviation	3.47		

Std. error	
a)1988-1987	1.18
b)1988-1986	1.28
c)1988-1985	1.56
d)1988-1984	1.51

t-value	
a)1988-1987	-7.48
b)1988-1986	-7.74
c)1988-1985	-2.37
d)1988-1984	-6.50

Lower Bass
Sand Discoloration

Sample #	Sand Disc.	Squares	square of sum
1	66.50	4422.25	
2	67.20	4515.84	
3	62.00	3844.00	
4	62.80	3943.84	
5	61.80	3819.24	
6	61.10	3733.21	
7	63.40	4019.56	
8	59.80	3576.04	
9	65.20	4251.04	
10	60.20	3624.04	
sums	630.00	39749.06	396900.00
mean	63.00		39690.00

St. Deviation	2.56

Std. error

a)1988-1987	1.36
b)1988-1986	1.43
c)1988-1985	.97
d)1988-1984	1.97

t-value

a)1988-1987	-5.37
b)1988-1986	-3.42
c)1988-1985	-1.50
d)1988-1984	-.19

River Mile 122
Sand Discoloration

Sample #	Sand Disc.	Squares	square of sum
1	70.20	4928.04	
2	68.80	4733.44	
3	71.00	5041.00	
4	67.20	4515.84	
5	67.80	4596.84	
6	65.30	4264.09	
7	70.90	5026.81	
8	71.90	5169.61	
9	72.60	5270.76	
10	69.00	4761.00	
sums	694.70	48307.43	482608.09
mean	69.47		48260.81
St. Deviation	2.28		

Std. error

a) 1988-1987	
b) 1988-1986	1.02
c) 1988-1985	1.10
d) 1988-1984	.99

t-value

a) 1988-1987	
b) 1988-1986	-1.93
c) 1988-1985	.83
d) 1988-1984	-1.71

Forester
Sand Discoloration

Sample #	Sand Disc.	Squares		
1	59.4	3528.36		
2	62.7	3931.29		
3	67.2	4515.84		
4	67.7	4583.29		
5	71.1	5055.21		
6	69.4	4816.36		
7	64.8	4199.04		
8	68.5	4692.25		
9	71.9	5169.61		
10	62.7	3931.29		
sums	665.40	44422.54	442757.16	square of
mean	66.54		44275.72	square/10
St. Deviation	4.04			

Std. error

a)1988-1987	1.35
b)1988-1986	1.42
c)1988-1985	1.30
d)1988-1984	2.07

t-value

a)1988-1987	-1.06
b)1988-1986	-4.75
c)1988-1985	-2.46
d)1988-1984	-1.02

Bedrock
Sand Discoloration

Sample #	Sand Disc.	Squares
1	69.0	4761.00
2	66.8	4462.24
3	70.5	4970.25
4	71.0	5041.00
5	64.7	4186.09
6	66.8	4462.24
7	66.2	4382.44
8	67.6	4569.76
9	66.5	4422.25
10	72.8	5299.84

sums	681.90	46557.11	464987.61 square of
mean	68.19		46498.76 square/10
St. Deviation	2.55		

Std. error	
a) 1988-1987	.96
b) 1988-1986	.96
c) 1988-1985	1.03
d) 1988-1984	1.34

t-value	
a) 1988-1987	-1.35
b) 1988-1986	-3.46
c) 1988-1985	-.01
d) 1988-1984	-1.75

Dubendorff
Sand Discoloration

Sample #	Sand Disc.	Squares	
1	72.7	5285.29	
2	74.2	5505.64	
3	70.8	5012.64	
4	74.3	5520.49	
5	70.9	5026.81	
6	70.4	4956.16	
7	69.9	4886.01	
8	71.9	5169.61	
9	71.8	5155.24	
10	71.4	5097.96	
sums	718.30	51615.85	515954.89 square of
mean	71.83		51595.49 square/10
St. Deviation	1.50		

Std. error

a) 1988-1987	.93
b) 1988-1986	.73
c) 1988-1985	.88
d) 1988-1984	.93

t-value

a) 1988-1987	.82
b) 1988-1986	3.02
c) 1988-1985	2.49
d) 1988-1984	1.74

Deer Creek
Sand Discoloration

Sample #	Sand Disc.	Squares	
1	68.2	4651.24	
2	72.3	5227.29	
3	73.0	5329.00	
4	66.5	4422.25	
5	73.1	5343.61	
6	64.4	4147.36	
7	68.8	4733.44	
8	66.4	4408.96	
9	62.1	3856.41	
10	69.5	4830.25	
sums	684.30	46949.81	468266.49 square of
mean	68.43		46826.65 square/10
St. Deviation	3.70		

Std. error

a)1988-1987	1.38
b)1988-1986	1.35
c)1988-1985	1.25
d)1988-1984	

t-value

a)1988-1987	2.18
b)1988-1986	1.29
c)1988-1985	2.38
d)1988-1984	

Pancho's Kitchen
Sand Discoloration

Sample #	Sand Disc.	Squares	
1	64.2	4121.64	
2	62.8	3943.84	
3	67.5	4556.25	
4	65.0	4225.00	
5	69.1	4774.81	
6	68.5	4692.25	
7	64.0	4096.00	
8	68.3	4664.89	
9	65.4	4277.16	
10	68.7	4719.69	
sums	663.50	44071.53	440232.25 square of
mean	66.35		44023.22 square/10
St. Deviation	2.32		
Std. error			
a)1988-1987	.97		
b)1988-1986	1.21		
c)1988-1985	1.41		
d)1988-1984	1.40		
t-value			
a)1988-1987	-3.07		
b)1988-1986	-2.55		
c)1988-1985	-.60		
d)1988-1984	.32		

Lower National
Sand Discoloration

Sample #	Sand Disc.	Squares		
1	64.2	4121.64		
2	65.2	4251.04		
3	66.3	4395.69		
4	67.3	4529.29		
5	64.9	4212.01		
6	67.2	4515.84		
7	68.4	4678.56		
8	63.7	4057.69		
9	70.3	4942.09		
10	64.6	4173.16		
sums	662.10	43877.01	438376.41	square of
mean	66.21		43837.64	square/10

St. Deviation 2.09

Std. error

a)1988-1987	.95
b)1988-1986	.84
c)1988-1985	1.01
d)1988-1984	1.16

t-value

a)1988-1987	.62
b)1988-1986	-3.58
c)1988-1985	-.88
d)1988-1984	2.27

Upper Lava
Sand Discoloration

Sample #	Sand Disc.	Squares	
1	73.7	5431.69	
2	70.7	4998.49	
3	70.8	5012.64	
4	0.0	.00	
5	0.0	.00	
6	0.0	.00	
7	0.0	.00	
8	0.0	.00	
9	0.0	.00	
10	0.0	.00	
sums	215.20	15442.82	46311.04 square of
mean	71.73		4631.10 square/10
St. Deviation	34.66		

Std. error

a) 1988-1987

b) 1988-1986

c) 1988-1985

d) 1988-1984

t-value

a) 1988-1987

b) 1988-1986

c) 1928-1985

d) 1988-1984

Lower Lava
Sand Discoloration

Sample #	Sand Disc.	Squares		
1	69.5	4830.25		
2	67.0	4489.00		
3	68.0	4624.00		
4	68.2	4651.24		
5	69.2	4788.64		
6	68.4	4678.56		
7	70.6	4984.36		
8	71.0	5041.00		
9	70.4	4956.16		
10	72.0	5184.00		
sums	694.30	48227.21	482052.49	square of
mean	69.43		48205.25	square/10

St. Deviation 1.56

Std. error

a) 1988-1987	1.12
b) 1988-1986	1.05
c) 1988-1985	.72
d) 1988-1984	

t-value

a) 1988-1987	-3.08
b) 1988-1986	1.72
c) 1988-1985	2.35
d) 1988-1984	

River mile 186
Sand Discoloration

Sample #	Sand Disc.	Squares
1	64.6	4173.16
2	66.0	4356.00
3	64.3	4134.49
4	63.9	4083.21
5	64.9	4212.01
6	64.9	4212.01
7	62.9	3956.41
8	63.2	3994.24
9	63.7	4057.69
10	68.1	4637.61

sums	646.50	41816.83	417962.25 square of
mean	64.65		41796.22 square/10

St. Deviation 1.51

Std. error

a) 1988-1987 .59

b) 1988-1986 .62

c) 1988-1985 .84

d) 1988-1984 .67

t-value

a) 1988-1987 -11.43

b) 1988-1986 -7.93

c) 1988-1985 -7.51

d) 1988-1984 -11.00

Helicopter Pad
Sand Discoloration

Sample #	Sand Disc.	Squares		
1	61.2	3745.44		
2	62.7	3931.29		
3	62.7	3931.29		
4	61.9	3831.61		
5	64.1	4108.81		
6	64.2	4121.64		
7	61.9	3831.61		
8	67.6	4569.76		
9	66.4	4408.96		
10	62.6	3918.76		
sums	635.30	40399.17	403606.09	square of
mean	63.53		40360.61	square/10
St. Deviation	2.07			

Std. error

a) 1988-1987

b) 1988-1986

c) 1988-1985

d) 1988-1984

t-value

a) 1988-1987

b) 1988-1986

c) 1988-1985

d) 1988-1984

River Mile 194
Sand Discoloration

Sample #	Sand Disc.	Squares		
1	66.8	4462.24		
2	67.3	4529.29		
3	63.6	4044.96		
4	67.5	4556.25		
5	67.5	4556.25		
6	67.4	4542.76		
7	65.2	4251.04		
8	65.7	4316.49		
9	69.3	4802.49		
10	66.6	4435.56		
sums	666.90	44497.33	444755.61	square of
mean	66.69		44475.56	square/10
St. Deviation	1.56			

Std. error

a) 1988-1987

b) 1988-1986

c) 1988-1985

d) 1988-1984

t-value

a) 1988-1987

b) 1988-1986

c) 1988-1985

d) 1988-1984

Indian Canyon
Sand Discoloration

Sample #	Sand Disc.	Squares	
1	67.2	4515.84	
2	75.4	5685.16	
3	67.6	4569.76	
4	68.6	4705.96	
5	71.5	5112.25	
6	64.7	4186.09	
7	68.8	4733.44	
8	69.8	4872.04	
9	68.1	4637.61	
10	70.0	4900.00	
sums	691.70	47918.15	478448.89 square of
mean	69.17		47844.89 square/10
St. Deviation	2.85		

Std. error

a)1988-1987	1.12
b)1988-1986	1.02
c)1988-1985	
d)1988-1984	

t-value

a)1988-1987	-2.68
b)1988-1986	-1.88
c)1988-1985	
d)1988-1984	

Granite Park
Sand Discoloration

Sample #	Sand Disc.	Squares	
1	69.8	4872.04	
2	72.4	5241.76	
3	72.8	5299.84	
4	67.7	4583.29	
5	68.0	4624.00	
6	67.5	4556.25	
7	64.9	4212.01	
8	66.7	4448.89	
9	69.6	4844.16	
10	71.0	5041.00	
sums	690.40	47723.24	476652.16 square of
mean	69.04		47665.22 square/10
St. Deviation	2.54		

Std. error

a)1988-1987	1.64
b)1988-1986	1.12
c)1988-1985	1.05
d)1988-1984	1.06

t-value

a)1988-1987	-.32
b)1988-1986	-.83
c)1988-1985	-.80
d)1988-1984	.10

Pumpkin Bowl
Sand Discoloration

Sample #	Sand Disc.	Squares		
1	65.8	4329.64		
2	68.2	4651.24		
3	68.8	4733.44		
4	66.2	4382.44		
5	62.0	3844.00		
6	68.6	4705.96		
7	67.3	4529.29		
8	65.3	4264.09		
9	0.0	.00		
10	0.0	.00		
sums	532.20	35440.10	283236.84	square of
mean	66.52		35404.60	square/10
St. Deviation	2.25			
Std. error				
a) 1988-1987	1.09			
b) 1988-1986	.91			
c) 1988-1985	1.04			
d) 1988-1984	.90			
t-value				
a) 1988-1987	-2.43			
b) 1988-1986	-3.30			
c) 1988-1985	-2.02			
d) 1988-1984	-4.77			

Upper 220
Sand Discoloration

Sample #	Sand Disc.	Squares
1	62.7	3931.29
2	64.3	4134.49
3	65.2	4251.04
4	65.8	4329.64
5	67.0	4489.00
6	64.6	4173.16
7	63.6	4044.96
8	67.7	4583.29
9	64.5	4160.25
10	64.3	4134.49

sums	649.70	42231.61	422110.09 square of
mean	64.97		42211.01 square/10

St. Deviation 1.51

Std. error

a) 1988-1987	.78
b) 1988-1986	.73
c) 1988-1985	.87
d) 1988-1984	

t-value

a) 1988-1987	-5.41
b) 1988-1986	-5.07
c) 1988-1985	-2.27
d) 1988-1984	

Materials List

40 Meter tape
Black board and chalk for showing river miles
Camera with black and white film
3 One Meter squares
12 Whirl Packs per beach
Water proof marker and pad
4 sifting jars with 150 micron stainless steel mesh
appartus
48 Petri dishes
#7 coarse grade filter paper (12 per beach)
Tweezers
Colorguard II Reflectometer
Data sheets and pencils for recording data
Clipboard
Computer diskettes
Large plastic bags for sample storage
2 Work tables

CHAPTER III

SEDIMENTARY STRUCTURES IN BEACHES AND BARS OF THE COLORADO RIVER IN THE GRAND CANYON

Anne Fifield and Marilyn Thomson

INTRODUCTION

The sedimentary structures found in the beaches (sandbars) of the Colorado River in the Grand Canyon have been predominately formed by eddies. Within the canyon, eddies occur in the river current downstream from a channel constriction (usually caused by a debris fan that has formed at the mouth of a side canyon) at the point where the channel widens once again (Fig. III-1) (Schmidt and Graf 1987).

Examination of sedimentary structures provides information on the depositional history of eddy bars of the Colorado River in the Grand Canyon. The conditions under which these bars were formed can be reconstructed by examining the sedimentary structures found in cross sections of the bar deposits. Common sedimentary structures found in river deposits include laminae bedding, cross-bedding, convoluted bedding, ripple marks, and forset beds. These structures are formed under various depositional conditions. Some of the structures, especially ripple marks, can be seen presently forming along the water's edge. Previous studies have been done by students at Northern Arizona University in the GLG 538-626 Grand Canyon course over the past seven years.

OBJECTIVES

1) Identify the various sedimentary structures found in the eddy bar deposits along the Colorado River.

2) Interpret these structures and reconstruct the conditions during deposition.

METHODS

Materials:	2 shovels
	cement trowel
	Brunton compass
	ruler
	machete
	current meter
(for peels)	1 can clear Krylon acrylic spray
	2 packages of cheesecloth
	scissors
	dissecting needles
	1 dozen disposable paint brushes
	1 gallon Krylon latex acrylic
	plastic pail

Procedure:

1. A site was chosen at the cutbank of the beach.

2. Approximately three-foot-deep trenches were dug parallel and perpendicular to the direction of flow of the main current of the river.

3. The sides of the trenches were smoothed with a cement trowel to expose the sedimentary structures.

4. The trenches were photographed; scale was shown by adding a ruler. River mileage and trench numbers were recorded on a small (6" x 8") chalkboard.

5. The trenches were sketched, with direction of the trench and dip of the beds measured with a Brunton compass and recorded.

6. Latex peels were made at selected sites. The following method was used:
   a. Cheesecloth was cut at least 10 cm longer than the trench was deep.
   b. The cheesecloth was anchored on top of the trench with dissecting needles.
   c. The cheesecloth was then flipped back up off the smooth trench wall.
   d. Clear acrylic spray was applied evenly over the trench wall surface to be covered by the peel.
   e. The cheesecloth was flipped back down over the trench wall. Needles were then inserted along the edges of the cheesecloth to hold it in place.
   f. Krylon latex acrylic was then applied by paintbrush with light upward motions and allowed to dry.
   g. A second coat was applied after the first was dry.
   h. The next morning the peel was removed and compass orientation, river mile, and year were written on the back of the peel.

Procedure for current meter:

1) A site was located in clear water where ripples were being formed.

2) The current meter was assembled and placed on the riverbed in moving water.

3) Meter clicks per minute (heard using earphones) were recorded and the current velocity calculated (using accompanying chart).

4) Ripple wavelength and height were measured.

RESULTS AND DISCUSSION

During the eleven-day raft trip, trenches were dug at ten beaches. With the exception of Lower National and Pumpkin beaches, the sedimentary structures were not well defined. Because of erosion at Pumpkin Beach, the sedimentary structures there were well exposed in a natural gully. Thus, this report will discuss only the structures at Lower National and Pumpkin beaches.

Lower National Beach

Lower National Beach (Mile 166.6) is located directly downstream from the debris fan deposited by run-off from National Canyon (Fig. III-2). The concave-shaped sand beach, which is contained upstream by cobbles and boulders and downstream by talus from the cliff above, was deposited by an eddy in the Colorado River in the flood of 1983. High water scoured out the previous deposit at that location and deposited new sand as the water level subsided (Schmidt and Graf 1987). To expose a cross section of sedimentary structures in the deposit, we dug a trench approximately 12 feet long, perpendicular to the shoreline.

At the bottom of the four-foot-deep trench, planar bedding was dominant. Planar beds are formed in conditions of high current velocity (Collinson and Thompson 1982), consequently these beds were the first to be deposited as the water level dropped. The sand was medium to fine grained, and not very micaceous. Above the planar beds, several clay lenses appeared as isolated ripple form sets. Above them, the layers in the cross section were composed of symmetrical ripples. Such ripples are formed during a flood when the water carries a high sediment load. Upon reaching an area of quiet water, such as an eddy, the sediment is deposited by rippled currents (Fig. III-3) (McKee 1965).

Pumpkin Beach

Pumpkin Beach (Mile 212.9) sediments were also deposited during the 1983 flood. Heavy rains in the summer of 1988 eroded out a large gully facing 84 degrees east, perpendicular to the river. The gully was approximately nine feet deep and thirty feet long, and extended across most of the beach (Fig. III-6).

The most northerly point of the gully, farthest from the shore, contained one set of large cross-beds two to three feet in length, dipping 27 degrees toward the shore (Fig. III-4). The large cross-beds indicate deposition during a high water stage of the 1983 flood. From the center of the beach southward to the shore, smaller cross-beds with ripples on their surface were present, dipping 24 degrees toward the shore (Fig. III-5). These structures indicate deposition at a lower water stage with less current velocity.

CONCLUSIONS

In a recent study of sedimentary deposits on the Colorado River in the Grand Canyon, Schmidt and Graf (1987) determined Pumpkin Beach to be a channel margin deposit, lacking the characteristics of a separation or reattachment deposit (Fig. III-1), or a deposit whose location in relation to a recirculation zone was not known. Our study indicates that the flow that deposited Pumpkin Beach in 1983 was recirculated. The beds dipped toward the shore, with the lee side facing away from the river. This was true for both the upper and lower regime deposits found in the gully. The dip suggests that the flow was from the northeast. That is, the current recirculated at Pumpkin Beach, flowing upstream (as in an eddy) at the point of deposition.

Exposed sand deposits at both National and Pumpkin beaches were deposited during the high water of 1983, and both are currently being eroded. Both contain deposits that suggest upper level flow regime water which then subsided. Both beaches were initially deposited by high volumes of water, with additional deposition as the water level dropped.

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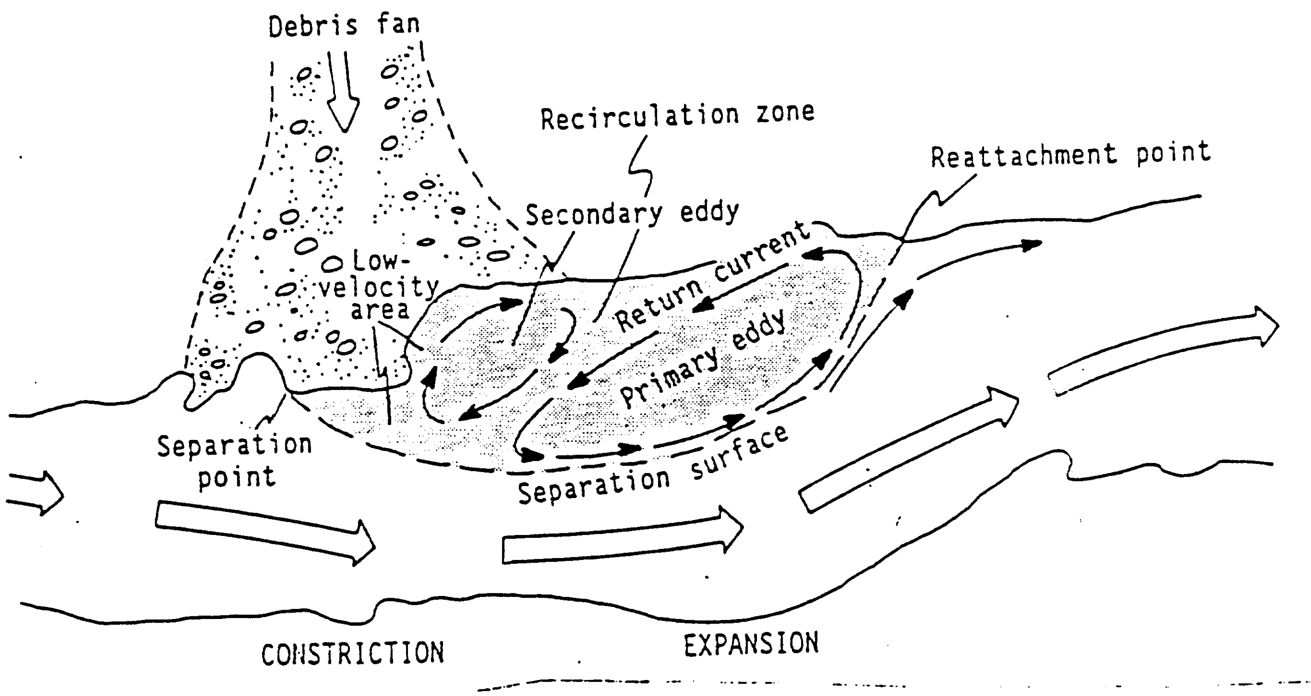

Figure III-1. Flow patterns and configurations in a typical back eddy zone. From Schmidt and Graf, 1988.

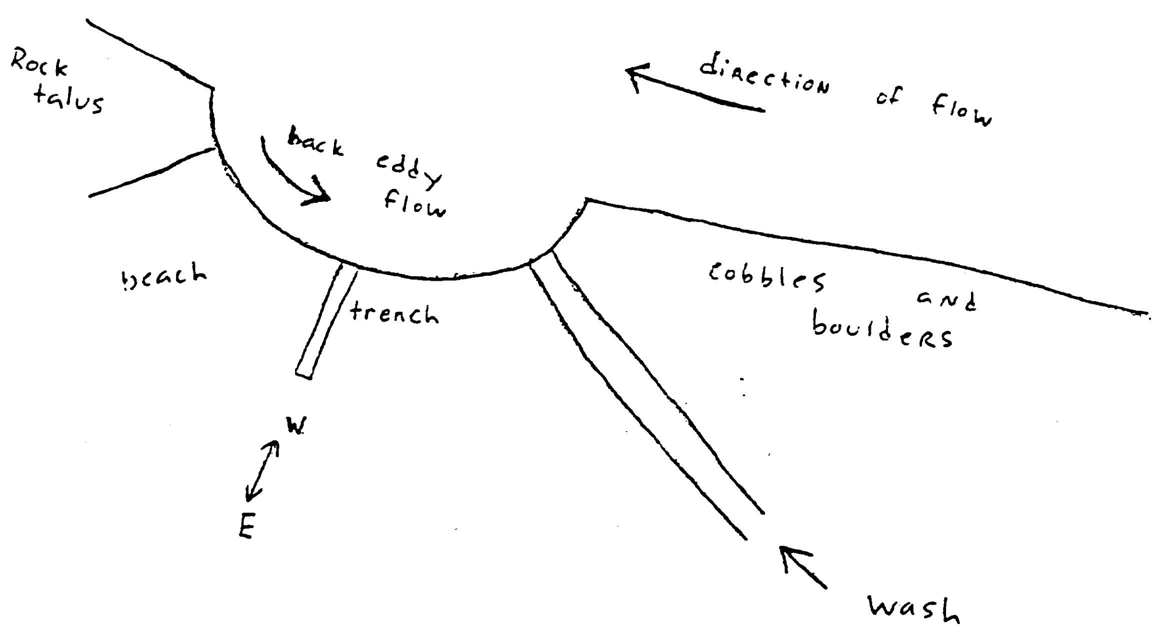

Figure III-2. Diagram of Lower National Beach.

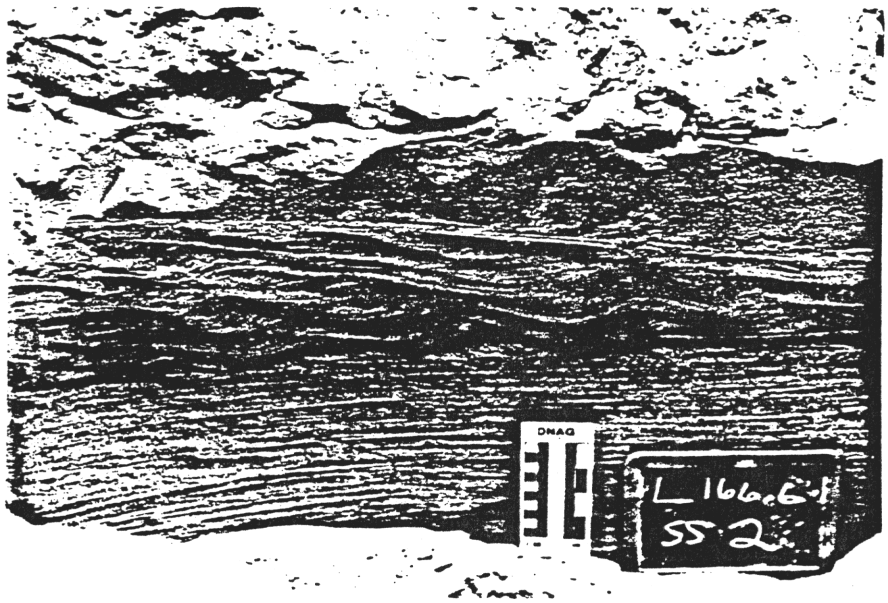

Figure III-3. Planar bedding and ripples at Lower National Beach.

Figure III-4. Large crossbeds at the north end of the gully at Pumpkin Beach

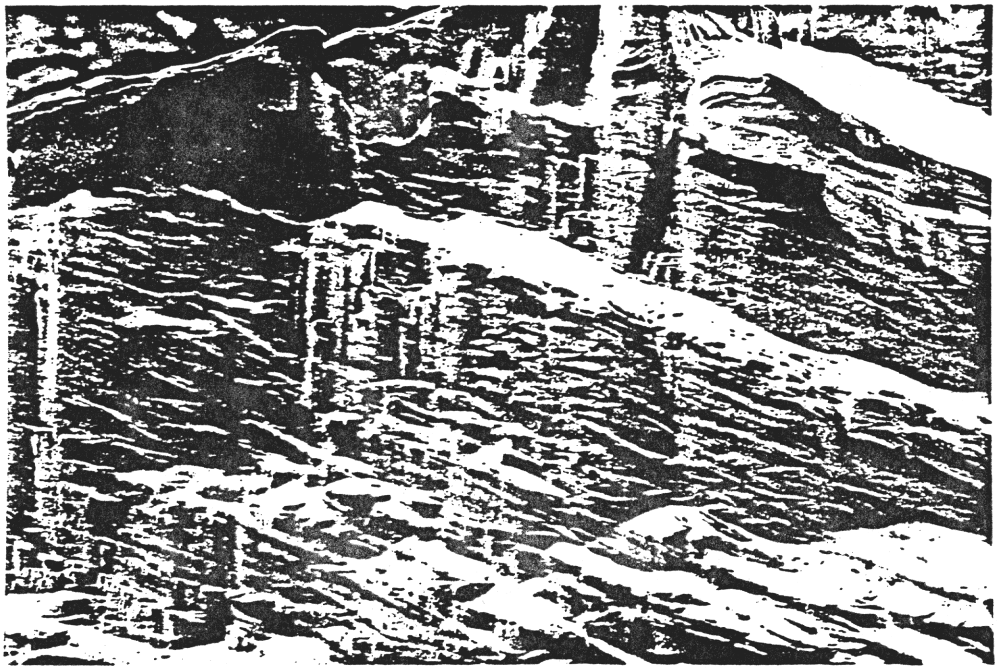

Figure III-5. Crossbeds with ripples near the shore of Pumpkin Beach.

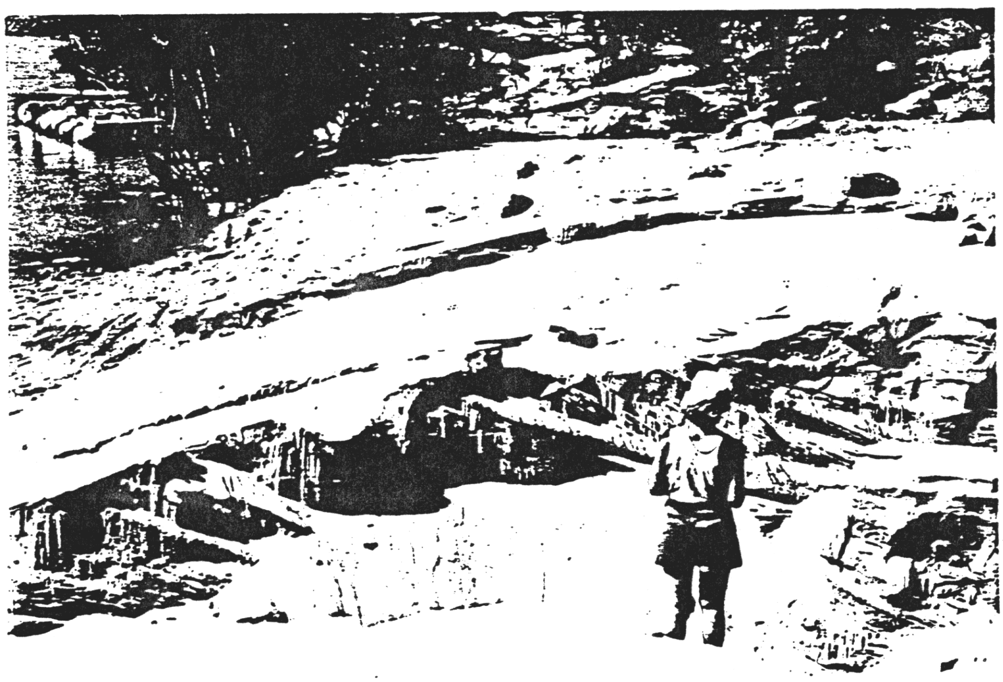

Figure III-6. The gully at Pumpkin Beach completely exposed. North is to the right.

CHAPTER IV

COLORADO RIVER BEACH CAMPSITE EVALUATION
GRAND CANYON NATIONAL PARK

Margery Detring

INTRODUCTION

River beaches, alluvial terraces, are a product of a dynamic river. Prior to the completion of Glen Canyon Dam, seasonal sediment-laden floodwaters deposited sand and silt on alluvial fan deposits and bedrock or talus along the river, replenishing and cleansing beaches. After the completion of Glen Canyon Dam in 1963, beaches along the colorado River have not been subject to the natural periodicity of sediment-rich flood waters. Due to retention of sand and silt in Lake Powell, the terraces have been progressively eroded by wind deflation, mass wasting, sheet wash, flash flood, reworking by fluctuating river flows (Dolan et al. 1977) and footstep degradation (Valentine and Dolan 1979). Also due to lower river flow, a new zone of riparian vegetation has developed which slows beach erosion in some areas (Turner and Karpiscak 1980).

Campsite beaches were inventoried in 1973 (Weeden et al. 1975), in 1983 (Brian and Thomas 1984), in 1987 (Kalinowski et al. 1988), and again in 1988 to determine campsite changes. Campsites were inventoried for camp size, degree of active erosion, shoreline composition and flash flood potential. During the 1987 study, the evaluators concluded that the majority of campsites were not in equilibrium. The beaches were changing even though the Colorado is now a regulated river.

This report presents the results of the 1988 inventory made in conjunction with the annual Northern Arizona University Research Expedition, 17 July through 5 August, 1988. Thirty beaches were evaluated and the results compared with previous studies.

METHODS

In the 1987 study, also conducted by Northern Arizona University, 49 beaches were evaluated between Lees Ferry and Diamond Creek. In this report 30 beaches will be covered. The number of camps evaluated is smaller for several reasons. The water level was very low at the beginning of the expedition, requiring that Crystal Rapid be passed before weekend low water, necessitating deletion of some stops. Also some campsites previously inventoried as 2 or 3 sections of a larger camp, for example upper, middle, and lower Pancho's Kitchen, became one site, Pancho's Kitchen, in this inventory. Differences between sections of camp were noted in the field notes.

Materials used were the River Campsite Inventory Data form (Fig. IV-1) and a Brunton compass. Evaluation using the data form was subjective, but some consistency was maintained by using the following guidelines:

1. Camps are identified by mileage downstream from Lees Ferry with an accuracy of 0.1 mile, and by common or topographic name whenever possible. A left-bank camp is indicated by "L" and a camp on the right when looking downstream is marked "R."

2. Capacity or size of the beach refers to the area open to camping, cooking, and group use. "Small" is defined as a camp area large enough to accommodate 15-20 people; "medium," 21-40 people; and "large," 31-40+ people.

3. Shoreline composition is determined by subjectively assessing percentage of shoreline covered by vegetation, rock armoring (or in some cases ledges), and sand. Walking along the shoreline and climbing up rocks above the site improved accuracy in assigning percentages. When making tables the largest percentage was used to describe the shoreline; for example, Awatubi (River Mile 58.1) has 1% rock armoring, 51% vegetation, and 48% sand. For tabulation purposes Awatubi's shoreline is considered vegetated.

4. Erosion of shoreline was initially noted in three categories: active cutbanks, inactive or stabilized cutbanks, and no erosion apparent. At 18.2 Mile campsite a fourth category was added: limited erosion without cutbanks. This category was commonly used on steeply sloped camps with sand loss like Bedrock campsite. Comparison of this camp using last year's photos showed a loss of about 12 inches of beach sand because rocks not observable in the photo now protrude 12 inches above the beach surface.

5. Beach equilibrium was labeled stable, in flux, or unstable. This is a predictive value based on the assumption that the beaches will continue to erode until the beach is in balance or is removed. A stable condition was indicated by a stabilized beach profile with low angle and protection from erosion provided by vegetation, armoring, or rock jetty. In flux indicates variability associated with a semi-stabilized beach profile with a moderate angle often partially protected from erosion by physical features. An unstable condition was indicated by active erosional faces with a steep angle, often with active current at shoreline.

6. Flash flood potential was determined by checking placement of side canyons along or through the campsites and relationships between strong current and active cutbanks.

RESULTS

In classifying campsites by data sheet categories, comparison between percentages in 1987 and 1988 showed less than 10% change in camp capacity and shoreline composition (Tables IV-1 and IV-3). This small change could have been produced by the slight change in campsite selection, viewer bias, and variation in river flow during the trip (5,000-29,000 cubic feet per second, Bureau Of Reclamation communication). Although camp capacity and shoreline composition is affected by erosion over a year's time, these two factors seem constant from the data at hand. Erosion shifted toward an intermediate (inactive cutbank or limited mass-wasting type) type of erosion. This change may have been the result of adding another category of erosion this year.

Flash flood potential figures (Tables IV-1 and IV-3) are within 10% of last year's figures for beaches with low and medium potential, but larger for the "no" and "high" categories. Since the flood potential is related to current, slope, and placement of side canyon drainages, all of which change only slowly over time, I must conclude differences are the result of viewer differences in the two groups involved or some other, unknown, element.

Beach equilibrium (Tables IV-1 and IV-3) show a redistribution between stable (43 to 27%) and in flux (6 to 23%) categories, with a marked decline in beaches inventoried as stable. The unstable beach percentage remained constant (51 to 50%). The beaches are continuing to gain and lose sand because of normal erosion, camper footfall, and minimal deposition.

Table IV-2 uses a 4x4x3 matrix to cluster campsites. A summary of sites into high erosion/low erosion sets shows 60% of those inventoried are in the medium to high set and 40% in the none to low erosion set.

CONCLUSIONS

Although comparisons of matched beaches were not done this year, trends can be seen by comparing photos of campsites from previous years and projecting changes from erosional observations. First, about a quarter of the 1988 campsites appear to be in dynamic equilibrium with the river at its current flow levels. Another quarter are growing and declining in response to varying environmental conditions in and along the river. Half are actively changing. Most campsites did not change radically from one inventory to the next, although larger trends may be seen in five- to ten-year comparisons of matched campsites. Three-quarters of the camps are continuing their evolution toward equilibrium in the new post-dam scenario.

Loss of beach is generally gradual due to low flow in the river and increased vegetation to protect the terraces. These tend to reduce the effects of fast current, sheet wash, wind movement, tributary flash flood, and footstep-induced mass wasting. The Colorado River campsites are changing slowly under the influence of locally controlling beach and river factors. The system continues to fluctuate toward equilibrium.

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Kalinowski, A., et al. 1988. Chapter XIV: Colorado River beach campsite inventory, Grand Canyon National Park, Arizona., pp. 117-129, In: Colorado River investigations VI, July-

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RIVER CAMPSITE INVENTORY

DATA FORM

River Mile ______________________ L R Date ______________________

Camp Name ______________________ Recorder ______________________

________________________________ ______________________
(Draw map on back if needed)

Capacity: Small Medium Large

Shoreline Composition (%)

_________ Vegetated by: ____
_________ Rock armoring: ledge boulders rocks
_________ Sand

Erosion of Shoreline (%)

_________ Active cutbanks @ ________ M in height
_________ Inactive cutbanks @ ________ M in height
_________ Limited erosion with no cutbanks
_________ No erosion

Beach equilibrium: Stable Influx Unstable

Flash Flood Potential: None Low Medium High

Approximate beach profile slope: ______________________ %

Other comments:

Figure IV-1. Amended campsite inventory form for future campsite monitoring.

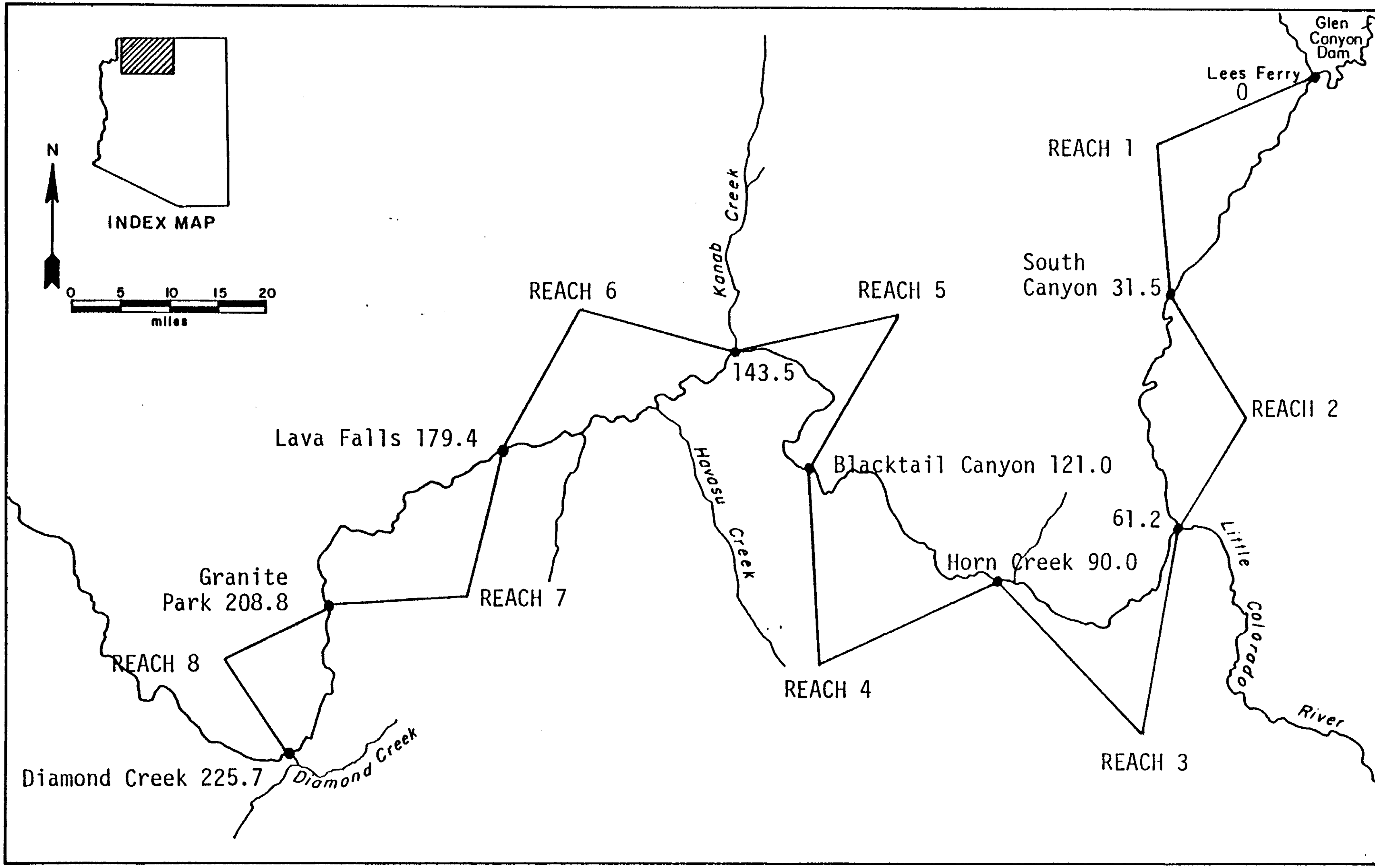

Figure IV-2. Map of the Colorado River through Grand Canyon National Park illustrating the eight 30-mile reaches.

Table IV-1. Summary of the 1988 Colorado River Beach Campsites.

	Number	Percent	Total
Capacity			
Small	7	23	
Medium	12	40	
Large	11	37	30
Shoreline Composition			
Vegetation	3	10	
Rock	13	43	
Sand	14	47	30
Erosion Type			
Active	7	23	
Inactive	3	10	
Limited	10	33	
None	10	33	30
Beach Equilibrium			
Stable	8	27	
Influx	7	23	
Unstable	15	50	30
Flash Flood Potential			
None	4	13	
Low	8	27	
Medium	9	30	
High	9	30	30

Table IV-2. 4x4x3 Matrix (Capacity x Erosion Type x Erosion Potential) for the 30 campsites surveyed in 1988.

Capacity - Erosion Type	Erosion Potential				
	None	Low	Medium	High	Total
Small - Active	0	0	0	0	0
Small - Inactive	0	0	0	0	0
Small - Limited	0	0	1	1	2
Small - No Erosion	1	1	2	0	4
Medium - Active	2	0	2	0	4
Medium - Inactive	0	1	0	0	1
Medium - Limited*	0	2	1	1	4
Medium - No Erosion	1	1	0	1	3
Large - Active	1	0	0	2	3
Large - Inactive	0	1	0	1	2
Large - Limited	0	0	1	3	4
Large - No Erosion	0	1	2	0	3

	Small	Medium	Large	Total
No Erosion/Low Erosion	2 (6%)	7 (23%)	3 (10%)	12 (40%)
Active/High Erosion	4 (13%)	5 (17%)	9 (30%)	18 (60%)

*Note: "Limited" category was added in 1988 for campsites eroding without cutbanks to compare data with 1987 3x3x3 matrix, categories 3 and 4 can be added together.

Table IV-3 1988 Colorado River Campsite Inventory.

Beach	River Mile	Side	Camp Name	Size[1]	Actual[2] Erosion	Beach[3] Equilibrium	Shoreline[4] Composition	Flash[5] Flood Potential	Human Impact Done?	Beach Profile Done?
1	8.2	L	Badger	1	4	1	3	2	Y	N
	18.2	L	18.2 Mile[6]	1	3	3	2	3	N	N
	29.0	L	Shinumo Wash	2	3	2	3	3	Y	N
	30.3	R	Fench Fault	2	1	3	2	2	N	N
	34.7	L	Nautiloid	2	4	3	2	3	N	Y
	41.0	R	Buck Farm	3	3	1	2	3	N	N
2	58.1	R	Awatubi	3	2	1	1	3	Y	N
	64.6	R	Carbon Creek	2	1	3	3	1	N	N
3	75.5	L	Neville's Rapid	3	4	1	3	2	Y	Y
	81.1	L	Grapevine	3	3	3	2	2	Y	Y
4	93.2	L	Upper Granite	2	2	3	1	1	Y	Y
	93.3	L	Lower Granite[6]	1	3	3	2	3	N	N
	108.3	L	Lower Bass	2	4	2	3	1	Y	N
	120.1	R	Blacktail	3	4	2	2	2	N	Y
	122	R	122 Mile Creek	2	1	3	3	2	Y	Y
	122.8	L	Forster	2	3	2	3	2	Y	Y
5	131	R	Bedrock	2	3	3	2	1	Y	Y
	132	R	Dubendorf	2	3	2	3	1	Y	N
	136.6	L	Upper Poncho's Kitchen	2	1	3	3	0	Y	Y
6	151.6	R	Ledges[6]	1	4	1	2	0	N	Y
	166.5	L	Upper National	3	3	3	2	3	N	Y
	166.6	L	Lower National	3	1	3	2	3	Y	Y
	180	R	Lower Lava	1	3	3	3	2	N	Y
7	186	L	186	3	1	2	3	3	Y	N
	194	L	194	3	2	2	3	1	N	Y
	206.5	R	Indian Canyon	1	4	1	2	2	Y	N
	208.8	L	Granite Park	3	1	3	1	0	Y	Y
8	212.9	L	Pumpkin Bowl	1	4	3	2	1	Y	N
	220		Upper 220	2	4	1	3	0	Y	Y
	220.1		Mid-220	3	4	1	3	1	Y	Y

1. 1=small; 2=medium; 3=large
2. 1=active; 2=inactive;3=limited; 4=none
3. 1=stable; 2=influx; 3=unstable
4. 1=vegetation; 2=rock armored; 3=sand
5. 0=none; 1=low; 2=medium; 3=high
6. omit from further study

Table IV-3. (continued)

Legend:

River Mile	=	Distance downstream from Lees Ferry (miles)
Side	=	Side of river when viewed downstream: "L" = left, "R" = right
Size	=	Camp area large enough to accommodate a river party
1 = small	=	15-20 person group
2 = medium	=	21-30 person group
3 = large	=	31-40+ person group
Actual Erosion	=	Type of erosion present
1 = active	=	cutbanks, unstable
2 = inactive	=	cutbanks, stabilized
3 = limited	=	erosion, no cutbanks
4 = none	=	no erosion apparent
Beach Equilibrium		
1 = stable	=	no erosion
2 = influx	=	deposition taking place
3 = unstable	=	erosion noticeable

Shoreline Composition

1 = vegetation
2 = rock armoring
3 = sand

Flash Flood Potential

0 = none
1 = low
2 = medium
3 = high

Human Impact
(sand discoloration)

Y = yes survey took place
N = no did not survey

Beach Profile Study

Y = Yes
N = No

CHAPTER V

WATER TURBIDITY AND TEMPERATURE OF THE COLORADO RIVER IN GRAND CANYON

Gary L. Fahrenz

INTRODUCTION

Much of the area drained by the Colorado River is arid land with little vegetation cover to hold back sediment during periods of heavy run-off. In pre-Glen Canyon Dam days, the river in the Grand Canyon was red in color, carrying an average of 140 million tons of sediment per year. Since the building of the dam upstream, sediment has been trapped in Lake Powell. Therefore, the water entering the canyon is now clear with little turbidity. Any sediment entering the river now must come from tributaries and side canyons below the dam, generally carried by melting snow or heavy summer rains.

Glen Canyon Dam has altered the temperature of the river as well. Before the dam, water temperatures fluctuated between winter lows near 32 degrees F to summer highs approaching 80 degrees F. Since the filling of Lake Powell, dam-released water exits the reservoir from the hypolimnetic zone, a region of cold (<50 degrees F) and near constant temperature approximately 200 feet below the surface. Consequently, river water temperatures no longer reach the extremes they once did, nor do they fluctuate seasonally.

An understanding of the temperature and turbidity of the Colorado River along its course in Grand Canyon is important to understanding the resulting biological community. For example, if the water is clear, a euphotic zone is present where light can penetrate and plants such as Cladophera (algae) can photosynthesize. The algae in turn provide food for amphipods and diatoms, which then are eaten by trout. The clarity of the water is necessary for the growth, reproduction, and survival of these and other aquatic species of plants and animals. The temperature range also has a limiting effect on the variety of fish able to breed and flourish, and on the plant community that supports the fish.

OBJECTIVES

With the use of Secchi Disc and surface temperature readings, the turbidity and water temperature can be determined at various locations along the Colorado River between Lees Ferry and Diamond Creek. These data will record any changes in turbidity and temperature that may occur from the mixing of water from tributaries and side canyons entering the Colorado River. Data will be collected at all water levels and from the main current and eddies to see if any correlations can be made.

METHODS

Water temperatures in degrees Fahrenheit were collected using a glass, mercury thermometer held 1-6 inches below the surface. A round, 8-inch diameter, black and white disk suspended on a chain (called a Secchi Disc) was lowered into the river at designated locations. These generally bracketed major tributaries and side canyons. The disc was lowered into the water until it disappeared from sight when observed from three feet above the water. The depth of the descent was measured by the chain marked in feet.

RESULTS

Table V-1 and Figures V-1 and V-2 present both turbidity and temperature results. The turbidity data showed a great decrease in clarity as we passed the Paria River confluence, dropping from 10.5 feet to 4.5 feet. On day two, the river cleared to 6.5 feet visibility until we passed the Little Colorado River (which was running very muddy), where visibility dropped to 1.5 feet. We lost another 1.0 feet of visibility upon passing Bright Angel Creek, which was also muddy. The river slowly began to clear until major thunderstorms occurred while we were camped just below Deer Creek. The following day, both Kanab and Havasu creeks showed evidence of major flooding, and Tuckup was in flood as we passed, running at approximately 1-2,000 cfs and contributing sufficient sediment to the river to reduce visibility to 0 feet. Through the last 50 miles of the trip to Diamond Creek, visibility cleared somewhat to stabilize at 1.0 feet. Turbidity was measured several times in the current and in an eddy at the same check point, and no difference in turbidity was noticed.

The temperature of the river increased 11 degrees F in the 225 miles from Lees Ferry to Diamond Creek (Table V-1). The graph "Surface Water Temperature, Colorado River" (Fig. V-2) shows gradual warming downstream of about 1 degree F per 30 miles. Between Mile 90 and Mile 150, the temperature warmed 5 degrees F for an average of about 1 degree F per 12 miles. The river temperature stabilized at 60 degrees F through the last 45 miles of the trip. No difference in temperature was noted between main channel and eddies, nor between high and low water volumes (at the same check point).

CONCLUSIONS

The clarity of the water showed marked drops following the Paria River, the Little Colorado River, Kanab Creek, and Tuckup Canyon. All these tributaries were muddy, and their sediments are believed to have decreased the clarity of the Colorado River.

During our river trip, July 27-August 6, 1988, the flow of water discharged from Glen Canyon Dam averaged lows of 5,000 cfs and highs of 20,000 cfs, with extremes of 3,340 to 29,652 cfs. The turbidity of the river was slightly higher during high water flows than during low water flows throughout the trip.

The water temperature rose at on a gradual curve all the way downstream. The fastest rise in temperature occurred between the Little Colorado River and Havasu Creek. This rapid temperature change could be the result of two factors: 1) higher turbidity in the water causing a greater absorption of the sun's heat, and 2) the east-west orientation of this stretch through the widest part of the canyon resulting in more hours of direct solar gain.

Table V-1. Table showing the day, time, mile, temperature, and turbidity of all data collection sites.

Day	Time	Mile	Temperature (degrees F)	Turbidity (feet of visibility)
1 7/27/88	1:05 pm	1	49	10.0
	3:50 pm	8	50	5.5
	4:18 pm	11.5	50	4.5
	5:20 pm	18.2	50	4.5
2 7/28/88	9:00 am	30	50	5.5
	12:55 pm	38.5	51	6.5
	2:50 pm	41.5	51	5.5
	4:20 pm	52	51	4.5
	6:30 pm	58	51	4.5
3* 7/29/88	10:10 am	59	51	2.5
	10:51 am	62	51	1.5
	4:28 pm	74	52	1.25
	6:17 pm	77	52	1.25
4 7/30/88	7:30 am	81	52	0.5
	11:50 am	87.5	52	0.5
	2:00 pm	98	53	0.25
	5:00 pm	108	55	0.25
5 7/31/88	8:00 am	120	56	0.5
	6:00 pm	120	56	0.5
6 8/1/88	8:35 am	123	57	0.75
	2:15 pm	131.5	58	0.5
	5:00 pm	136	58	0.5
7 8/2/88	7:30 am	136.5	58	0.75
	10:00 am	140	58	0.75
	10:35 am	143.5	59	0.25
	2:50 pm	159	59	0.25
	4:45 pm	165	59	0.0 **
8 8/3/88	8:30 am	166.5	59	0.5
	6:00 pm	166.5	59	0.5
9 8/4/88	10:15 am	167	59	0.5
	11:30 am	179	59	0.75
	1:30 pm	180	60	0.75
	3:40 pm	185.5	60	1.0
10 8/5/88	8:40 am	194	60	1.0
	10:00 am	205	60	1.0
	2:25 pm	207	60	1.0
	3:00 pm	209	60	1.0
	7:00 pm	220	60	1.0
11 8/6/88	7:50 am	220	60	1.0
	9:30 am	225	60	1.0

* Woke with river up to 25,000 cfs and very muddy.
** Tuckup Canyon in flash flood (1-2,000 cfs).

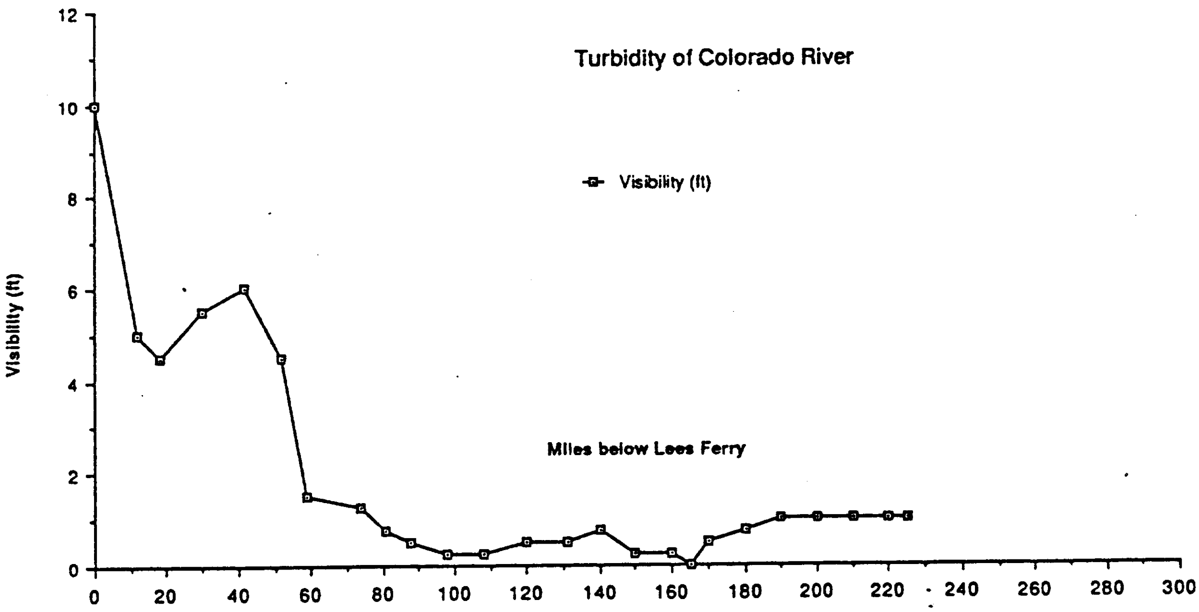

Figure V-1. Turbidity of Colorado River in Grand Canyon, measured in feet of visibility.

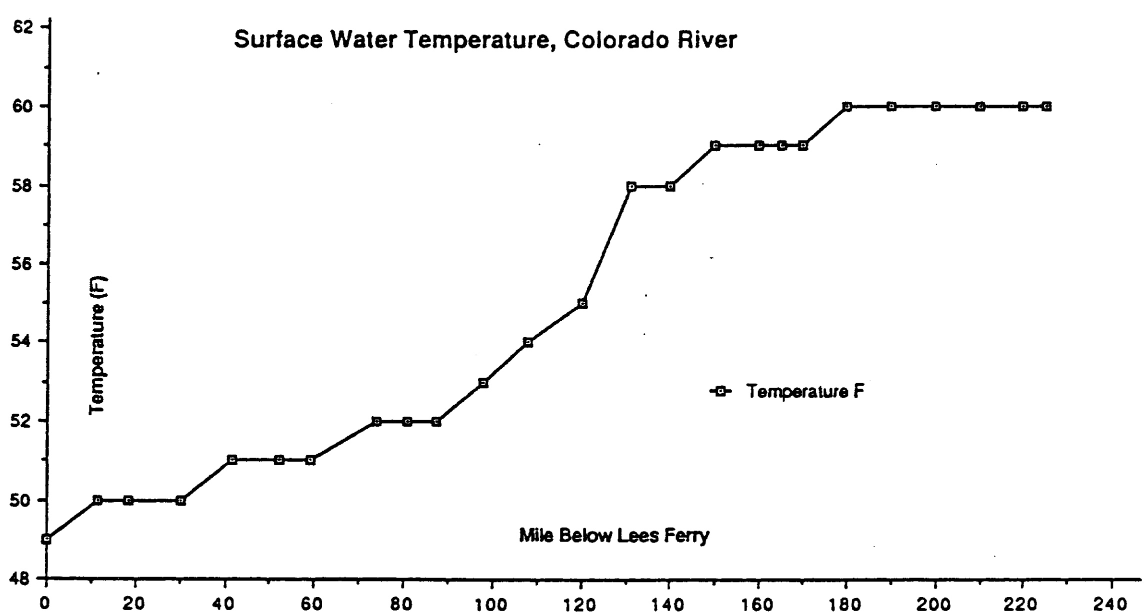

Figure V-2. Surface water temperatures for Colorado River in Grand Canyon

CHAPTER VI

SALINITY STUDY OF THE COLORADO RIVER AND SELECTED TRIBUTARIES FROM LEES FERRY TO DIAMOND CREEK

Barner David Loucks

INTRODUCTION

This year for the first time the annual Northern Arizona University class on the geology and ecology of Grand Canyon included in its research topics a salinity check of the Colorado River and selected tributaries in the park. The study area extended from Lees Ferry down 225 miles to Diamond Creek.

Before man was present to interact with the river, the Colorado flowed virtually unchecked from the high western slopes of the Colorado Rocky Mountains to the Gulf of California. The Green River, a major tributary, flowed unrestrained down from Wyoming through eastern Utah to join the Colorado. The drainage basins of these two rivers and lesser tributaries to the Colorado are often made up of rock formations that contain large quantities of salt. Both surface run-off and ground water seepage can leach the salt from the rock. A significant quantity of this salt-laden water finds its way to the Colorado giving the river a natural salinity content.

With the introduction of dams on the Colorado River and some of its tributaries, salinity of the river increased dramatically. There are two reasons for this. First, when water is impounded behind a dam and its surface area increases greatly, evaporation increases proportionately to surface area. As water evaporates, the salt concentration in the water left behind increases. It is generally accepted that Lake Powell loses about one million acre-feet of water (about 325 billion gallons) a year to evaporation. The second impact of dams on salinity is caused by drawing water out of reservoirs for irrigation. Grand Valley, a man-made oasis in western Colorado, is a case in point. It depends entirely upon the Colorado River for water. Canals divert a large share of the river over fields. The water percolates through the soil, passing through thick beds of mineral salts as it makes its way back to the river. The water that leaves the river has a salinity content of about 200 parts per million (ppm). The returning water has a salinity content of around 6,500 ppm (Reisner 1986). Other irrigation projects along the river contribute salt as well, if not to the same degree.

OBJECTIVES

The purpose of this study was to collect data on the salinity of the Colorado River and several of its tributaries in Grand Canyon and to determine if a pattern of salinity would emerge.

METHODS

Samples of water were tested for salinity levels at 16 points along the river from Mile 0 to Mile 220. Samples from eight tributaries were tested as well.

Salinity was measured using a Myron L Delux DS Meter. This meter, powered by a nine-volt battery, is calibrated from 0 to 2,500 ppm. Basically, it measures the conductivity of the water. The greater the amount of total dissolved solids (TDS) in the water, the greater the conductivity.

Before each reading, the meter was calibrated. To do this, the red set button was pushed. If the needle did not automatically register 2,250 ppm, it was set at that reading by the investigator. Once the meter was calibrated, the water sample was poured into the plastic tube on top and a reading taken.

As a control, samples of distilled water and Flagstaff City water were tested separately before and after the research trip. As expected, the distilled water gave a 0 reading. The Flagstaff water read at 90 ppm both times.

RESULTS

The results of the salinity tests conducted on the Colorado River during this investigation are listed in Table VI-1. No salinity data from previous studies are given in this preliminary report.

The findings of this study show that the salinity of the Colorado River increased from 550 ppm at Lees Ferry (Mile 0) to 650 ppm at Mile 220. There were peak readings of 650 ppm at three other locations along the river. Measurements from tributaries ranged from 210 ppm to >2,500 ppm.

CONCLUSIONS

The overall increase of 75 ppm in a 220-mile stretch of river seems significant. It may be due to a combination of highly saline tributaries and very high run-off from side canyons caused by a series of heavy rainstorms that occurred during the trip.

Earlier this year, the Bureau of Reclamation released a report entitled, "Estimating economic impacts of salinity of the Colorado River." The Bureau states that the salinity level at Parker Dam (downstream of Grand Canyon) was 542 ppm in 1986. This is substantially lower than the readings I got toward the end of our trip (625-650 ppm in the stretch from Mile 120.1 to 220)(see Table VI-1). It does not seem reasonable to assume, as these data suggest, that the river becomes less saline downstream. On the contrary, there is every reason to believe that it becomes more saline. This contradiction could mean erroneous data collection or an increase of at least 100 ppm in salinity in two years. This would be a substantial increase in that length of time.

Table VI-1. Summary of salinity test data, July 27-August 6, 1988.

Day	Mile Location	Time	PPM	Comments
1	0 Mile (Lees Ferry)	8:30 am	550	C,L
	8 Mile	2:25 pm	500	C,I
2	29 Mile	6:02 pm	560	C,L
	Vasey's Paradise (31.7 Mile)	10:10 am	210	T
3	58.1 Mile (Awatubi)	6:00 am	600	C,H
	Carbon Creek (64.4 Mile)	11:00 am	>2500	T
4	81.1 Mile (Grapevine)	7:00 am	675	M,H
	Bright Angel Creek (87.5 Mile)	am	212	M,T
5	120.1 (Blacktail Canyon)	3:00 pm	590	M,H
	Blacktail Creek (120.1 Mile)	3:20 pm	1800	T,L
6	120.1 (Blacktail Canyon)	7:30 pm	625	M,I
	122.8 Mile	11:28 am	600	M,I-L
	Deer Creek (136.1 Mile)	4:30 pm	240	T,C
7	136.6 (Pancho's Kitchen)	7:15 am	640	M,L,AR
	151.6 (Ledges)	12:45 pm	625	M
	Ledges tributary (151.6 Mile)	12:50 pm	1300	T
8	166.5 (Upper National)	6:00 am	600	M,L
	National Creek (166.5 Mile)	3:00 pm	1500	T
	166.5 (Upper National)	8:14 pm	650	M,H
9	166.5 (Upper National)	6:40 am	650	M-C,L
	Tributary (182 Mile)		1050	T
	183 Mile	3:00 pm	625	M,I
10	194 Mile	6:05 am	650	M,I-H
11	220 Mile	7:10 am	625	M,I-H
*	Paria River	4:20 pm	735	M,L
*	Little Colorado River	1:30 pm	560	M,L
*	Lake Powell (Stateline Beach)	3:10 pm	460	C

Key: AF=After Rain C=Clear Water M=Muddy Water
H=High CFS I=Intermediate CFS L=Low CFS T=Tributary
*=Measurements taken after trip on August 9, 1988.

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CHAPTER VII

SMALL MAMMAL POPULATIONS WITHIN THE COLORADO RIVER CORRIDOR

D. Kendall, L. Kendall, R. Block, M. Block

INTRODUCTION

This study was designed to determine small mammal use of four distinct habitats along the Colorado River corridor from Lee's Ferry to 220 Mile Beach. Mammal populations in the corridor have been described since the completion of Glen Canyon Dam (Hoffmeister, 1971; Ruffner, 1975, 1976, 1978). The four habitats were described as zones by Carothers (1976), and limited trapping of small mammals was done before and just after the flood of 1983 (Trimble, 1982; Spears, 1983).

The habitat zones (Figure VII-1) are: 1) Talus - desert vegetation, 2) Terrace - old high flood zone vegetation, 3) new beach/boulders - short lived invasion species, 4) new riparian - Tamarix, Salix, Pluchea.

In 1982, the new riparian zone 1 yielded the most small mammals (63%) after twenty years of uninterrupted plant habitat growth. The small mammals were on high ground zone 1 (47%) in 1983, after the new riparian zone 4 vegetation had been swept away. In 1987, despite the recovery of the new riparian zone 4 plant community, the small mammals were trapped in greater number in zone 2 (43%).

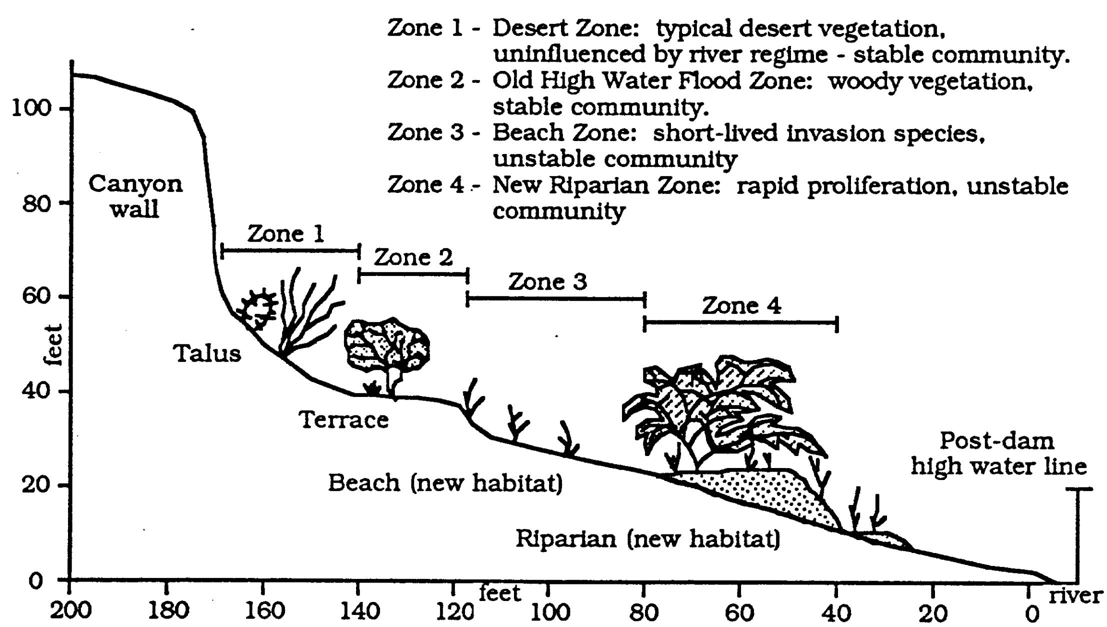


Figure VII-1. Diagrammatic cross-section of vegetation zones in the Inner Gorge of the Colorado River in Grand Canyon after construction of Glen Canyon Dam (adapted from Carothers, et. al., 1979).

OBJECTIVES

This is a continuation of studies designed to look at changes in mammal populations along the Colorado River corridor. A comparison of data should show differences in small mammal populations both overall or in specific life zones.

METHODS

During the eleven day river trip, mammals were trapped on eight beaches (Blacktail Canyon and National Beach were trapped on two nights each) using Sherman live traps baited with oatmeal, granola, or cooked rice. Traps were set in the evening and distributed in proportion to the amount of habitat zone present. At dawn, mammals were weighed, sexed, identified by species, and released unharmed (see Field Notes for measurements).

RESULTS

Table VII-1 shows a wide range in numbers of animals captured on each beach. The table compares the number of animals trapped to the numbers of traps set in each zone per night. The totals of animals captured by zone from Tables VII-1 and VII-2 are compared with similar data from previous years in Figure VII-2.

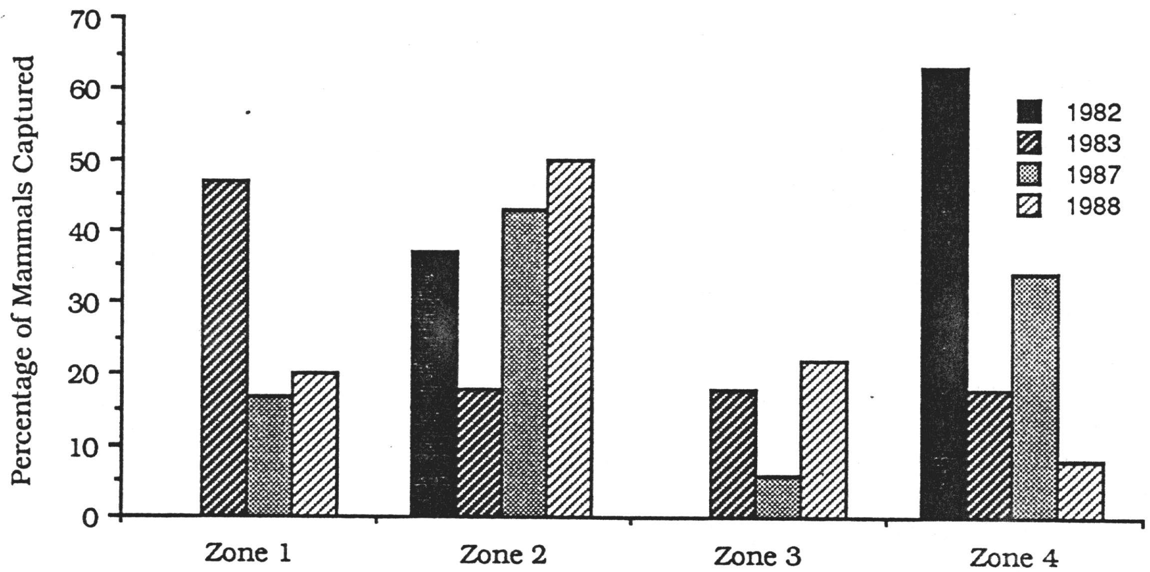
Figure VII-3 provides a comparison between the relative percentages of the seven species studied in 1982, 1983, 1987 and 1988.

Table VII-1. Mammals captured by beach and habitat zone.

Date	Beach	Zone 1 animals/traps	Zone 2 animals/traps	Zone 3 animals/traps	Zone 4 animals/traps	Total total/traps
07-27	30-Mile [R30.0]	0/44	5/35	0/00	0/00	05/79
07-28	Awatubi [R 58.1]	8/10	7/15	2/25	0/25	17/75
07-29	Grapevine [L 81.1]	1/20	0/00	0/00	0/00	01/20
07-30	Blacktail [R 120.1]	0/22	7/21	2/21	3/21	12/85
07-31	Blacktail [R 120.1]	0/22	8/21	1/21	1/21	10/85
08-01	Pancho's [L 137]	0/00	6/15	0/15	0/00	06/30
08-02	Upper National [L 166.5]	3/10	7/22	4/22	0/00	14/54
08-03	Upper National]L 166.5]	4/10	5/22	7/22	0/00	16/54
08-04	194-Mile [L 194.0]	3/22	1/22	3/22	4/22	11/88
08-05	220-Mile [R 220.0]	1/22	4/22	3/22	0/10	08/76
		20/182 (20%)	50/195 (50%)	22/170 (22%)	08/99 (8%)	100 (100%)

Table VII-2. Mammals captured by species and habitat zone.

Species	Zone 1	Zone 2	Zone 3	Zone 4	Total	% of Total
Peromyscus maniculatus	0	0	0	0	0	(00%)
Peromyscus eremicus	14	16	17	5	52	(52%)
Peromyscus crinitus	0	6	2	0	8	(08%)
Peromyscus boylii	4	23	3	3	33	(33%)
Perognathus formosus	0	0	0	0	0	(00%)
Perognathus intermedius	0	0	0	0	0	(00%)
Neotoma albigula	1	2	0	0	3	(03%)
Neotoma lepida	1	3	0	0	4	(04%)
Total per zone	20	50	22	8	100	
Percent of total per zone	(20%)	(50%)	(22%)	(08%)	(100%)	



1982 data adapted from Table VI-1, Trimble (1982)
1983 data adapted from Table 9-2, Spears (1983)
1987 data adapted from Table IX-1, Rotstein (1987)
1988 data adapted from Table IX-1, this publication

Figure VII-2. Percentage of mammals captured by zone.

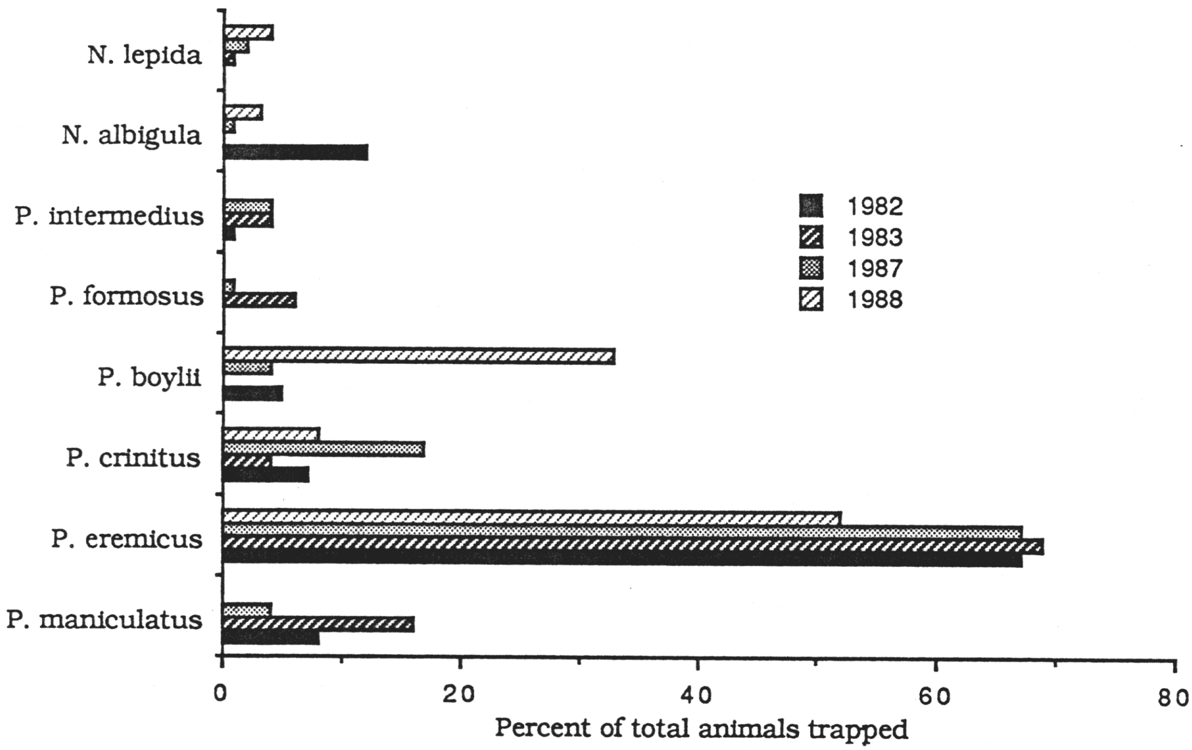


Figure VII-3. Percentage of small mammal species caught by year.

CONCLUSION

Many of the results in the 1987 small mammal research project were found to be continued this year, with some surprising new discoveries.

One hundred small mammals were caught in ten nights on eight beaches, of a total of 646 traps set. The trap success rate would therefore be 15%, as compared to 13% last year. A total of 646 traps were set with 82 small mammals caught in 1987.

More mammals were caught in zone two than in any other zone, and the Peromyscus eremicus (52%) continued to dominate the population, as first commented upon by C. Hart Merriam (1890), and has been noted by others in previous studies. No Peromyscus maniculatus, Perognathus formosus or Perognathus intermedius were trapped. The two species of Neotoma together increased from 3.7% of the total number of animals in 1987 to 7% of the total in 1988.

The most significant change noted in 1988 data is the surprising increase in the number of Peromyscus boylii, from 3% of the total mammals caught in 1987 to 33% of the total mammals in 1988. Seventy-three percent (24 of 33) of the Peromyscus boylii were found on the the right side of the river. This corresponds with the fact that the P. boylii were only found on the right side of the river until recently, when it has been thought that they have migrated to the north, or left side, by crossing the river at the Phantom Ranch Bridge. (personal communication, S.W. Carothers).

The variation in capture success rate appears to be related to three principle variables: choice of beaches for trapping, number of traps set and weather. Cooler nights yielded more mammals, especially after rain, as cited in the 1987 study. Different beaches were trapped in each year. The size of the beach and the life zones at each camp determined the number of traps set each night. Many traps were found to be defective, and at 194-Mile beach, the team numbered the traps as described in the Addendum.

Beaches with high numbers of ants (Blacktail and RM 220) yielded traps with many ants and few mammals. On each of these two beaches one Peromysucs boylii was killed by ants before the traps were checked at dawn. It is likely that the small mammal population on these beaches is limited due to the competition for the same food sources.

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FIELD NOTES

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ADDENDUM

1. Traps should be cleaned before using. This mammal team did clean up the traps after the trip, so they should be easier to use for the next group.

2. Traps should be numbered in such a way to make laying and collecting of traps quicker and most efficient. This team did number twenty-two (22) traps for each of the four zones. They were numbered as such: 1-1, 1-2, 1-3, etc. for zone one; 2-1, 2-1, 2-3, etc. for zone two, and the same procedure for zones three and four.

3. If the group is preparing to stay at a camp overnight for two nights, as we did at Blacktail and National, it is advised that after the first night, the traps are all checked in the morning, and the empty ones are tapped to release the trap, to prevent a critter from going into the trap during the day and dying from the heat.

4. Flagging traps is helpful. It is recommended that the flagging is cut and ready to use before the trip. This will insure easier recognition of all traps in the morning, especially if someone else helps to set the traps, as well as if the traps are set out after dark.

CHAPTER VIII

LIZARD DENSITY STUDIES ALONG THE COLORADO RIVER IN GRAND CANYON NATIONAL PARK

Debra Metteer, Peggy Benenati, and Beverly Oothoudt

INTRODUCTION

This project attempts to quantify the preferred lizard habitat and density in the Colorado River's four environmental zones (Figures VIII-1a and 1b). Zone 1, farthest from the river, features typical desert scrub vegetation. Zone II, a stable community of woody vegetation dominated by acacia and mesquite, marks the old high water flood line (OHWL). The river reached this OHWL during the high water releases from Glen Canyon Dam in 1983 for the first time since the dam was constructed in 1963. Zone III, a sandy beach area, is an unstable vegetative zone primarily used for camping. Zone IV, the new high water level (NHWL), consists mainly of the exotic tamarisk (*Tamarix chinensis*) and the native plant species arrowweed (*Tessaria sericea*) and coyote willow (*Salix exigua*). The proliferation of this riverside vegetation is a direct result of controlled river flows from Glen Canyon Dam that prevent scouring floods. Until recently, it was thought by many that the tamarisk in the new high water line was of little or no value. However, findings by Warren and Schwalbe (1986) indicate that this NHWL zone is not only richly inhabited by reptiles, but possibly may be the preferred habitat.

OBJECTIVES

The objectives of this project are as follows:

1. To compare the densities of lizards in all four zones.
2. To determine the types of vegetation most inhabited by lizards.
3. To determine if there is a relationship between ambient and soil temperature and the density of lizards.

HYPOTHESES

Previous studies in this course and as reported by Warren and Schwalbe (1986) indicate that Zone IV (NHWL) provides more shelter for protection and greater food source, and therefore should have a greater density of lizards than the other zones.

Lizards are cold-blooded and dependent upon temperature of the environment for their body temperature. The density of observed lizards, therefore, would be expected to increase in all zones with increasing temperature as lizards move about.

METHODS

This project attempted to sample all four zones at as many beaches as possible.

1. Three observers walked through all the zones at each study beach for periods ranging from 10 to 20 minutes. One observer was responsible for Zone I, the second for Zone II, and the third covered both Zones III and IV.
2. The number and type of lizards seen during that period were recorded.
3. Accurate records were kept of the type of vegetation present where the lizards were spotted.
4. Temperature of the soil and ambient temperature were taken at each site prior to the tabulation.

Data sheets are provided to facilitate the gathering of information (Figure VIII-7)

MATERIALS:

1. 3 clipboards
2. data sheets
3. watches
4. pencils/pencil sharpener
5. 1 air thermometer, 1 soil thermometer
6. reference books: A Guide to Field Identification Reptiles of North America, by H.M. Smith and E.D. Brodie, Jr. and The Audubon Society Field Guide of North American Reptiles and Amphibians, by J.L. Behler.

RESULTS

Table VIII-1 and Figure VIII-2 present the various environments in which the reptiles were found according to zones. Of all individuals observed, 59% were found on rock, 15% near desert scrub, 15% near mesquite, 14% near tamarisk, 7% on sand without vegetation, and 1.5% near acacia. No lizards were found near seep-willow, coyote willow, or arrowweed.

Table VIII-2 and Figure VIII-3 present the density of lizard types observed per minute in each zone. Zone 4 had the highest density of all lizard types except the desert spiny lizard.

Table VIII-3 presents the density of lizards observed per minute in each zone. There is a discrepancy between individuals per minute in each zone and the actual time spent observing in each zone.

Figure VIII-4 presents total number of individuals observed in each zone. Zone IV showed twice as many lizards as Zones I and II.

Figure VIII-5 and Figure VIII-6 represent the number of lizards observed compared to the ambient and soil temperatures. There was a definite increase in lizards observed within the soil temperature range of 32 degrees and 35 degrees Celsius in all zones. Ambient air temperatures within the range of 32 degrees and 37 degrees Celsius also showed in increase in number of lizards observed in all zones.

CONCLUSIONS

According to the data, the highest percentage of lizards were found on rocks. Equal percentages of lizards were found around tamarisk, mesquite, and desert scrub. The least favored environment were acacia and sand.

Zone IV was found to be the preferred habitat for all lizard types except the desert spiny, which supports previous study results and the hypothesis.

The data that represents the density of lizards observed per minute and the total number of lizards observed per zone are not accurately related due to the variation in time spent in observing the lizards. Table VIII-3 and Figure VIII-4 demonstrate this discrepancy. Recommendations for future studies have been made to alleviate this difference.

The soil temperature range of 32 degrees and 35 degrees Celsius showed the highest number of lizards observed in all zones. The ambient temperature range of 32 degrees and 36 degrees Celsius also showed an increase in lizard density in all zones. There appears from this study to be a narrow range of temperatures (soil and air) where there is an increase in lizards observed in all zones. The data show a limit to the relationship between lizards observed and temperature increase. After 37 degrees Celsius, the number of lizards observed declined. This disagreed with the original hypothesis that an increase in temperature would result in an increase in lizards.

RECOMMENDATIONS

1. Each zone on each beach should be observed for the same amount of time.

2. The lizard study team should observe the beach before other people move about on it, disturbing the lizards and preventing an accurate count.

3. Observers need to look at actual lizard specimens before attempting to identify the lizards in the field.

4. Only specify "sand" or "rock" if no vegetation is near. Determine in advance the maximum distance required to record vegetation.

5. Observe as many beaches as possible with all four zones for consistent data collecting.

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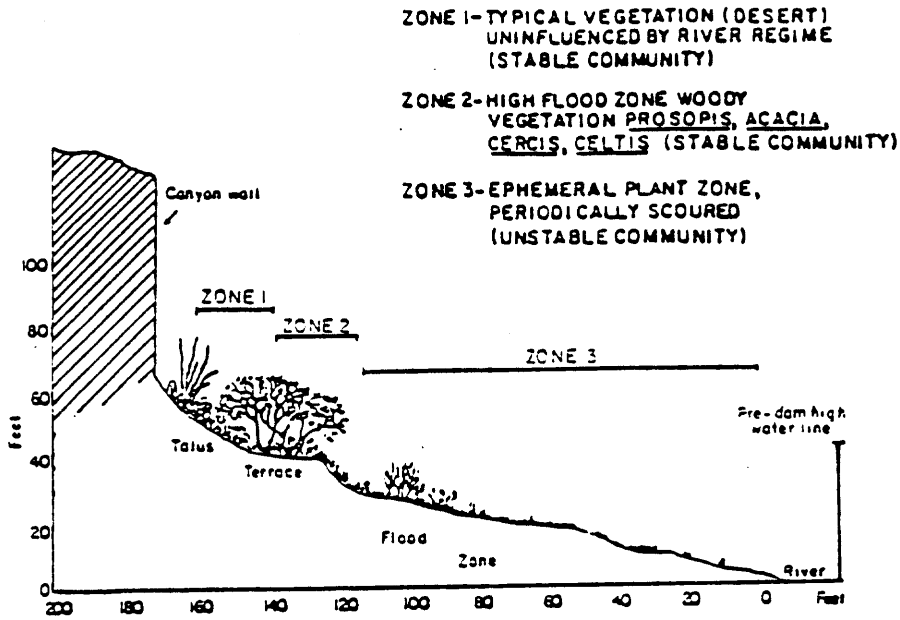

Figure VIII.1a. A Profile of the vegetative zones of the Colorado River floodplain in the Grand Canyon prior to the construction of Glen Canyon Dam

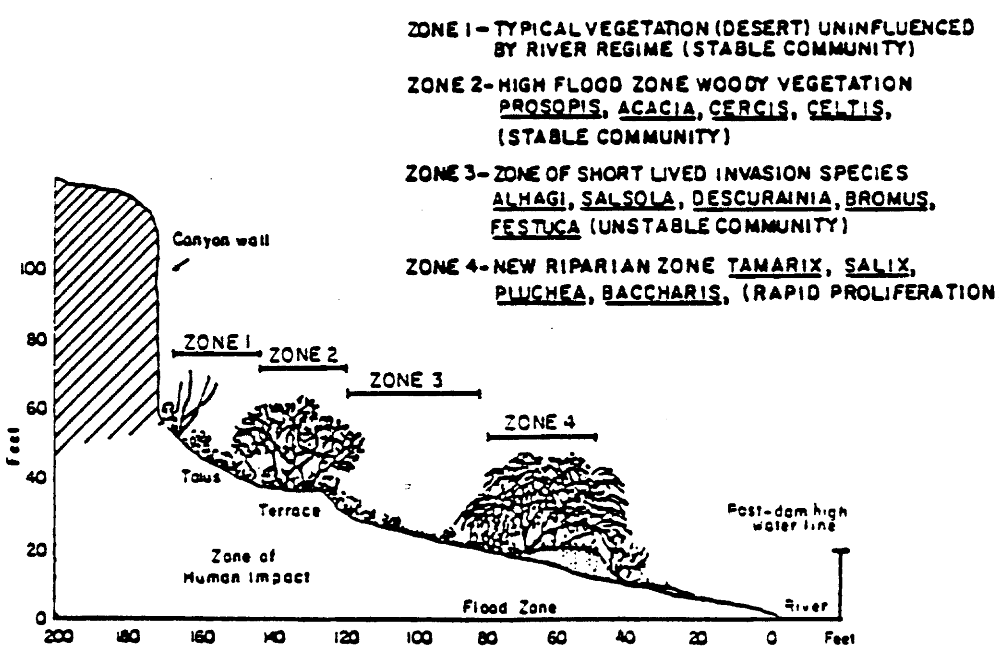

Figure VIII.2b. A profile of the vegetative zones of the Colorado River floodplain in the Grand Canyon 13 years after the impoundment of Colorado River waters by Glen Canyon dam

Table VIII-1 Reptiles Found in Various Environments

Vegetation	Zone 1 Number Observed	%	Zone II Number Observed	%	Zone III Number Observed	%	Zone IV Number Observed	%	All Zones Number Observed	%
Tamarisk	0	0	4	10	6	46	17	18	27	14
Seep Willow	0	0	0	0	0	0	0	0	0	0
Coyote Willow	0	0	0	0	0	0	0	0	0	0
Arrowweed	0	0	0	0	0	0	0	0	0	0
Acacia	0	0	1	2	0	0	0	0	3	1.5
Mesquite	0	0	8	21	0	0	0	0	29	15
Desert Scrub	21	45	9	23	0	0	0	0	30	15
Rock	26	55	17	44	5	39	68	70	116	59
Sand	0	0	0	0	2	15	12	12	14	7
Total	47	100	39	100	13	100	97	100	196	100

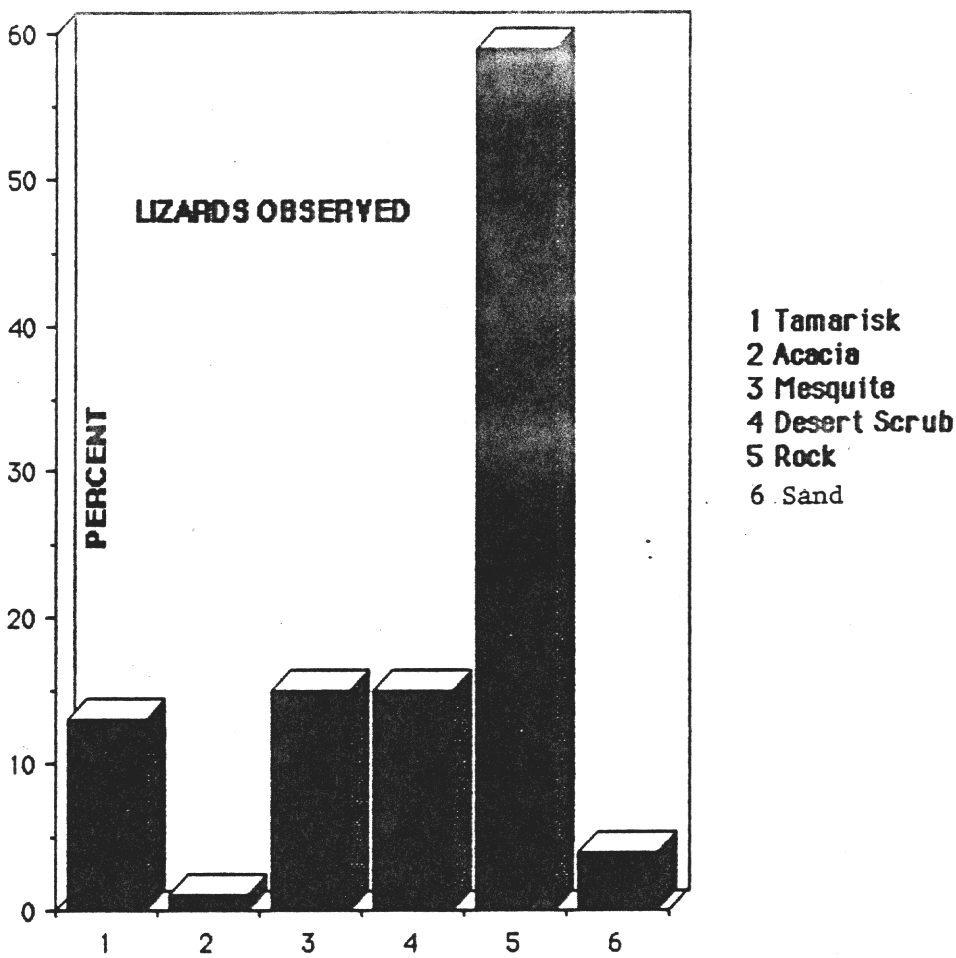

Figure VIII-2. Percent of lizards observed on each plant type or substrate.

Table VIII-2. Number of Lizards Observed.

	Zone I		Zone II		Zone III		Zone IV	
	Number	/minute	Number	/minute	Number	/minute	Number	/minute
Side Blotched	18	.05	4	.017	2	.023	32	.171
Desert Spiny	2	.006	10	.04	2	.023	6	.032
Western Whiptail	2	.006	1	.004	2	.023	24	.128
Tree	23	.07	23	.10	7	.080	29	.155
Others	2	.006	1	.004	0	0	6	.171
Totals	47	.138	39	.165	13	.149	97	.657
Total Minutes Observed	336		232		87		187	
Total Lizards Observed	47		39		13		97	

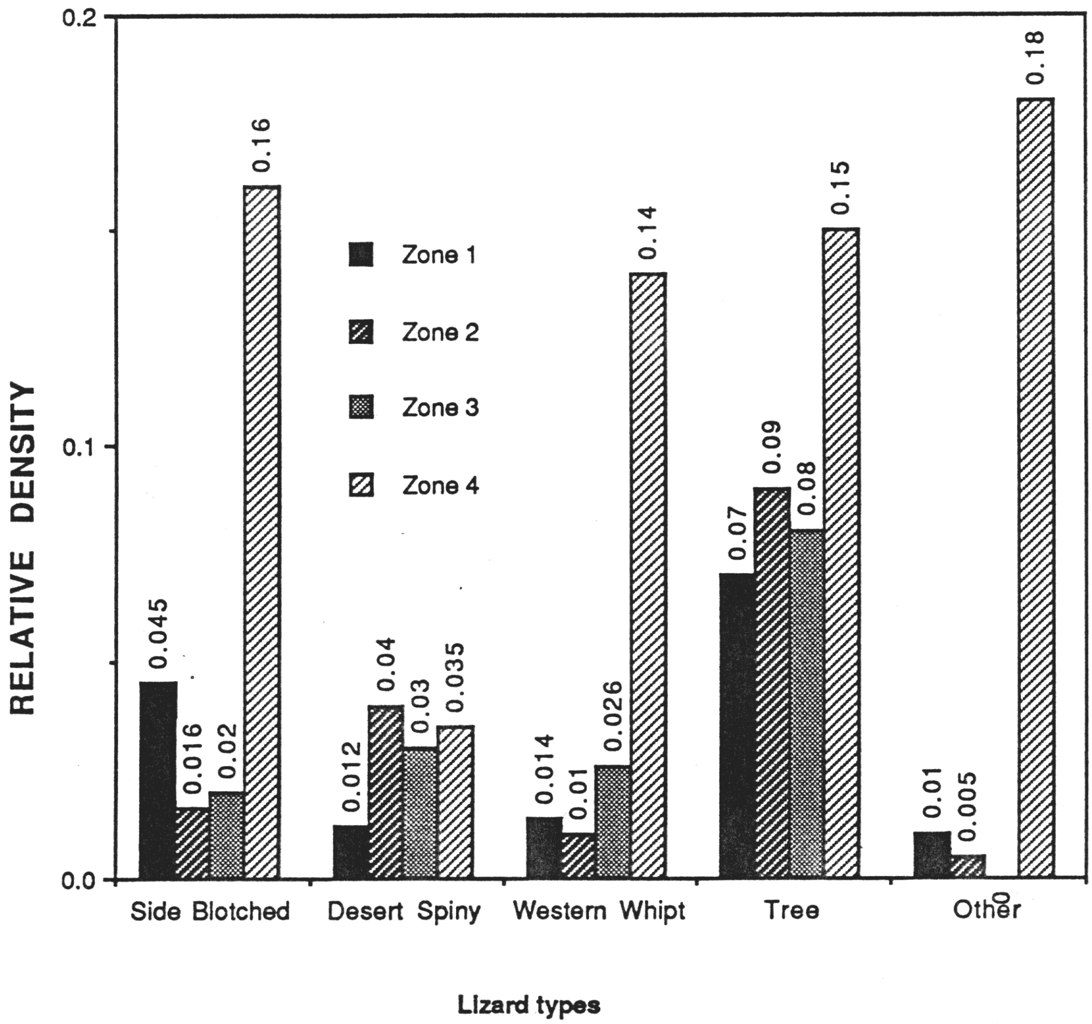

FIGURE VIII-3. RELATIVE DENSITY OF LIZARDS (INDIVIDUALS PER MINUTE) IN ALL ZONES.

TABLE VIII-3. RELATIVE DENSITY OF LIZARDS (INDIVIDUALS PER MINUTE)

Zones observed	Individuals Per minute	Total Minutes	Total Lizards
ZONE 1	0.14	336	47
ZONE 2	0.17	232	39
ZONE 3	0.15	87	13
ZONE 4	0.52	187	97

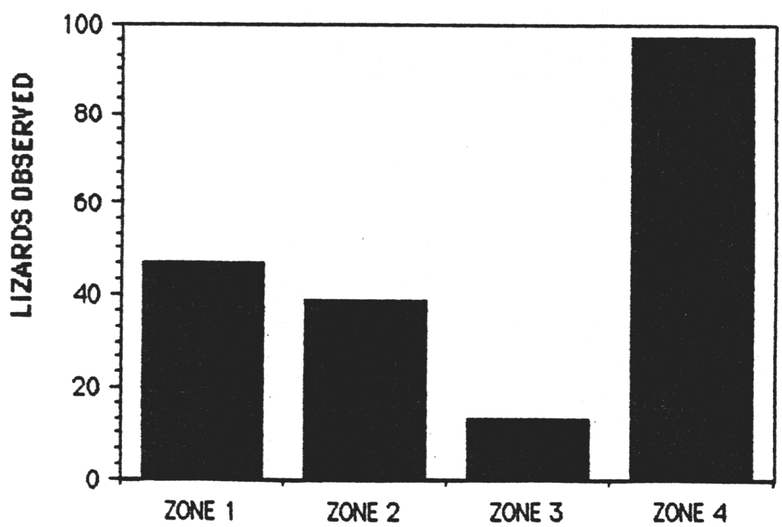

FIGURE VIII-4. TOTAL NUMBER OF LIZARDS OBSERVED

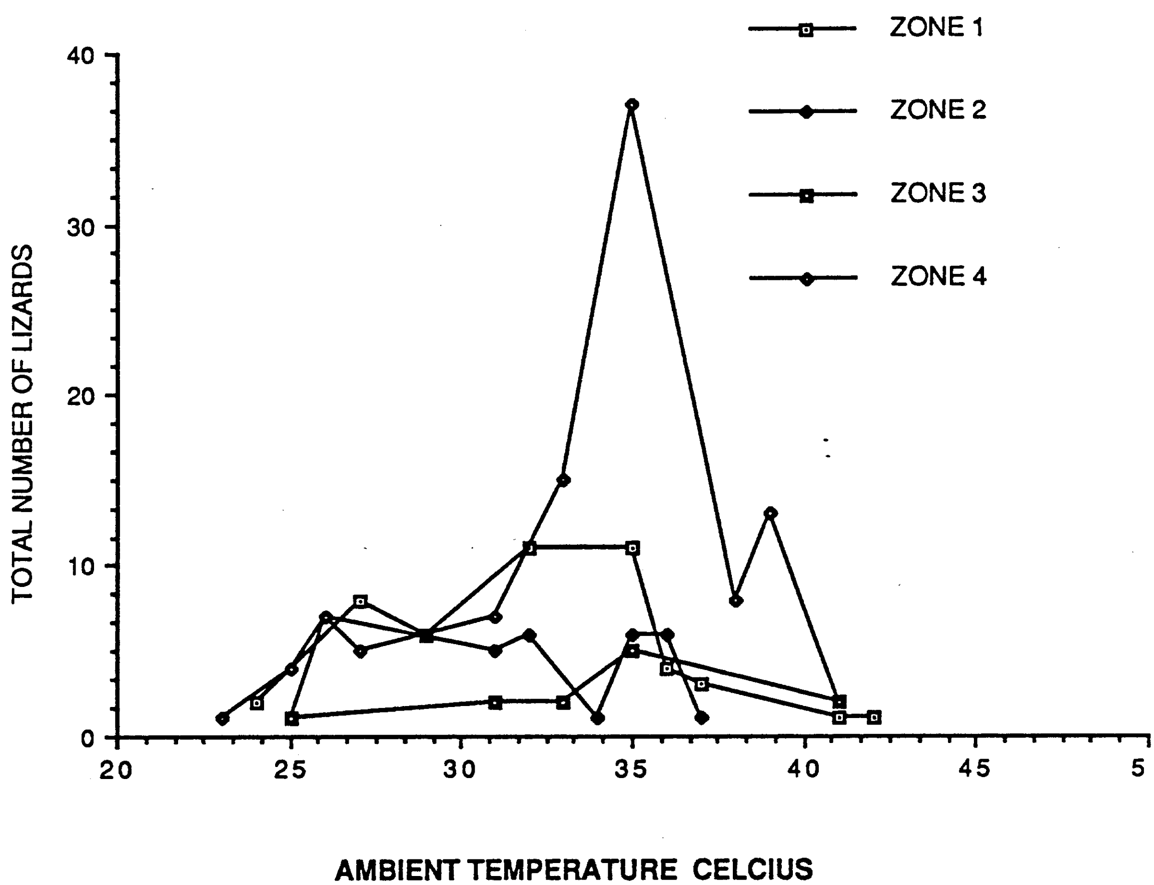

FIGURE VIII-5. OBSERVATIONS OF LIZARDS AS A FUNCTION OF TEMPERATURE

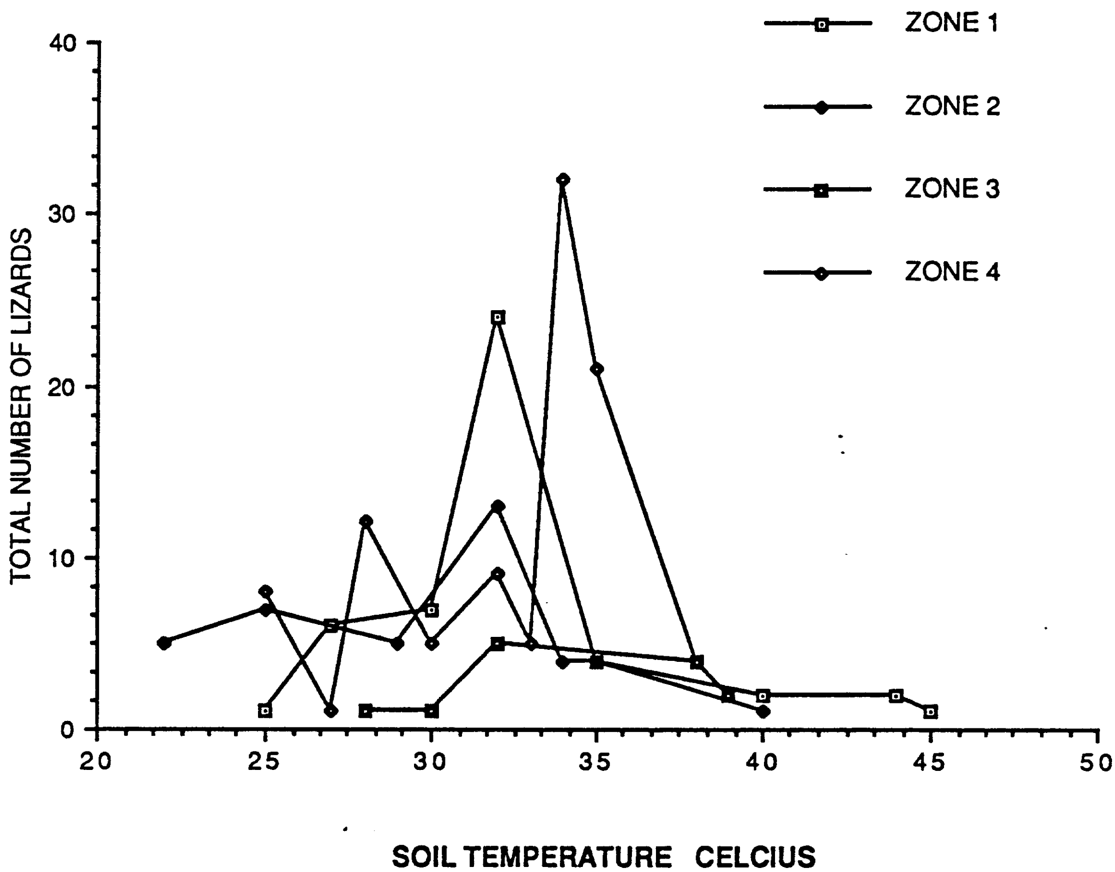

FIGURE VIII-6. OBSERVATION OF LIZARDS AS A FUNCTION OF SOIIL TEMPERATURE

REPTILE PROJECT DATA SHEET - AUGUST 1988.

OBSERVER________________ BEACH NAME (RIVER MILE)______________

DATE___________ TIME START_______TIME STOP______

AMBIENT TEMPERATURE___________ LAPSED TIME_________

VEGETATION ZONE: 1 2 3 4

SPECIES REPTILE: 1 2 3 4 5 6 7

SPECIES VEGETATION: 1 2 3 4 5 6 7 8

Total Number
Percent
TOTAL INDIVIDUALS PER MINUTE ________

KEY TO ZONES
1 - desert vegetation
2 - Old High Water Line
3 - Zone of Human Impact
4 - New High Water Line

KEY TO REPTILES
1 - side blotched lizard
2 - desert spiny lizard
3 - western whiptail
4 - tree lizard
5 - desert collared lizard
6 - chuckwalla
7 - __________

KEY TO VEGETATION
1. tamarisk
2. seep willow
3. coyote willow
4. arrowweed
5. mesquite
6. acacia
7. desert scrub
8. rock
9. sand

NOTES

Figure VIII-7. Example of reptile project data sheet.

CHAPTER IX

SOCIOLOGICAL DATA REPORT

Kelcy Thompson

INTRODUCTION

This report includes a log of all stops made while traveling down the Colorado River on the 11-day Northern Arizona University Grand Canyon research expedition of 1988, and presents data collected on the number of daily boat and aircraft contacts. Comparisons will be made with data from previous NAU research trips; in addition, one aspect will be added: a subjective analysis of how these contacts affected the quality of the experience for the participants.

METHODS

The following data were transcribed in a waterproof, columned, pocket-size notebook: day, river mile, location name, miles covered per day, arrival and departure times, duration of stay, reason for stop, contact size (number of boats and people), group name and whether seen before, type of boat trip, type of contact, duration of contact, type of aircraft, duration of time seen and/or heard, whether our campsite was within sight or sound of others, and whether the campsite was the scheduled one or an alternate.

RESULTS

During the river trip, a total of 47 stops (exclusive of camping) were made: 30 for beach research projects, 9 at attraction points, and 8 for lunch (Table IX-1). There were two layovers, of two nights and a day each, at Blacktail and National canyons. Layovers allowed students to prepare and present oral reports on their projects, process samples of beach sand collected, and, in the case of Blacktail, hike up to the Bright Angel Shale to study trace fossils.

There were a total of 45 river contacts, 29 with 8 separate commercial groups and 16 with 5 private groups (Table IX-2 and Fig. IX-1). The largest number of contacts on one day (8) occurred on the first day, when we covered 30 miles. In 1987, the expedition traveled only 25 miles on the day with most contacts (18); however, they stopped at two attraction points that day. That may account for the greater number of contacts relative to miles traveled.

The number of aircraft observed began to increase dramatically on Day 4 (Table IX-3 and Fig. IX-1). Helicopters were observed from Day 3 through Day 6, as in last year; however, on Day 5 this year, geologic work in Blacktail Canyon limited observation. This may account for many fewer sightings on that day compared to last year. From Day 8 through Day 10, more observations of multi-engine aircraft were noted than last year.

Seven of our ten nights on the river, we camped alone; four nights other groups could be seen or heard (Pancho's Kitchen, Upper National, and 220 Mile Beach); and on three nights we had to seek alternate campsites because other groups had taken the ones we had planned on (Nights 1, 7 and 8). Other groups were encountered at four of the nine attraction point stops (Phantom Ranch, Matkatamiba, Deer Creek Falls, and Parashant Canyon).

Five questions were informally submitted to members of this expedition regarding their personal feelings about the boat and aircraft encounters. Eleven responses were received and tallied. The results are presented in Table IX-4.

CONCLUSIONS

The number of boat contacts was much lower than last year; only in 1983 and 1985 were fewer sightings reported. However, the aircraft sightings were triple last year's (1987=154; 1988=459). The expedition members queried overwhelmingly felt that the aircraft contacts were a negative aspect of this trip.

Table IX-1. Trip schedule, 1988.

Day	River Mile	Location of Stop	Reason for Stopping
1	0	Lees Ferry	Put In
	8	Badger Rapid	BR;L
	18.2	Upper 18 Mile Wash	BR
	29	Shinumo Wash	BR
	30	Fence Fault	C
2	31.6	Stanton's Cave	AP
	31.7	Vasey's Paradise	AP
	34.7	Nautiloid Canyon	BR
	41	Buck Farm Canyon	BR;L
	53	Upper Nankoweap	BR
	58.1	Awatubi	BR;C
3	64.6	Carbon Creek	AP
	65.5	Lava Canyon	L
	75.5	Nevills Rapid	BR
	81.1	Grapevine	BR;C
4	87.5	Phantom Ranch	AP
	93.2	Upper Granite Rapid	BR;L
	108.5	Lower Bass Camp	BR
	120.1	Blacktail Canyon	BR;C
5		Layover at Blacktail	
6	122	122 Mile	BR
	122.8	Forster Canyon	BR
	125	Fossil Canyon	AP;L
	131	Bedrock Rapid	BR
	132	Dubendorff Rapid	BR
	136	Deer Creek	BR
	136.1	Deer Creek Falls	AP
	136.6	Pancho's Kitchen	BR;C
7	146	Matkatamiba	AP
	151.6	Ledges	BR?
	160	160 Mile	L
	166.5	Upper National Canyon	BR;C
8		Layover at National	
9	179	Upper (above) Lava Falls	BR
	180.9	Lower (below) Lava Falls	BR
	183	183 Mile	L
	186	186 Mile	BR
	187.2	Helicopter Pad	BR
	187.7	Whitmore Pictographs	AP
	190.2	190 Mile	BR
	194	194 Mile	BR;C
10	198.5	Parashant Canyon	AP
	207	Indian Canyon	BR
	208.8	Granite Park	BR;L
	213	Pumpkin Bowl	BR
	220	220 Mile	BR;C
11	225	Diamond Creek	Take Out

Key: AP=Attraction Point BR=Beach Research
C=Camp L=Lunch Stop

Table IX-2. Contacts with private groups (PG) and commercial groups (CG), 1988.

Day	Miles Covered	River-River	River-Shore	Shore-Shore	Shore-River	Daily Total
1	30	PG 1 (3x)	PG 2 CG 1	CG 1 CG 2	PG 1	8
2	28.1		CG 2	CG 2	CG1 CG 2	4
3	23	PG 3	PG 3 PG 4			3
4	39		CG 1	CG 1 CG 2 CG 4	CG 1 CG 2 PG 3	7
5	Layover					
6	16.5	PG 3 CG 5		PG 3 CG 5	CG 4	5
7	29.9	PG 5 CG 2	PG 5		PG 3 PG 5 CG 2	6
8	Layover					
9	27.5		CG 3 (2x) CG 6 (2x)		CG 3 CG 6	6
10	26	PG 3	CG 3	CG 7	CG 3 (2x) CG 8	6
Total		PG=7 CG=2	PG=4 CG=8	PG=1 CG=8	PG=4 CG=11	45

PG 1: 3 oarboats; 6 people
PG 2: 3 motorboats; 11 people
PG 3: 4 motorboats; 3 kayaks; 15 people
PG 4: 3 oarboats; 10 people
PG 5: 5 oarboats; 15 people

CG 1: 1 motorboat; 20 people
CG 2: 6 oarboats; 31 people
CG 3: 4 oarboats; 16 people
CG 4: 2 motorboats; 34 people
CG 5: 1 motorboat; 15 people
CG 6: 1 motorboat; 17 people
CG 7: 2 motorboats; 32 people
CG 8: 2 motorboats; 28 people

Table IX-3. Aircraft encounters, 1988.

Day	Miles Covered	Single Engine			Multi-Engine			Helicopter			Total
		Heard	Seen	Both	Heard	Seen	Both	Heard	Seen	Both	
1	30			2			1				3
2	28.1	2		3			2				7
3	23	1	1	8						2	12
4	39	1	7	33	4		5		5	10	65
5	Layover			4			2				6
6	16.5	19	1	54		2	10			13	99
7	29.9	9		9		5	3				26
8	Layover	2		3		45	38				88
9	27.5			3	6	2	108				119
10	26				3	3	28				34
Totals		34	9	116	13	57	197		5	25	459

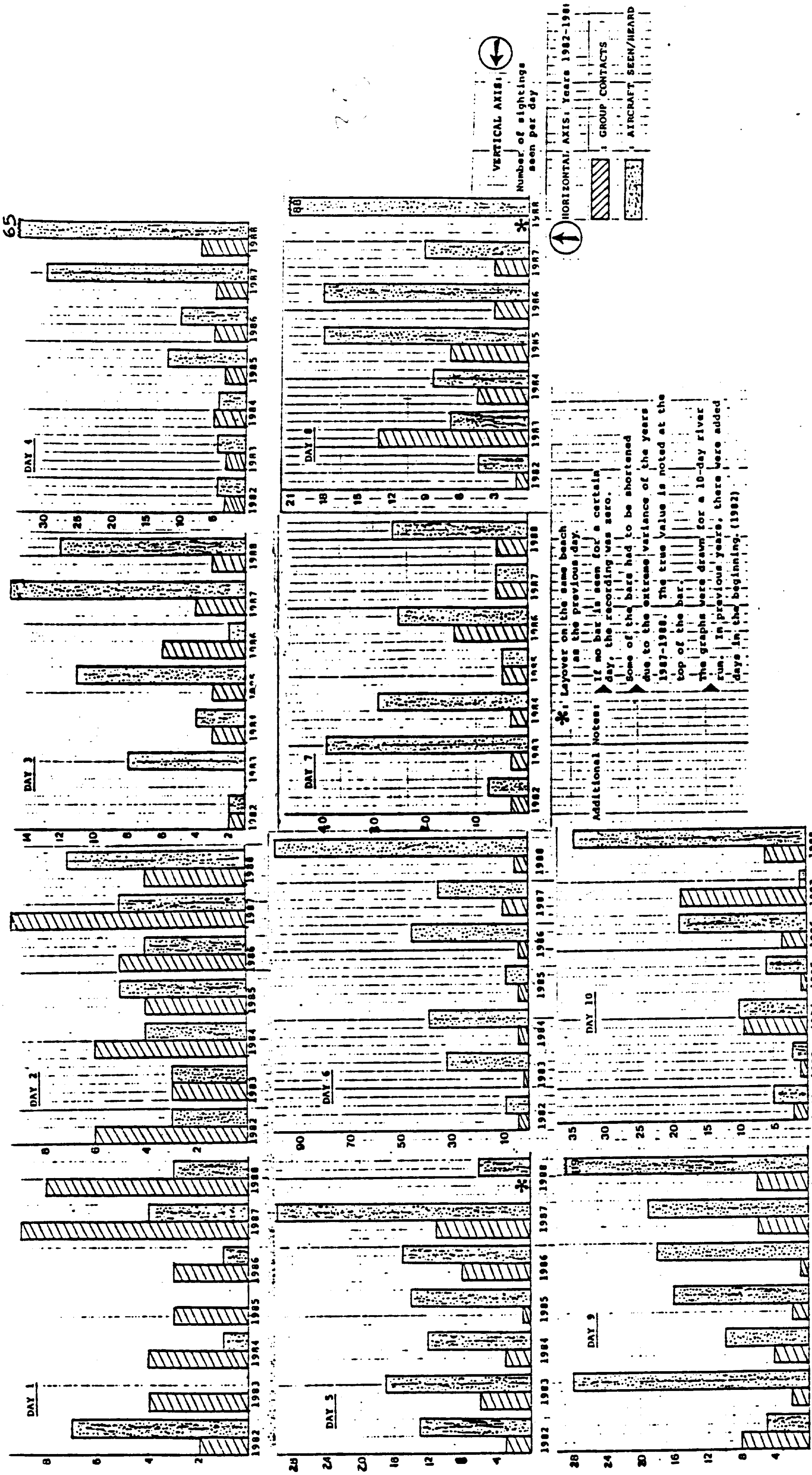

FIGURE IX-1. DAILY BOAT AND AIRCRAFT CONTACTS, 1982-1988

TABLE IX-4. QUALITY OF EXPERIENCE SURVEY

Question 1. Were you aware of the numbers of boat contacts made during this expedition?

11 yes, but with one person saying 'they were not a big deal'

Question 2. Did they affect the quality of your experience? How?

2 no

3 yes—was too crowded

4 yes—but enjoyed the camaraderie

2 yes—sometimes too many groups in one place

Question 3. Were you aware of the numbers of aircraft in the Grand Canyon?

5 yes—very much aware

4 sometimes—only the louder ones

2 not very aware

Question 4. Did they affect the quality of your experience? How?

7 yes— felt intruded upon, interfered with tranquility, too common, too loud

1 sometimes— depending upon activity (hiking, etc.)

3 no—not heard because of motorized boat, reassuring in case of emergency

Question 5. What changes, if any, would you offer?

8—more limitations on aircraft: reduce numbers of flights, especially commercial flights, or regulate them more closely

1—no change

1—no answer

2—also wanted numbers of river trips regulated or reduced