COLORADO RIVER INVESTIGATIONS II

July-August, 1983

by

Students and Staff of Geology 538-626

Edited By

Stanley S. Beus, Northern Arizona University

and

Steven W. Carothers, Flagstaff, Arizona

Submitted To

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

FEBRUARY, 1984

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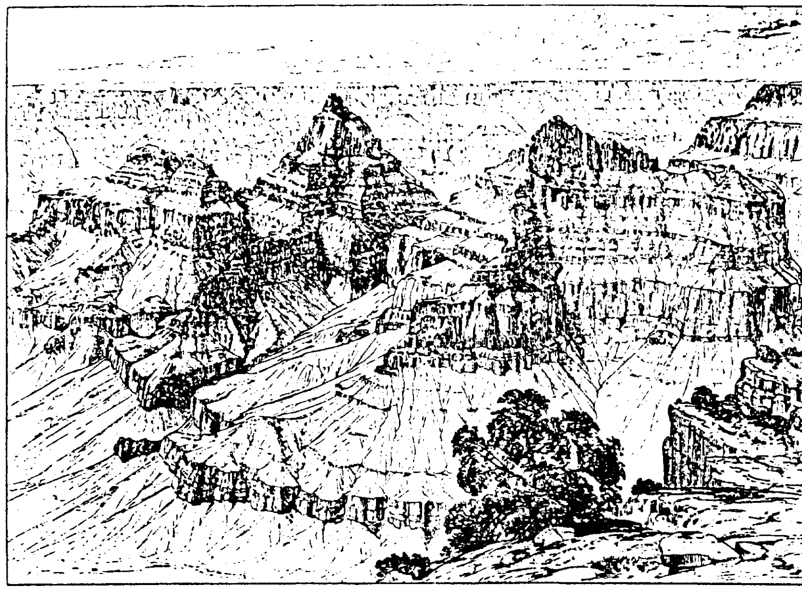
INTRODUCTION

This report presents results of a five-week, six-semester hour course (Geology 538-626) offered through Northern Arizona University (July 8 through August 10, 1983) in collaboration with the Museum of Northern Arizona and Grand Canyon National Park. The course involved approximately three weeks of classroom and laboratory instruction and about 13 days of field work, most of which was a ten-day research expedition down the Colorado River from Lee's Ferry to Diamond Creek.

The course outline is presented in Table 1-1, the river travel schedule in Table 1-2, and list of participants in Table 1-3. A copy of the original research proposal to the National Park Service is also included.

The research project reports are all at least partly student outlined and present results of a variety of investigations undertaken.

GEOLOGY in the GRAND CANYON COUNTRY



LOCATION: Studies are based on the University campus and at temporary field stations on both rims of the Grand Canyon. Flagstaff is located in the pine forests of the Colorado Plateau at an elevation of 7,000 feet, and within one hour driving radius of the San Francisco volcanics, Precambrian metamorphics, igneous intrusions, and several canyons in which are exposed stratigraphic sections of rocks ranging in age from Precambrian through Cretaceous. The Grand Canyon is within two driving hours distance.

GEOLOGY 538 (3) – 626 (3)

Natural History—Grand Canyon
Elements of Geology—Grand Canyon
July 8 – August 10

An integrated six-credit field biology and geology course sponsored by NAU and the Museum of Northern Arizona in cooperation with Grand Canyon National Park. The geology and biology of northern Arizona including the Grand Canyon of the Colorado is the major emphasis of the course. Lecture and laboratory work is combined with field investigations of resources in the Grand Canyon. The major field work consists of a **10-DAY RAFT TRIP THROUGH THE GRAND CANYON** from Lee's Ferry to Diamond Creek (mile 225).

Tuition and Fees (approximate) $400
River Trip $650

Faculty: Dr. Stanley S. Beus, Professor of Geology, NAU; Dr. Steven Carothers, Research Biologist, MNA.

GEOLOGY 607 (3)

Earth History
July 7 – July 22

A basic course in the history of the earth and its inhabitants through geologic time. Emphasis will be on the rock and fossil record as exhibited in northern Arizona and southern Utah and will include a three-day trip to National Parks in Utah and Arizona.

Tuition and Fees (approximate) $130
Transportation on Field Trips . . . . $ 40

Faculty:
Dr. Stanley S. Beus, Professor of Geology, NAU.

GEOLOGY 599 (3)

Geology of Arizona
July 23 – August 10

A basic course in the geology of Arizona designed primarily for people who have had little or no course work in geology. The major emphasis will be the examination of evidence in the rocks which has led to the interpretation of the geologic history of the state, extending back nearly two billion years. One three- to five-day camping field trip to selected parts of the state.

Tuition and Fees (approximate) $120
Transportation on Field Trips . . . . $ 40

Faculty: Dr. Dale Nations, Professor of Geology, NAU.

OPTIONAL FEES: University Dorm—Two to a room approximately $22 per week (private rooms and apartments are also available). University Cafeteria—Twenty-meal ticket approximately $35.

PREREGISTRATION: Required for 626 and 538 prior to ~~April~~ May 15, 1983.

INFORMATION AND APPLICATION
Chairman, Department of Geology, Box 6030, Northern Arizona University, Flagstaff, Arizona 86011.

GEOLOGY 538-626
GEOLOGY AND BIOLOGY IN THE GRAND CANYON

6 Credit Hours
Limit of 15 Participants

This course affords a unique opportunity for upper division undergraduate or graduate students to participate in a learning and research experience in the Grand Canyon country. The principal emphasis will be on reviewing the ecological and geological history of Grand Canyon National Park with special consideration given to resource management problems and the need for a working relationship between scientists and managers.

Participants will spend approximately 3 weeks in field, classroom, and laboratory instruction involving geology and biology of northern Arizona-southern Utah and resource management in the National Parks. The last 10 days of the course will be a float trip through the Grand Canyon from Glen Canyon Dam to Lake Mead.

Each participant will be involved in investigation and data gathering for a specific research project of interest to the Park Service and supervised by the two instructors. Possible investigations include:

Beach profiles as related to erosion and sedimentation

Sediment grain size as related to hydrologic and vegetational considerations.

Sedimentary structure and textures in river bars

River current velocity as related to beach erosion

Trace fossils in the Bright Angel Shale

Human impact on pre-selected river campsites

Analysis of ecological significance of dam-controlled intertidal zone of beach/river interface

Wildlife use of riparian habitat

Dates of Course: July 8, 1983 - August 10, 1983

Prerequisites: Upper division or graduate standing in <u>any</u> field and a compelling interest in natural history and resources of the Grand Canyon.

Cost:			
	Raft Trip	$600.00	
	Tuition and Fees	350.00	
	Bus Travel	100.00	(deposit payable w/application)
	TOTAL	$1,050.00	

May 27, 1983

Dear Canyon Pilgrims:

Welcome to the Geology 538-626 Grand Canyon class. Enclosed is a general summary outline of the class and other information.

COURSE TITLE:	The Biology and Geology of Grand Canyon and Northern Arizona
CREDIT HOURS:	Geology: 6 hours. May be used as an upper division or graduate credit in Earth Science or the Teaching of Biology degrees.
INSTRUCTORS:	Dr. Stanley S. Beus, Northern Arizona University Dr. Steven Carothers, Museum of Northern Arizona
DATES:	11 July - 9 August, 1983
LECTURE:	Science Building, Room 105
LABORATORY:	Science Building, Room 105 Museum of Northern Arizona and Grand Canyon Visitor Center/ Collections
APPROXIMATE DAILY SCHEDULE:	Lecture 9:00 - 12:00 a.m., MTWThF Laboratory 1:00 = 4:00 p.m. Field Trips 8:00 a.m. - 5:00 p.m. selected days
ACTUAL RIVER TRIP:	29 July - 7 August, 1983

INTRODUCTION

"The Biology and Geology of the Grand Canyon and the Colorado River" is a five week summer session course for upper division undergraduate or graduate students.

The principal emphasis of the material covered will be on reviewing the ecological and geological history of Grand Canyon National Park with special consideration given resources management problems, needs, and the need for a working relationship between scientists and managers.

In Grand Canyon, baseline ecological and geological research efforts (1869-1983) have provided a specific body of literature and unpublished reports that can be of immediate (applied, problem-oriented studies) or less immediate (basic research, frontiers of science) use to National Park Service managers in the decision-making process as that process relates directly to the stewardship of park lands. The relationship between, and the need for, basic and applied research efforts as they influence park management will be presented, with Grand Canyon National Park as a case history.

Specific topics to be considered include:

Biology - regional ecological community structure, aquatic and terrestrial systems, the influence of man on park resources, and recreation management.

Geology - Colorado Plateau structure, the formation of Grand Canyon, evolution of the Colorado River, igneous, erosion and sedimentary processes, geologic time, and canyon stratigraphy, beach stability at river campsites, sedimentary structures of beaches and bars, trace fossils in the Bright Angel Shale.

TEXTBOOKS REQUIRED*

*Guidebook to the Colorado River, Part I. 1968.
*Guidebook to the Colorado River, Part II. 1969.

by Hamblin and Rigby, Brigham Young University Geology Studies.

Additional readings include specific research reports to be provided by instructors.

*Available at N.A.U. Bookstore

SPECIAL EQUIPMENT FOR THE RIVER TRIP

To Wear on Rafts

hat (rain/sun) with tie-on
sunglasses (optional), elastic band for prescription glasses
T-shirt, short sleeved shirt
cotton shirt with long sleeves
raincoat

To Have Available During Day (in waterproof bag or 50 cal ammo box)

suntan lotion
snacks
day pack
books, maps
medicine
hand lens
camera, film
binoculars
field guides
notebook, pencil
cup
water bottle or canteen

Available Only in Camp (packed in waterproof bags while floating)

light tent (pair up) and ground cloth
sleeping pad or air mattress
light sleeping bag
complete change of clothes, including hiking shoes or boots and light jacket
cutoffs/swim trunks
toilet kit
extra prescription glasses
flashlight
lip ice or chap stick
insect repellent

NOTE: You should pack light. A canvas or cloth duffel bag works well, plus a small hand bag or airline flight bag for personal items needed during the day. Camera equipment should be packed in a waterproof container. Soft drinks can be purchased at the starting point.

On the river trip, we supply food, life jackets, eating utensils, first aid kits and portable toilets with tissue.

OTHER ITEMS

Insurance

Each participant will be covered by accident or sickness insurance for the period 19 July - 9 August (while we are on field trips) up to $1,500.

Housing on Campus

If you plan to stay on campus during the course you should:

a. apply now for housing (July 11-28)
b. send in the $35.00 deposit to the Housing Office (see blue (family) or yellow (individual) sheet on summer housing).

Meals on Campus

Available from dining halls. See summer school bulletin or enclosed material for details.

Application for Summer School

Bring enclosed yellow application form completed. You will need it to register on Monday, July 11.

Registration

Registration for the course will take place on Monday, July 11, beginning at 9:30 a.m. in Room 105 of the Science Building. We will register as a group in order to (hopefully) avoid waiting in lines at the Field House.

At registration on July 11 you should be prepared to pay $950.00 to N.A.U. for the balance of the course fees. Any housing or meal tickets will be paid separately as needed.

NOTE: Dates and prices for this course as indicated in the summer school bulletin, 1983 are inaccurate, please disregard.

We look forward to seeing you all on Monday, July 11, at 9:30 a.m., Room 105, Science Building, North Campus.

Sincerely,

Stan Beus & Steve Carothers

SSB/SC/cle
Attachments

Table 1-1. Course Syllabus, Geology 538-626, 1983

June 24, 1983

Dear Canyon Pilgrims in Geology 538-626:

This is an update on the coming river trip course and probably the last communication with you until we meet here Monday, July 11, at 9:30 a.m.!!

Enclosed is a list of participants, a tentative schedule, and suggested topics for class a ,ignment.

Date/Day	Time	Topics	Lab (1300)
7-11 M	0930	Registration, Orientation	Introduction to Research Projects; Resource Management in Grand Canyon
7-12 T	0830 (C)* 1100 (B)*	Ecological Systems Igneous Rocks in Grand Canyon	Native Plants and Animals: Management Dilema
7-13 W	0900 (B) 1100 (C)	Sedimentary Rocks Volcanic Rocks in Colorado Plateau Ecological Research in Grand Canyon	
7-14 Th	0830 (C)	Ecological Changes in Grand Canyon	Igneous Rocks
7-15 F	0830 (C)	River Dynamics, Hydrology	Student Research Projects: Beach Erosion on River
7-18 M	0830 (C)	Aquatic Ecology of the Colorado River	
7-19 through 7-21 T-Th	0700!!!	Field Trip to Southern Utah Bryce, Zion, Cedar Breaks	
7-22 F	0830 (C)	Terrestrial Ecology of the Colorado River	
7-25 M	0830 (B)	Sediments and Sedimentary Rocks	Sediments
7-26 T	0800	Field Trip to Grand Canyon	
7-27 W	0830 (B) 1900	Stratigraphy & Fossils in Grand Canyon Evening Orientation on River Trip	Sedimentary Rocks
7-28 Th	0900	QUIZ	Prepare for River Trip
7-29 through 8-7		RIVER TRIP	
8-8 M	0900	Complete Field Data, Turn in Notes, Course Summary	

*(C) Carothers
*(B) Beus

Oral Report Assignment

Each participant will research some aspect of Grand Canyon natural history and present an oral report (15 minutes) during the river trip.

SUGGESTED REPORT TOPICS

Beach erosion and sedimentation
Vegetation survival after floods
Displacement and mass wasting of river campsites
Human impact on pre-selected river campsites
Harvester ant density on beaches
Ecological significance of dam-controlled intertidal zone of beach/river interface
Trace fossils in the Bright Angel Shale
Structures and environments of the Dox Formation (Precambrian)

National park status for the Grand Canyon
Monoclines in the Colorado Plateau
Lava flows in the western Grand Canyon
John Wesley Powell and the Grand Canyon
Rapids in the Grand Canyon
Mining in the Grand Canyon
Distribution of amphibians and reptiles in riparian vegetation

Facies of the Toroweap Formation
The Butte fault
Structures and environments of the Coconino Sandstone (Permian)
Structures and environments of the Bass Limestone (Precambrian)
Fossils and environment of the Kaibab Limestone (Permian)
Cardenas lavas, eastern Grand Canyon
Colorado River "intertidal" zone effects on biota

There are other possibilities, let me know if you have preferences

See you all at 9:30 a.m., Monday, July 11, Science Building Room 105.

Sincerely,

Stanley S. Beus
Professor of Geology

SSB/cls
Enclosures

Table 1-2. PROPOSED SCHEDULE FOR MNA-NAU-PARK SERVICE RIVER TIP PROJECT
July 29-August 7, 1983

Day	Distance	Overnight Camp	Stops on the way (research stations)
1 Fri	35 miles	Nautiloid Cn mile 34.7	Mile 4, 8, 11, 18.2, 19.3, 20, 24.5, 29, 34.7
2 Sat	30	Lava Canyon area mile 65.5	Mile 43, 47, 53, 61.5, 65.4
3 Sun	29	Granite, mile 94	mile 68.5, 72, 75, 76, 81.1, 87.1, 93.5
4 Mon	31	Fossil Canyon mile 125	Mile 108, 109.4, 112.2, 114, 120, 124.3
5 Tue	0	" "	No river travel
6 Wed	40	National Cn mile 165	131, 136, 137, 145, 151.1, 156.9, 165
7 Thur	0	" "	No river travel
8 Fri	44	Granite park mile 209	Mile 179, 180, 185, 198, 209
9 Sat	0	" "	No river travel
10 Sun	16	Diamond Creek mile 225.6	Mile 219, 220 Exit Peach Springs Canyon

Table 1-3.

Geology 538-626 River Trip Participants, 1983

Betsy Burmaster
333 B W Oak
Flagstaff, AZ 86001

Betty Byars
30-150 SAC, N.A.U.
Flagstaff, AZ 86001

Dale Dancis
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Baumholder American High School
A.P.O. New York 09034

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Steven Kline
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Flagstaff, Arizona 86002

Stanley S. Beus
Department of Geology
Northern Arizona University
Flagstaff, Arizona 86001

GRAND CANYON NATIONAL PARK

RESEARCH PROPOSAL

SUMMER, 1983

GEOLOGY AND BIOLOGY INVESTIGATIONS

I. BEACH PROFILES:

In 1974, some 20 beach sites along the Colorado River in Grand Canyon were surveyed using a telescopic alidade. Topographic profiles from campsite to river shoreface were measured and recorded. In 1982, we resurveyed two of these sites, one of which showed a substantial erosion rate for the beach (about one foot per year).

It is proposed to examine and resurvey the remaining 18 sites to determine the amount of erosion (or construction) of the beaches by river flow and human use in the past nine years. The results will provide a clear picture of the amount and rate of change of the surface of these selected beach-campsite areas and permit a measure of the stability of these resources.

II. STREAM VELOCITY AT SELECTED BEACHES:

Measurements of the mean sand grain size of some 27 beach campsites in Glen Cnayon and Grand Canyon were taken in 1982. It is possible to predict from the sand grain size the minimum water current velocity required to initiate transport (and hence erosion) of the beach sand.

It is proposed to take accurate measurements of the river current velocity adjacent to these beaches at selected and timed high and low water positions. The results will provide a useful measure of the probability of beach erosion at various water levels and selected beach campsites along the river.

III. RIVER BAR STRUCTURES:

It is proposed to examine the shape, grain size and sedimentary structures of selected river bars along the Colorado River (probably Unkar, Mile 73, and Granite Park, Mile 94). River bars are not well studied, owing to their general inaccessibility. During low water periods, access to these bars (partially exposed even at high water) will permit gathering of data that may be significant in determining the construction of and depositional history of river bars on the Colorado River. This will provide basic data for sedimentary studies elsewhere and may allow the prediction of the behavior of these bars under the present controlled stream regimen of the Colorado River.

IV. RIVER MONITORING STUDIES:

During the 1982 Northern Arizona University/Museum of Northern Arizona Colorado River research trip, 38 beaches were sampled for evidence of human impact (charcoal, litter and sand discoloration). Data gathered were compared with similar studies that have been performed since 1976 in the ongoing National Park Service river monitoring program. During 1983, we will repeat these studies and evaluate change in beach quality through time.

V. SOCIOLOGICAL STUDIES:

During 1982, one student kept careful records on river/shore human contacts and aircraft contacts. The human contact data were gathered according to the techniques as detailed in the Resources Management River Contact Survey Handbook. These data will be gathered again and compared with the previous year's data.

VI. WILDLIFE USE OF RIPARIAN HABITAT:

Depending upon the expertise of the student, emphasis will be placed on greatly increasing the sample size of wildlife preference by vegetative species. Special attention will be focused on the Tamarisk or Salt Cedar

(*Tamerix chinensis*) and attempts will be made (on the basis of empirical data) to rank riparian vegetation as a function of size of vegetated areas, species or association of species and wildlife use. All vertebrates (reptiles, birds, and small mammals) will be censused, however, unless students are already trained in entomology. No attempt will be made to survey the terrestrial invertebrates.

Stanley S. Beus
Professor of Geology
Northern Arizona University

Steven W. Carothers
Research Associate
Museum of Northern Arizona

WATER DISCHARGE OF THE COLORADO RIVER

(Pre- and Post Glen Canyon Dam)

Dale Dancis
Summer, 1983
Northern Arizona University
Geology of the Grand Canyon

INTRODUCTION:

This past June, a record spring run off caused dramatically high water flows. These have not been seen since the Glen Canyon Dam was built in 1963. On June 29, 1983 at 2:00p.m. a record high of 96,340 c.f.s. (cubic feet/second) was recorded at Lee's Ferry Gauging Station. Officials at the Bureau of Reclamation were releasing three times as much water as normal from the dam in an effort to prevent reservoirs from overflowing. In Grand Canyon National Park the flooding of the Colorado River carried 30 foot logs downstream, submerged trees, washed away beaches and caused a 37 foot motorized raft to capsize in Crystal Rapid. This focused attention on the effectiveness and failure of the dam in controlling a flood.

The construction of dams, often by a federal agency, was greeted with enthusiam particularly during the 1930's. Advantages were obvious. Besides creating jobs for hundreds of people, dams prevented flood damage, irrigated farmland and provided a constant energy source for thousands of homes and businesses. The Hoover Dam on Lake Mead was built at this time with those objectives.

In 1963 Glen Canyon Dam was constructed. Its purpose was to provide hydroelectric power to the growing population of Arizona and other neighboring areas. At the time of its construction, conservationists were concerned about the Dam's effect on the environment. There is no point debating the pros and cons of a dam already built. The purpose of this paper is to present pre and post dam data on water flows in the Colorado River. Data will also be presented on the unexpected flooding of this past year.

WATER DISCHARGE DATA:

Prior to the Glen Canyon Dam, annual seasonal flooding occurred in the spring and summer as a result of heavy snows and rains. In Figure 2-1, the mean monthly flows for 1922-1962 (pre-dam years) are presented. Discharge rate increased during the spring and summer months from 5,262 c.f.s. to 52,420 c.f.s.- a rise of 47,158 c.f.s.

In contrast, mean monthly flows during 1966-1981 (post dam years) reveals a small seasonal impact. The increase from 9,125 c.f.s. to 15,065 c.f.s. is a rise of only 5,940 c.f.s.

In 1983, the year of the flood, an incomplete hydrograph (Figure 2-2) demonstrates the return to pre-dam conditions. During the spring-summer flood, the mean c.f.s. rose 54,580 c.f.s. The peak flow was considerably higher reaching 96,800 c.f.s. Figure 2-3 summarizes the discharge data in both pre- and post-dam eras.

An hourly hydrograph shown in Figure 2-4 demonstrates the attempts to control flooding by regulating discharge from the dam. Under ordinary circumstances, the discharge is higher during evening hours to provide more electricity (June 5). During the flood, water was released at a much higher rate throughout the day and night (June 29). The July 12 hydrograph indicates that the water discharge rate was returning toward normal.

CONCLUSIONS:

The flooding of this year parallelled the magnitude of pre-dam flooding conditions. The high flows resulted from unusually high percipitation and run off as well as the failure to anticipate high flows by persons in charge of regulating the water discharge through the dam. The water level in the lake should have been lowered earlier in the season. This action possibly could have prevented the flood.

The immediate effects of the flood on the environment within the Grand Canyon are discussed by other students throughout the remainder of this report. These high flows during the past spring dramatically highlight the remaining potential for future floods in the canyon region.

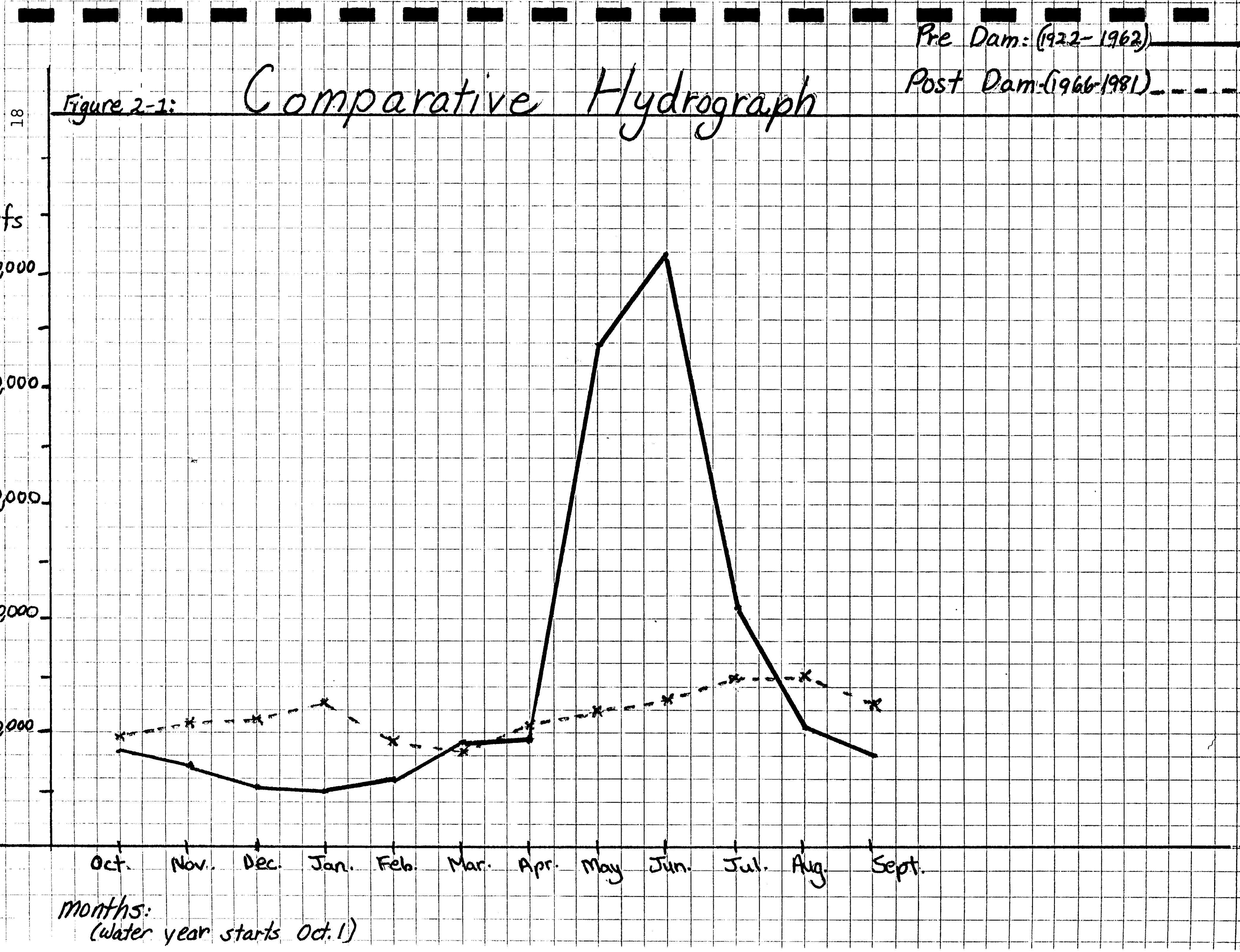
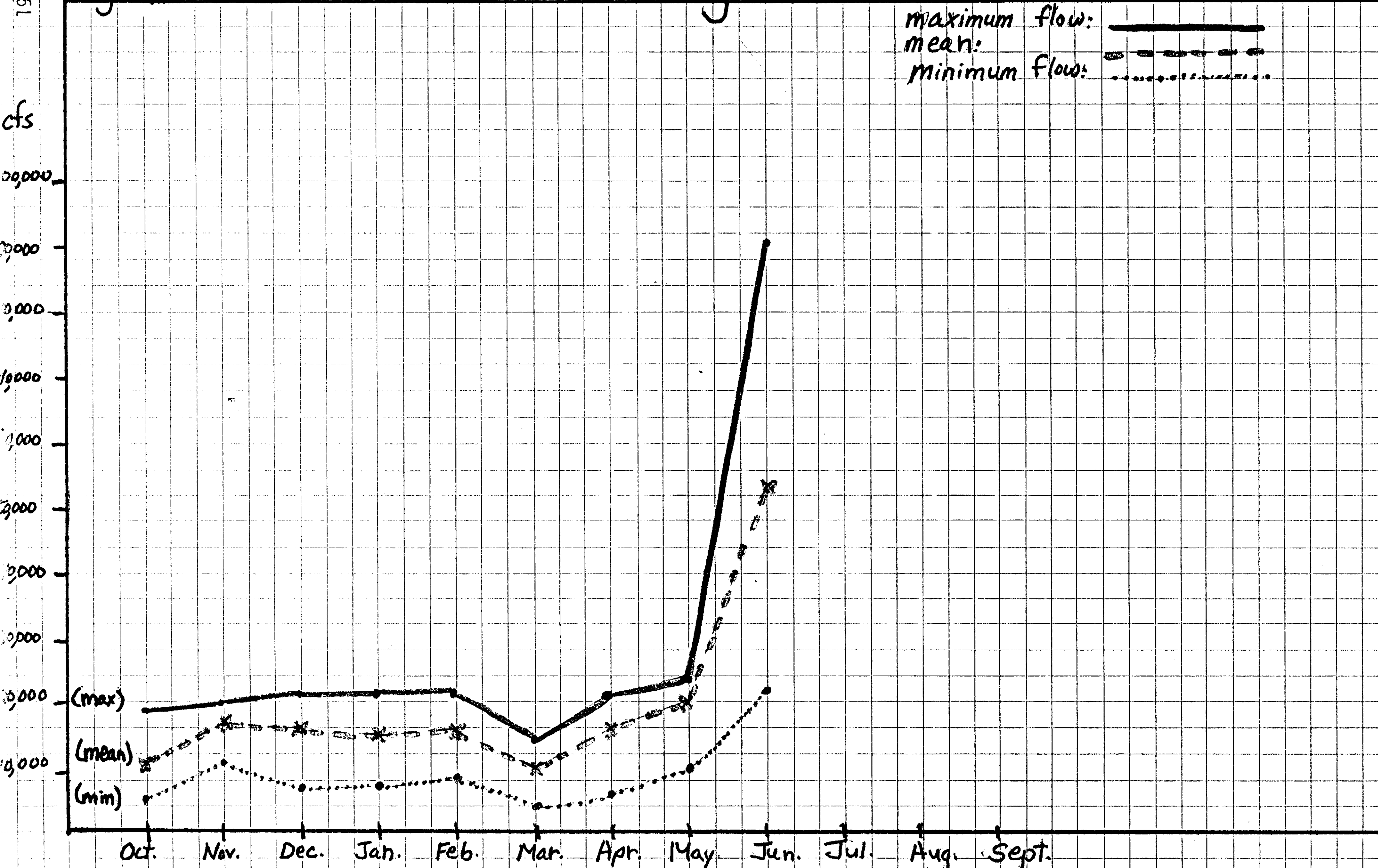


Figure 2-1: Comparative Hydrograph

Figure 2-2: 1983: Discharge

(Colorado River at Lee's Ferry)

(Provisional as of 8/83)



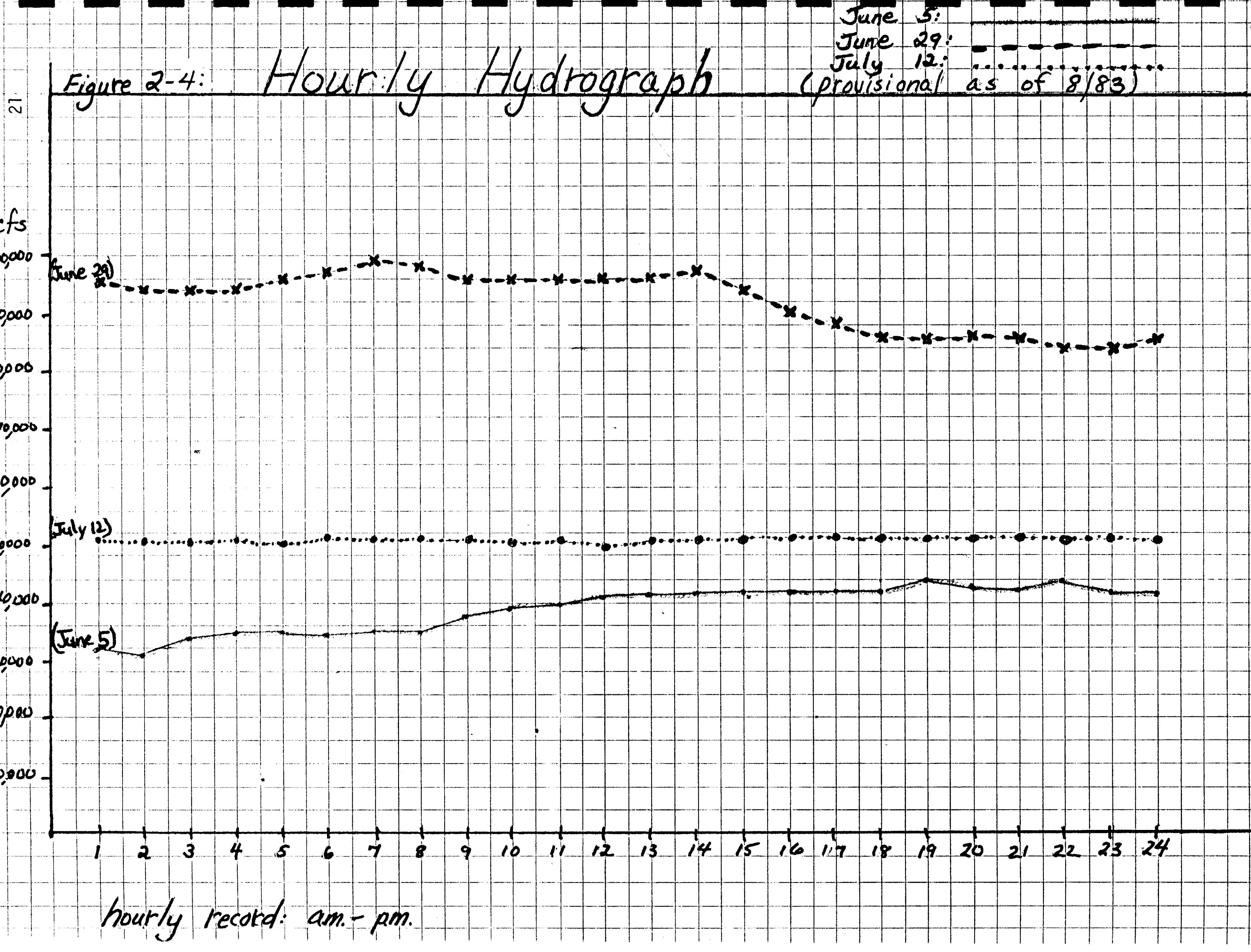


Figure 2-4: Hourly Hydrograph (provisional as of 8/83)

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Water Resources Division
(Colorado at Lee's Ferry, Arizona).

SHAPE, COMPOSITION AND CHARCOAL CONTENT OF COLORADO RIVER BEACH SANDS FROM SELECTED SITES IN GRAND CANYON

by

Frank B. Lojko

INTRODUCTION

This study is an extension of research conducted in 1982 titled "Colorado River Investigations I (Beus and others, 1982). The previous study involved collecting and sieving 56 samples from 26 beach sites between Glen Canyon Dam and Diamond Creek on the Colorado River in Glen Canyon and Grand Canyon. The initial purpose of the study was to identify particle size and mean size of sand samples. This study of the Colorado River beach samples was prompted by the need to identify composition, angularity and roundness of the sand grain samples previously collected.. Curiosity, insight, and general need of clarification broaden this study to address three additional questions: 1) is charcoal present in the six Nautiloid Beach samples collected? 2) can charcoal be measured in transect campsite samples? and 3) does the sand grain size vary significantly in response to depositional and erosional processes acting upon the Nautiloid beach?

STATEMENT OF THE PROBLEM

The purpose of the study is to identify particle size, roundness, angularity and composition of sand grains and samples collected from beaches along the Colorado River in the Grand Canyon region. The general intent of the investigation is to provide data that may contribute to understanding the erosional and depositional processes of the river.

SAMPLING

The study involved identifying angularity, roundness and composition of twenty beach and campsite samples previously collected from beaches of the Colorado River in Glen Canyon and Grand Canyon.

BEACHES	MILE MARKERS
Ferry Swale Beach	-11
Rock Art Beach	-9.5
Finger Rock Campsite	-7
Finger Rock Beach	-7
-3 Mile Beach	-3
Jackass Canyon	8
22 Mile, right bank dune	22
22 Mile, right bank beach	22
Nautiloid Beach (sites 1-6)	36
Nankoweap Beach	52
Unkar Beach	73
109 Beach	109
114 Beach	114
National Beach	166
219 Beach	219

In addition to angularity and roundness study, six sand samples collected from Nautiloid Beach (34.8-mile position, left bank) were sieved and measured for phi size, phi mean size and composition. The other 14 sand samples had been previously measured for phi mean and size.

Four additional transect samples were collected and tested for charcoal content. The additional sample sites involved are: Finger Rock Campsite #2 -7.5; 109 Beach, transect (09-4); 114 Beach, transect (14-4); and 219 Beach, transect 32m.

METHODOLOGY

Each of the 24 samples was observed separately with the aid of an American Optics stereoscope with 10 x 4 x 15 power magnification capabilities. A 10 cm diameter pyrex glass petri cover dish was used to randomly place samples into the dish for observation under the stereoscope. A circular white paper disc 95 mm in diameter was taped to the outer bottom of the petri dish. A fine red line was drawn bisecting the white paper disc. The petri dish served to contain grain samples for measurements, observation and identification under the stereoscope and the red line served as the reference line. Each sample collected and contained in a plastic bottle was shaken for one minute to evenly mix grain samples. Then, a random number of grains were poured into the petri dish for study. The first fifty grains of sand in contact with the red reference line were counted from left to right. The angularity, roundness and composition of each grain was recorded. The data were computed on a specialized data sheet showing the percentage of angular grains, subangular grains, subrounded grains, rounded grains, composite grains and the composition of the grains.

The methodology of using a petri dish and a white disc with a red reference line was pre-tested and proved to be statistically acceptable with less then $\pm 1\%$ error. Two separate beach samples were measured with five repetitions to establish statistical significance. The results significantly indicated this procedure and process to be valid for random sampling of angularity, roundness and composition of sand grains.

The roundness scales used were (Powers) and (Pinet) to classify each grain for angularity and roundness. A fine magnetic rod pen was used to discriminate questionable grains such as hematite and magnetite from charcoal grains. A dental probe was used to move grains about for better identification and also to crush charcoal composites and separate sand grains.

The six Nautiloid Beach samples were sieved using a Standard U.S. Sieve. Each sample was shaken for ten minutes. The individual sieve size samples for each sample plotted were weighed on an Ohaus Centigram high form triple beam balance. The data collected were converted to histograms and the mean phi size calculated.

INTERPRETATION OF DATA

Table 3-1 indicates the roundness scale and composition percentages for the fourteen beach sample sites. The total roundness scale percentage results: 20% angular, 49% subangular, 27% subrounded and 4% rounded. The total composition percentage results: 6% composite grains, 88% quartz, 1% olivine and 5% sandstone/quartzite.

Table 3-2, Tabulation of Angularity and Roundness-Composition, indicates the roundness scale and composition percentage for five of the six Nautiloid Beach samples. The total roundness percentage results are: 14% angular, 54% subangular, 29% subrounded and 3% rounded. The total composition percentage results are: 2% composite grains, 87% quartz, 5% quartzite, sandstone and feldspar, and 6%+ charcoal.

Graphs 3-1 to 3-10 are histograms of the data collected and compiled regarding the roundness and composition for each individual sampled site. Graphs 3-2 and 3-4 of Finger Rock and 22-Mile provide an interesting comparison of data between the beach and the campsite of Finger Rock and the dune and the beach of 22-Mile.

The roundness and composition data from the two sites are identical. Graphs 3-8, 3-9, 3-10 of Nautiloid Beach samples indicate the roundness scale and composition percentages. The data reflect fairly close similarity of all five samples with regard to composition and the roundness/angularity.

Graph 11 is a composite histogram of all 6 Nautiloid Beach samples. The bars of the histogram indicate the phi size of the samples.

Figure 3-1 is a cumulative scale for the mean phi size of the six sites sampled on Nautiloid Beach. The mean phi size for the beach is 2.3 classified as a fine sand or .193 mm in size. Figure 3-2 shows the frequency curves of the cumulative weights for each site sampled at Nautiloid Beach based on the Folk formula for calculating phi mean size.

Figure 3-3, profile schematic of Nautiloid Beach, indicates the sample sites and multiple line graph correlates phi size with the profile. The mean phi sizes for sites are: (#1) 3.1 (very fine sand), (#2) 2.6 (fine sand),(#3) 2.3 (fine sand), (#4) 2.1 (fine sand), (#5) 2.0 (medium sand) and (#6)1.9 (medium sand). The average mean phi size for Nautiloid Beach is 2.3 (fine sand) or 0.193 mm in diameter groin size. The sand samples measured increase in size from site #1 to #6 towards the water edge.

Figure 3-4 indicates the percentage of charcoal measured and counted from four separate beach samples. The samples were collected mainly from transect lines of the sand discoloration research study conducted in July of 1982 of the "Colorado River Investigation Study I." The four samples were collected from heavy traffic and camp areas used by river runners. The evidence of charcoal in the 6 Nautiloid Beach samples was verified in laboratory test measuring charcoal content ranging from 4% to greater than 12%. The application of a reflectometer was used to measure the sand discoloration of the six Nautiloid samples and correlate charcoal content with discoloration readings. The readings of discoloration ranged from 56.3 to 71.3 (Table 3-2 B).

SUMMARY OF RESULTS

The results of the studies in five major areas: composition, roundness/angularity, particle size, erosional and depositional processes, and charcoal and discoloration.

1. Composition: The 20 sand samples tested and measured were collected from 13 individual beach areas. The composition of the sand samples is predominately quartz. The total average composite percentage for the sampled sets is 92% (quartz).

2. Roundness and Angularity: The roundness and angularity of nineteen samples measured are predominately subangular with 51%. The other categories are 28% subrounded, 17% angular and 4% rounded. These data indicate that the sample beaches contain grains which appear not to have been abraded sufficiently to have "gone around twice." There is not enough evidence to conclude the origin of the grains or how much weathering and transport have occurred. The data only indicate the stages of angularity and roundness. The present scientific value of data is as a base for future studies and comparative analysis.

3. Particle Size: The average phi size for Nautiloid Beach is 2.3 or 0.193 mm (classified as a fine sand based on the Wentworth scale).

4. Erosional and Depositional Processes: The data collected from Nautiloid Beach indicate the gradual increase of sand grain size from sample site #1 on the beach campsite area to site #6 at the river edge. There are probably at least three major contributing factors for the change in grain size of sand grains at Nautiloid: wind erosion, fluctuation

of river level due to variation of discharge of water from the Glen Canyon Dam and area rainfall, and mass wasting caused by camper foot traffic. The current cross-bedding structures on the beach indicate major variation in water current direction and water level. The finer grains up slope may reflect weaker water and/or wind current transport.

5. Charcoal and Sand Discoloration: The charcoal is believed to be remains of earlier campfires. Charcoal measurements in the four transect samples of Finger Rock, 109 Beach, 114 Beach and 219 Beach, and the 6 samples at Nautiloid Beach, indicate an average of 6% charcoal content. The charcoal found in the samples has probably been deposited due to erosional and depositional processes operating since extensive camping on the Colorado River beaches began. Reflectometer measurements indicate higher discoloration in the very fine grain sand sample #1 and lesser discoloration in the lower sample sites at Nautiloid. This is substantiated by charcoal grain counts. Lower sections of the beach with larger grains have more exposure to high water which may tend to cleanse the beach and remove the charcoal.

REFERENCES

Beus, S. S. and others. 1982. A study of beach profiles as a measure of erosion, p. 16-19, in Colorado River Investigations 1. Northern Arizona University/Museum of Northern Arizona manuscript report submitted to Grand Canyon National Park, 131 p.

SAND GRAINS ANALYSIS TABLE 3-1

Composite Tabulation of Angularity and Roundness - Composition

Sample sites:	A	SA	SR	R	C G	Q	M/O	Misc.	C
Ferry Swale	22	38	34	6	12	84	O 2	A 2	
Rock Art	2	62	34	2	6	94			
Finger Rock (campsite)	18	40	30	12	18	82			
Finger Rock (beach)	24	38	30	8	14	80	M 2	S 4	
-3 Beach	12	70	14	4	22	54	O 2	QS 22	
Jackass Canyon	14	38	48	6		94	O 2	QS 4	
22 Mile Rt. Bank (dune)	24	36	34	6	2	90	O 2	QS 6	
22 Mile Rt. Bank (beach)	30	38	30	2	2	86		QS 12	
Nankoweap Beach	28	44	28		2	86	O 2	Q 10	
Unkar Beach	22	56	22			96		S 4	
109 Beach	20	60	18	2	2	98			
114 Beach	30	54	16			100			
National Beach	16	56	22	6		94		QS 6	
219 Beach	26	54	18	2		96		QS/Ca4	
Total	288	684	378	56	80	1234	O 12	QS 72	
Percentage (%)	20%	49%	27%	4%	6%	88%	1%	5%	
Total Quartz %					*	94%			

Key: A- angular, SA- subangular, SR- subrounded, R- rounded, C G- composite grains, Q- quartz, M/O- (M) magnetite, (O) olivine, Misc. QS- (Q) quartzite, (S) sandston

SAND GRAINS ANALYSIS TABLE 3-2

A. Composite Tabulation of Angularity and Roundness - Composition

Sample sites:	A	SA	SR	R	C G	Q	M/O	Misc.	C
Nautiloid Beach sample #1									*** (12%)
Nautiloid Beach sample #2	24	42	32	2		80	O 2	QSF 12	C 6
Nautiloid Beach sample #3	14	60	26			92		S 2	C 6
Nautiloid Beach sample #4	16	50	30	4	8	80		Q 8	C 4
Nautiloid Beach sample #5	8	60	32			92		S 2	C 6
Nautiloid Beach sample #6	10	58	24	8	2	92			C 6
Total	72	270	144	14	10	436	2	24	28
Percentage (%)	14%	54%	29%	3%	2%	87%	-	5%	6%
Total Quartz %					*	89%			

*** Nautiloid Beach sample #1: sand grains too small to identify angularity and roundness. Random sampling indicated a large percentage of charcoal(> 12%).

Key: A- angular, SA- subangular, SR- subrounded, R- rounded, C G- composite grains, Q- quartz, M/O- (o) olivine, Misc. QSF- (Q) quartzite, (S) sandstone, (F) feldspar, and C- charcoal.

B. Reflectometer Data
* Nautiloid Beach

Reflectometer Data
* Nautiloid Beach

SAMPLE SITE:	REFLECTOMETER READING:
#1 *	56.3
#2 *	63.5
#3 *	68.2
#4 *	68.3
#5 *	71.3
#6 *	67.0
	394.6 = average of 65.76

TABLE 3-3

Grain Sample Random Red Line Count Method

CHARCOAL STUDY

SAMPLE LOCATION:	All counts are based on fifty (50) grains per sample (including all fragments)
Finger Rock #2 Campsite -7.5 (mile marker) not a transect	Trial #1 number of charcoal fragments....... 2 Trial #2 number of charcoal fragments....... 2 Trial #3 number of charcoal fragments....... 2 % = 4% charcoal of total volume sampled
109 Beach Transect 109(09-4) 109 (mile marker)	Trial #1 number of charcoal fragments....... 3 Trial #2 number of charcoal fragments....... 3 Trial #3 number of charcoal fragments....... 3 % = 6% charcoal of total volume sampled
114 Beach Transect 114(14-4) 114 (mile marker) *upper 114	Trial #1 number of charcoal fragments....... 4 Trial #2 number of charcoal fragments....... 5 Trial #3 number of charcoal fragments....... 4 % = 8% charcoal of total volume sampled
219 Beach Transect 32m 219 (mile marker)	Trial #1 number of charcoal fragments....... 3 Trial #2 number of charcoal fragments....... 3 Trial #3 number of charcoal fragments....... 3 % = 6% charcoal of total volume sampled

NAUTILOID BEACH

PARTICLE MEAN SIZE

DATA:

SAMPLE NO.	CODE	GRAPHIC MEAN FORMULA $M_Z = (\phi 16 + \phi 50 + \phi 84)/3$	MEAN ϕ	MM. ~	GRAIN SIZE DES. WENTWORTH
1	●	$2.2+2.9+4.2=9.3/3=3.1$	3.1	.115	VERY FINE SAND
2	●	$2.1+2.4+3.3=7.8/3=2.6$	2.6	.163	FINE SAND
3	●	$1.8+2.2+2.8=6.8/3=2.26$	2.3	.193	FINE SAND
4	●	$1.5+2.1+2.6=6.2/3=2.06$	2.1	.23	FINE SAND
5	●	$1.4+2.0+2.5=5.9/3=1.96$	2.0	.25	MEDIUM SAND
6	●	$1.3+1.8+2.7=5.8/3=1.93$	1.9	.27	MEDIUM SAND
AVG.	■	NAUTILOID BEACH TRANSECT 2.31	2.3	.193	FINE SAND

Figure 3-1

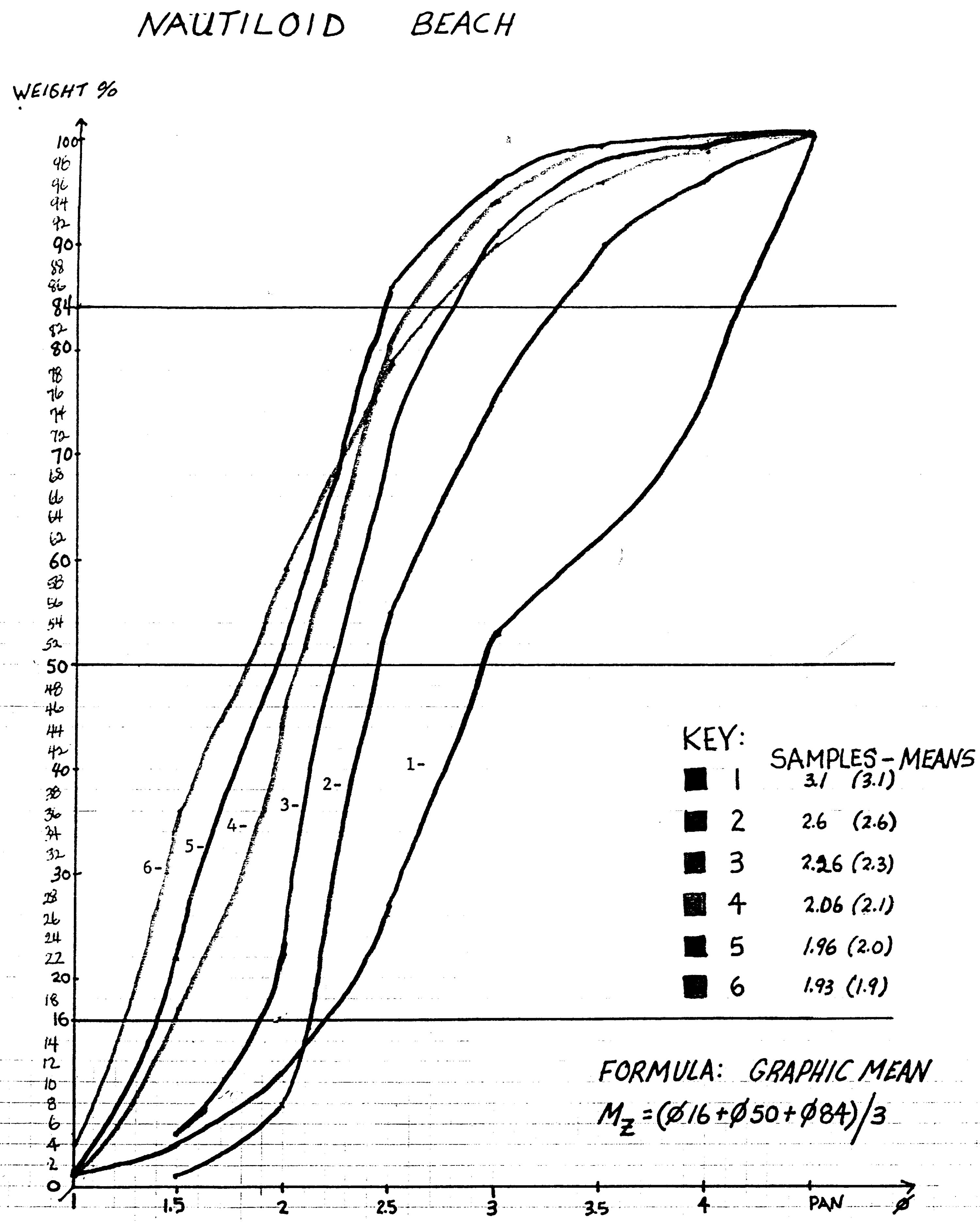

NAUTILOID BEACH
WEIGHT %
KEY:
SAMPLES - MEANS
1 3.1 (3.1)
2 2.6 (2.6)
3 2.26 (2.3)
4 2.06 (2.1)
5 1.96 (2.0)
6 1.93 (1.9)
FORMULA: GRAPHIC MEAN
$M_Z = (\phi 16 + \phi 50 + \phi 84)/3$
PAN
ø

Figure 3-2

NAUTILOID BEACH

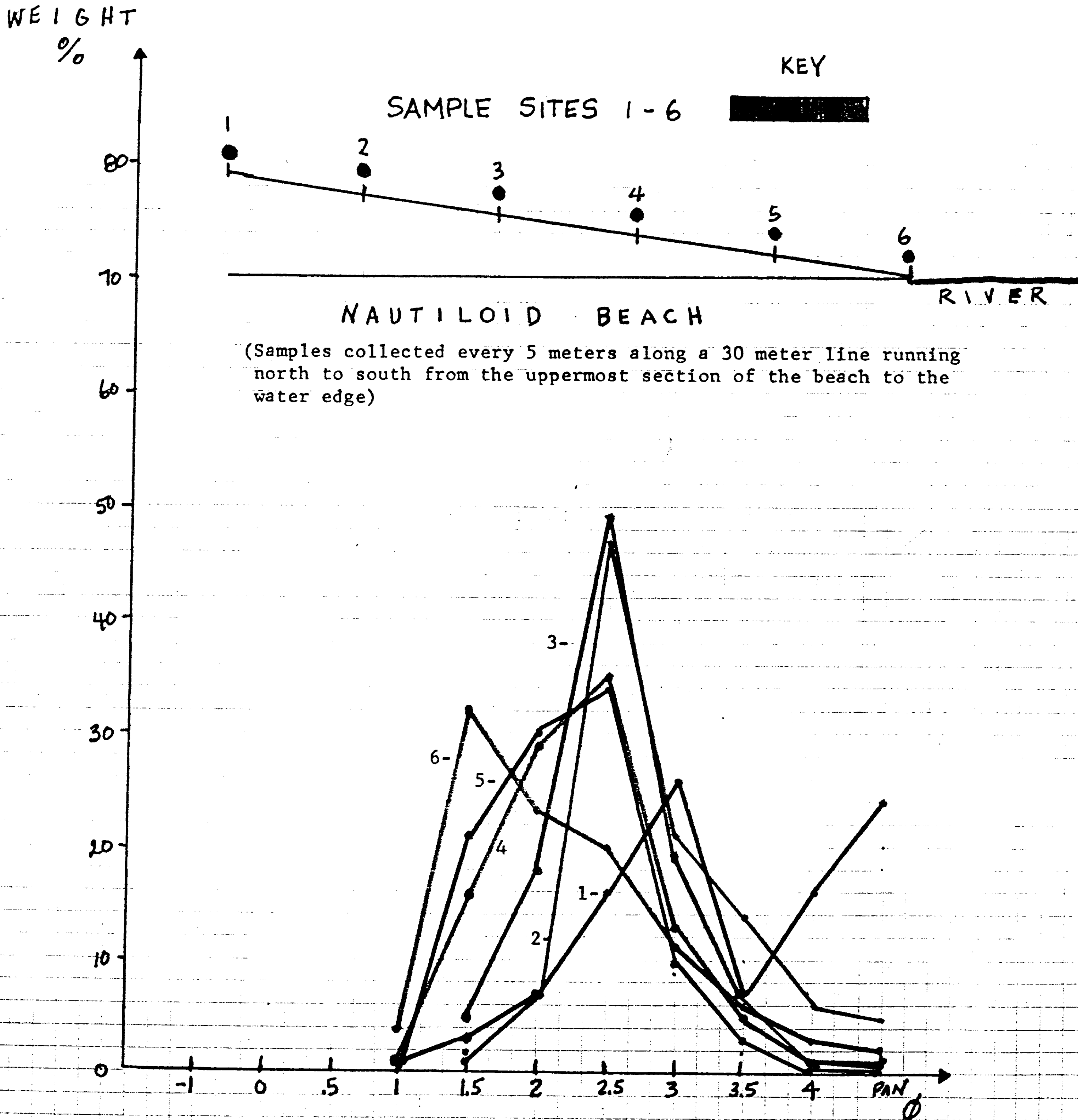


Figure 3-3

KEY:

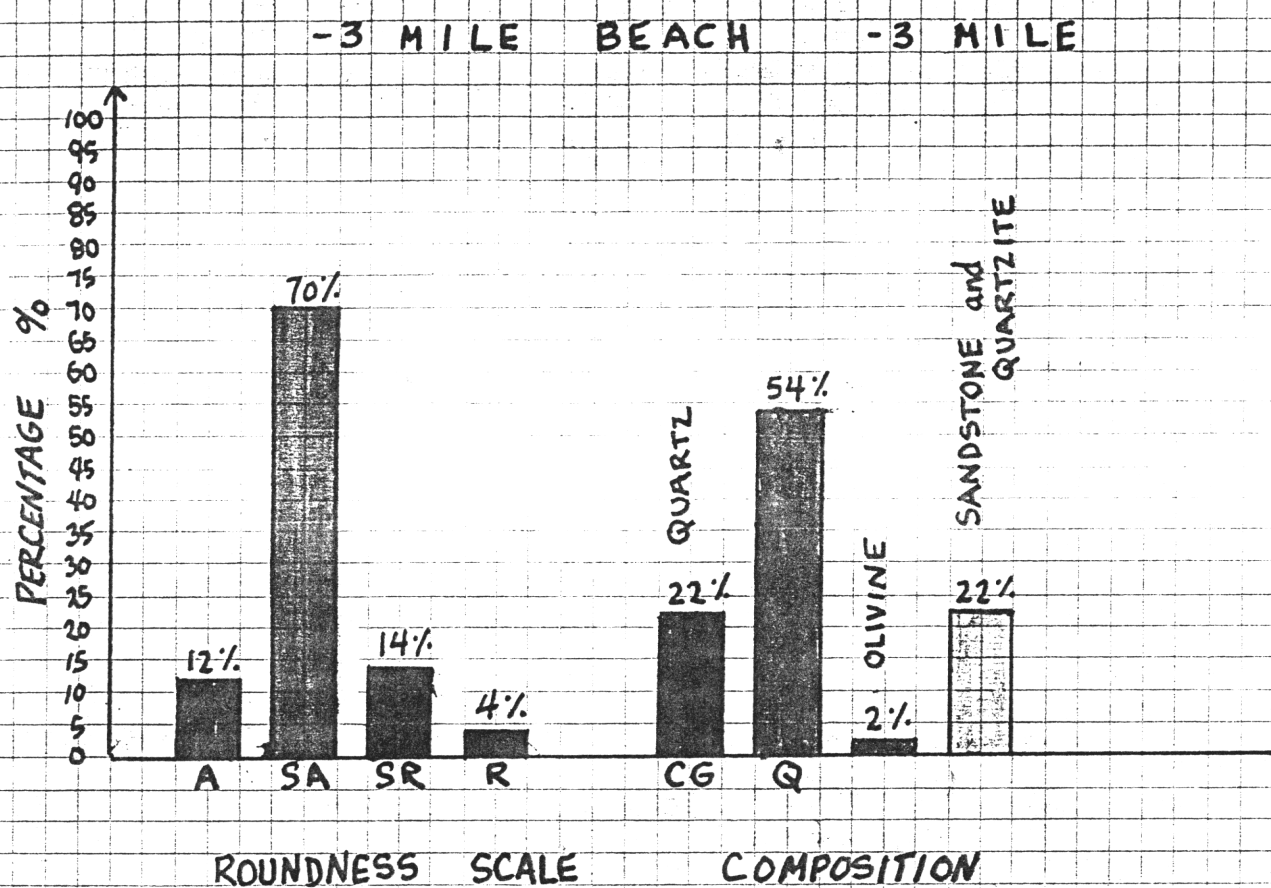
	(1)	(2)	(3)	(4)	(5)	(6)
A = ANGULAR	20%		14%		17%	
SA = SUBANGULAR	49%		54%		51%	
SR = SUBROUNDED	27%		29%		28%	
R = ROUNDED	4%		3%		4%	
CG = COMPOSITE GRAINS • (QUARTZ)		6%		2%		4%
Q = QUARTZ •		88%		87%		88% (• 92[illegible]
O = OLIVINE		1%				
AMPHIBOLE						
MAGNETITE						
SANDSTONE / QUARTZITE		5%		5%		
C = CHARCOAL				6%		

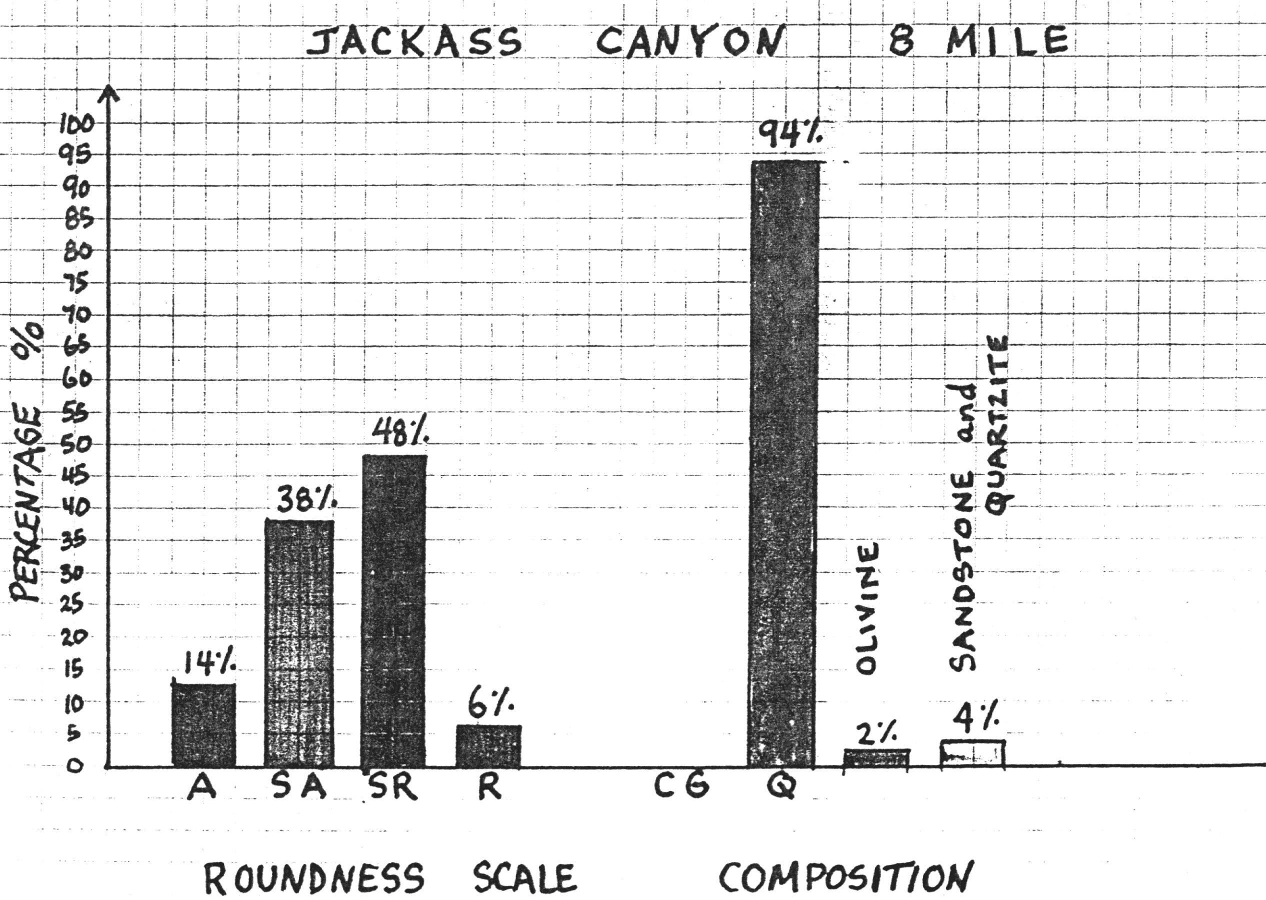
COLUMN:

1: TOTAL % 14 SAND SAMPLES - ROUNDNESS SCALE
2: TOTAL % 14 SAND SAMPLES - COMPOSITION
3: TOTAL % NAUTILOID SAMPLES - ROUNDNESS SCALE
4: TOTAL % NAUTILOID SAMPLES - COMPOSITION
5: • TOTAL % COLUMN DATA - 1 AND 3
6: •• TOTAL % COLUMN DATA - 2 AND 4

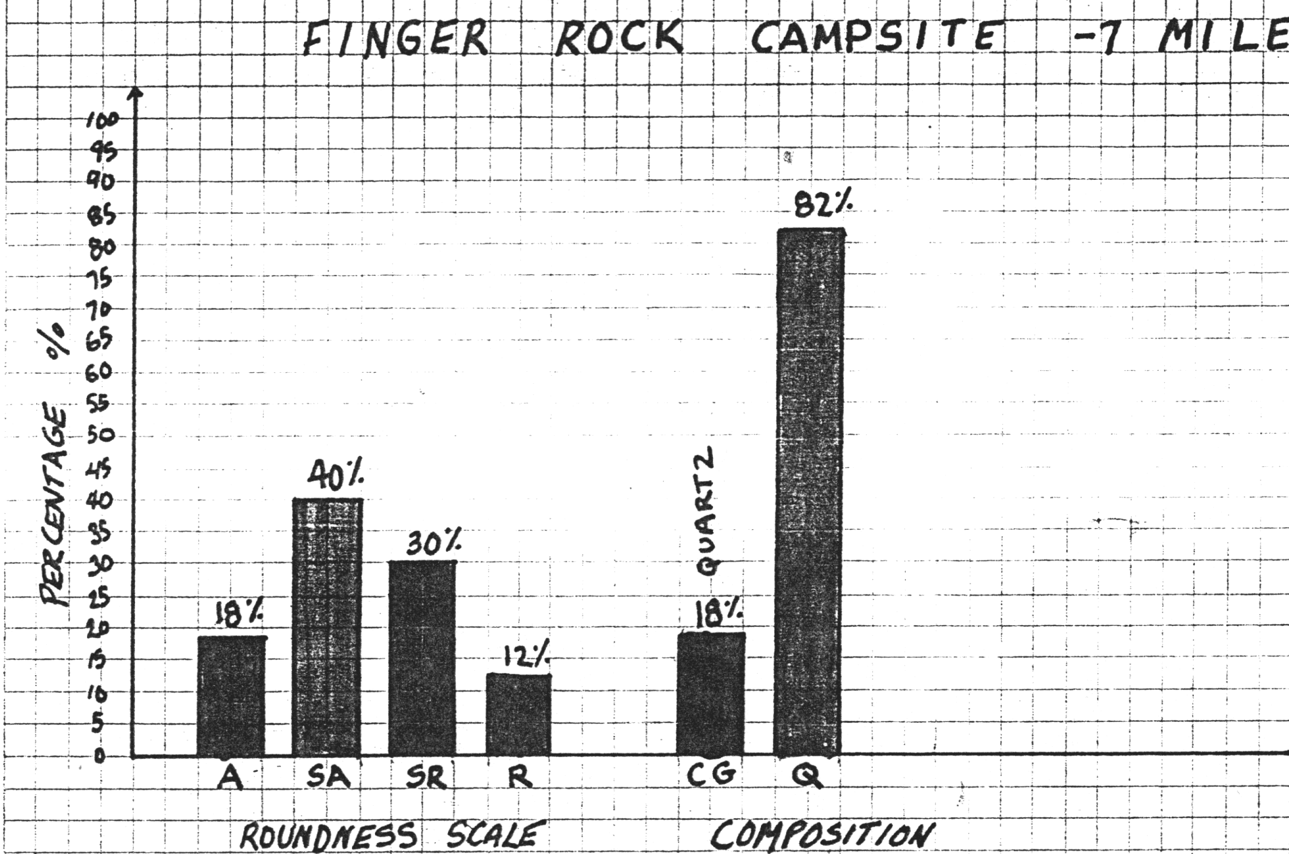
Figure: 3-4

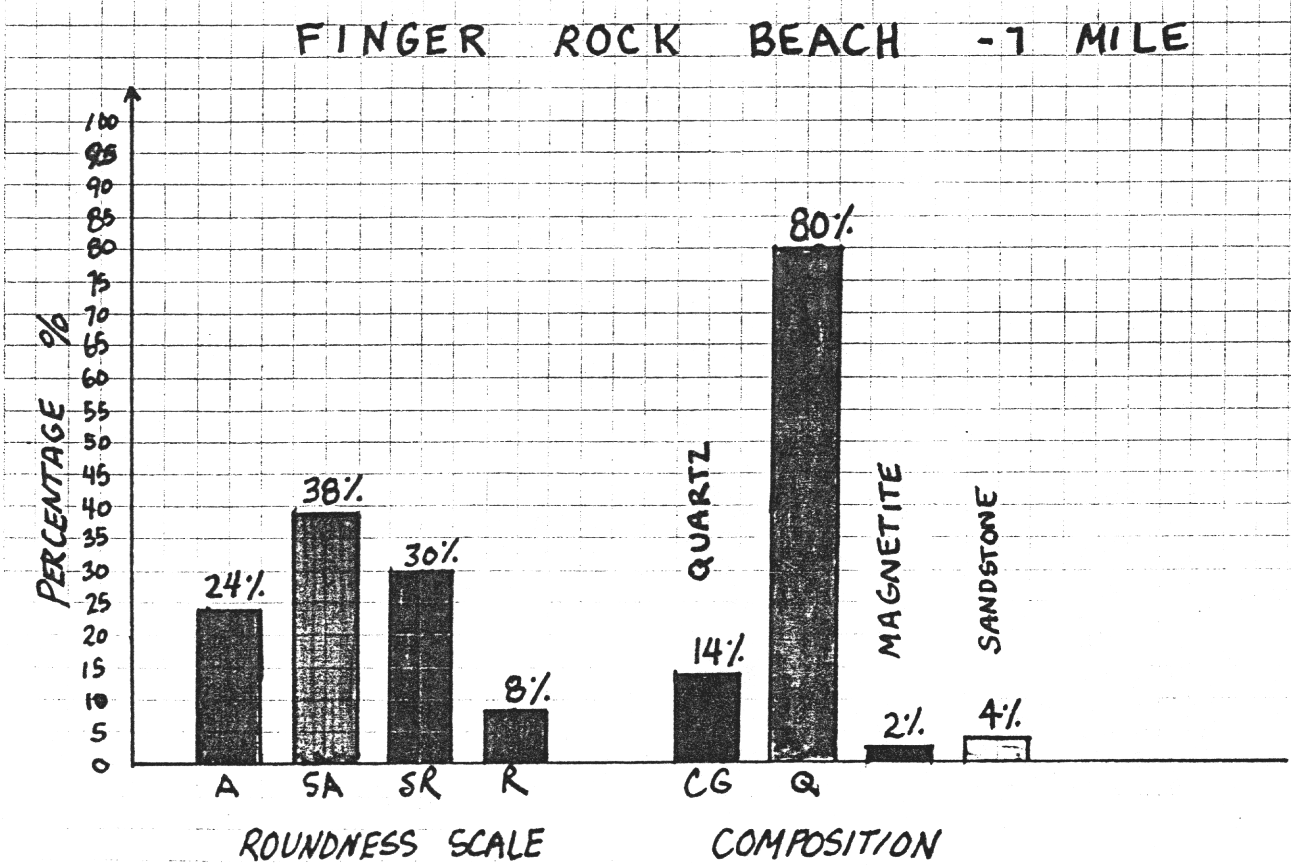
Graph 3-1


-3 MILE BEACH -3 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
12%
70%
14%
4%
22%
54%
2%
22%
QUARTZ
OLIVINE
SANDSTONE and QUARTZITE
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

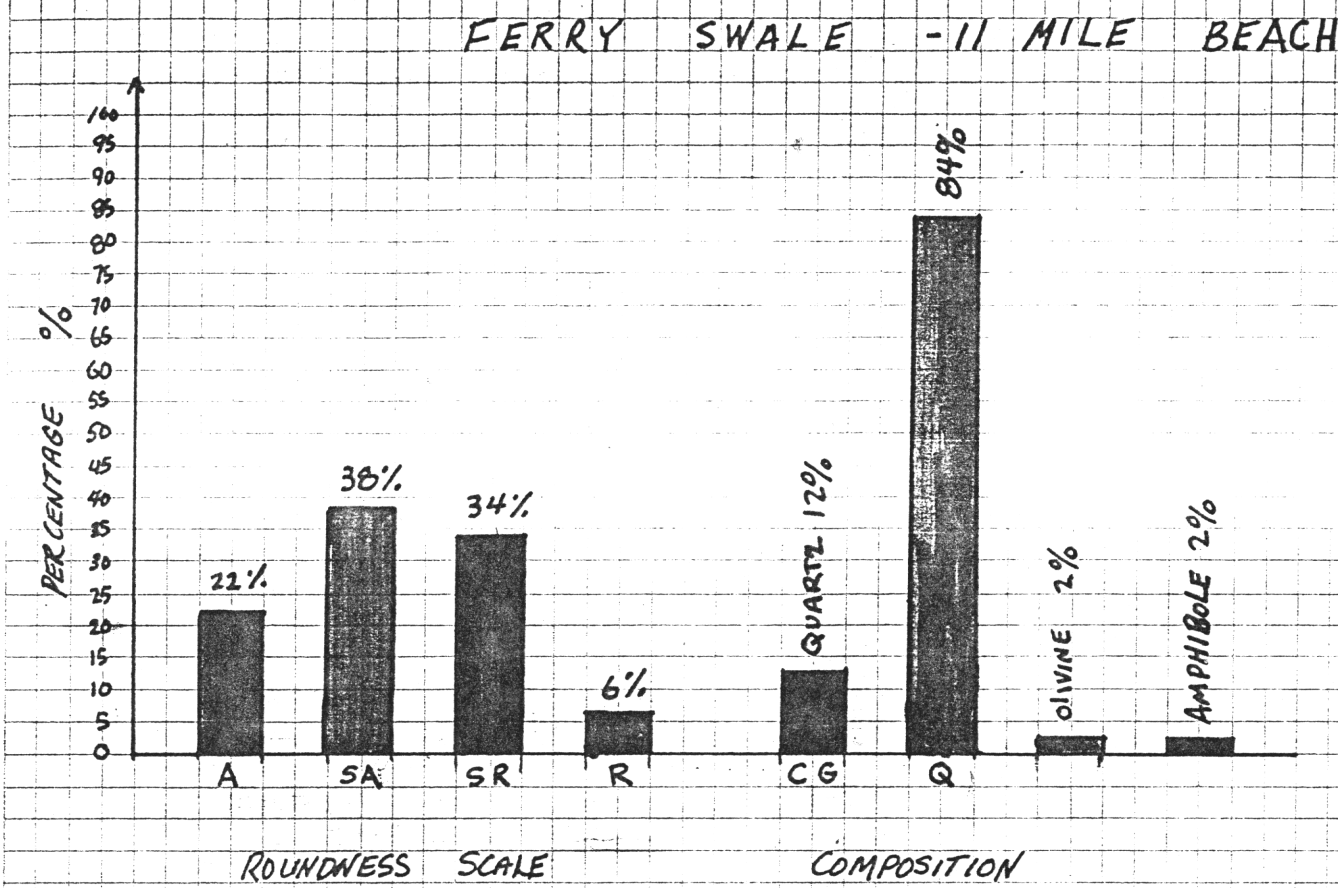

JACKASS CANYON 8 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
14%
38%
48%
6%
94%
2%
4%
OLIVINE
SANDSTONE and QUARTZITE
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

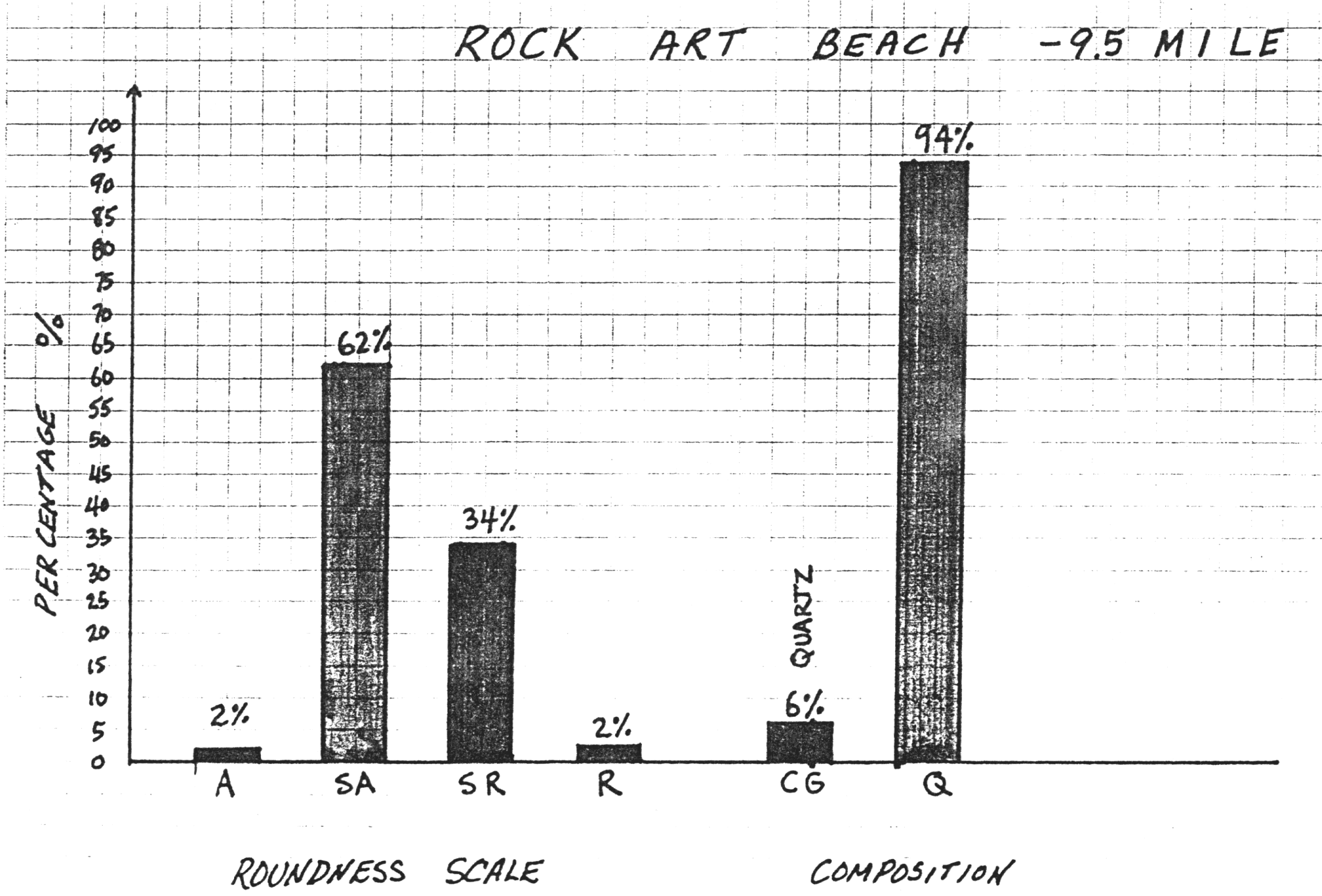
Graph 3-2


FINGER ROCK CAMPSITE -7 MILE
PERCENTAGE %
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
18%
40%
30%
12%
QUARTZ
18%
82%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

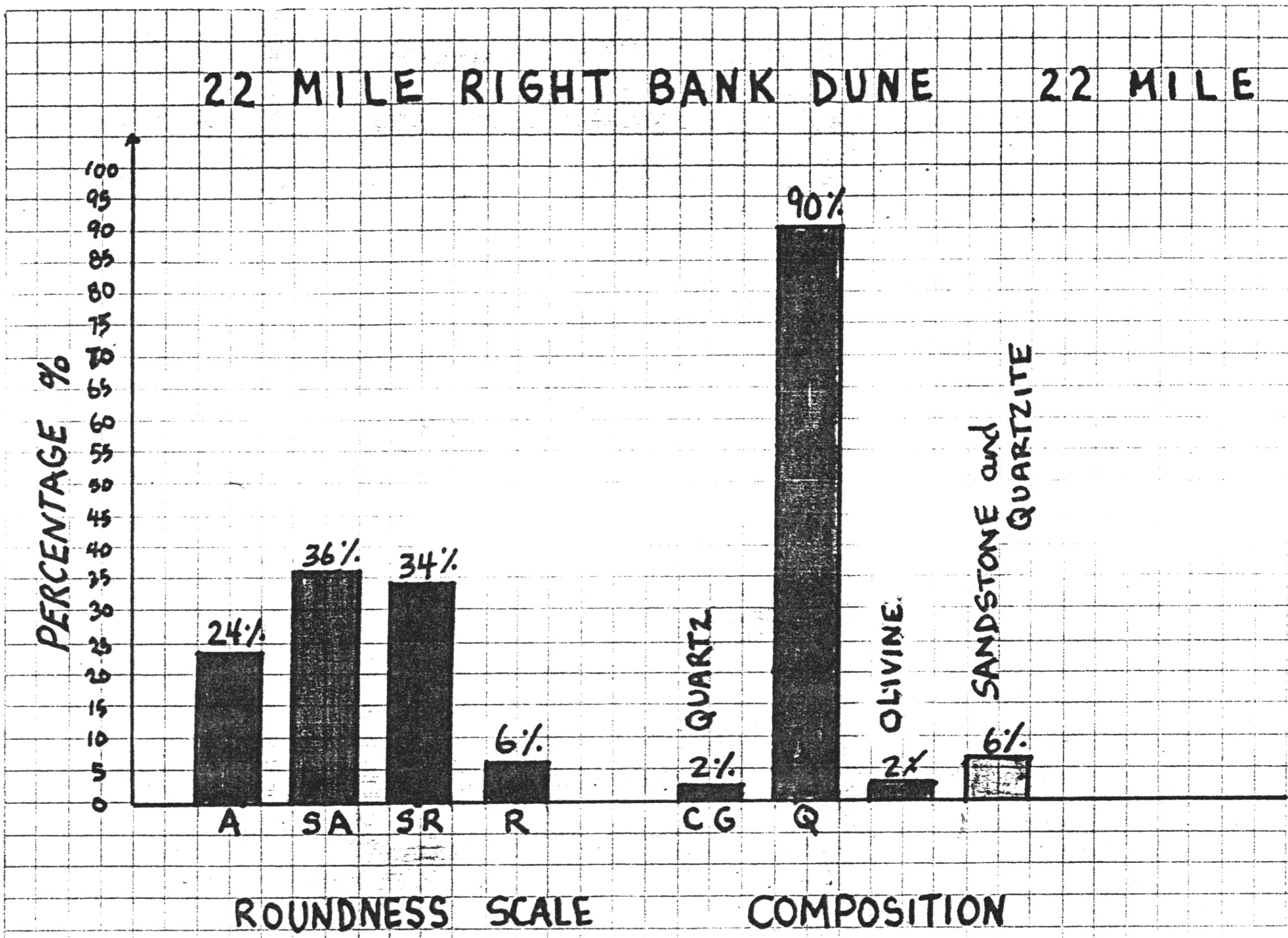

FINGER ROCK BEACH -7 MILE
PERCENTAGE %
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
24%
38%
30%
8%
QUARTZ
14%
80%
MAGNETITE
2%
SANDSTONE
4%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

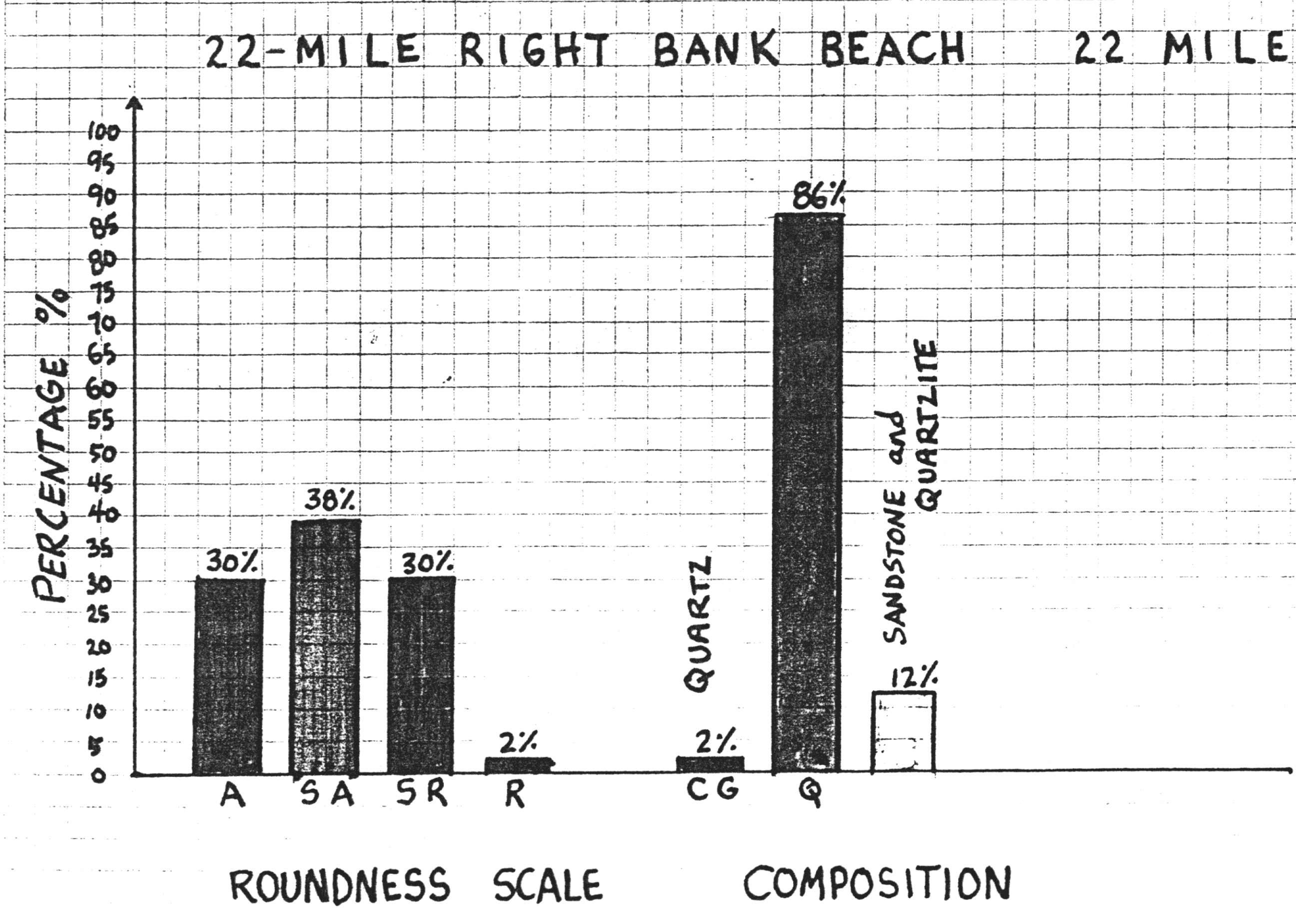
Graph 3-3


FERRY SWALE -11 MILE BEACH
PERCENTAGE %
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
22%
38%
34%
6%
QUARTZ 12%
84%
OLIVINE 2%
AMPHIBOLE 2%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

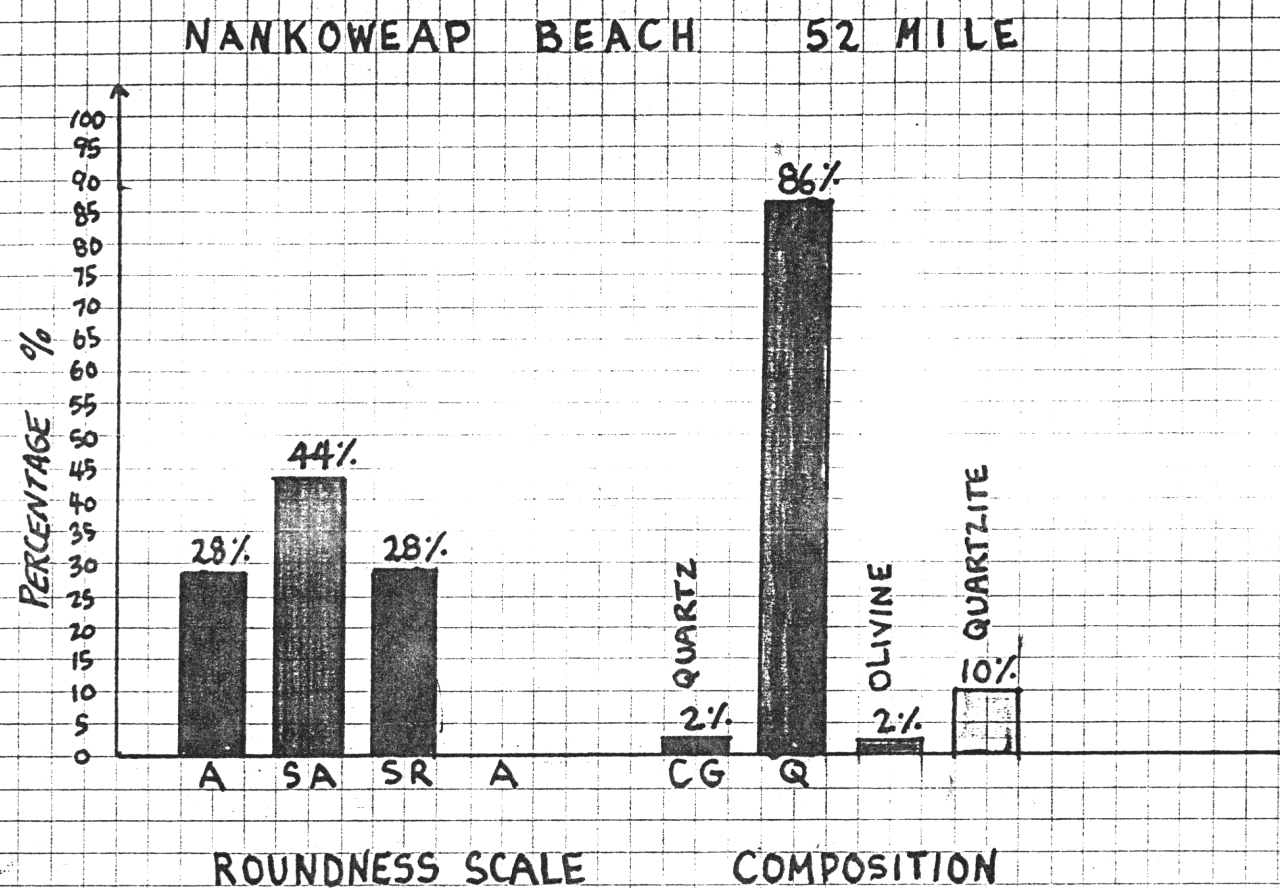

ROCK ART BEACH -9.5 MILE
PERCENTAGE %
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
2%
62%
34%
2%
QUARTZ
6%
94%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

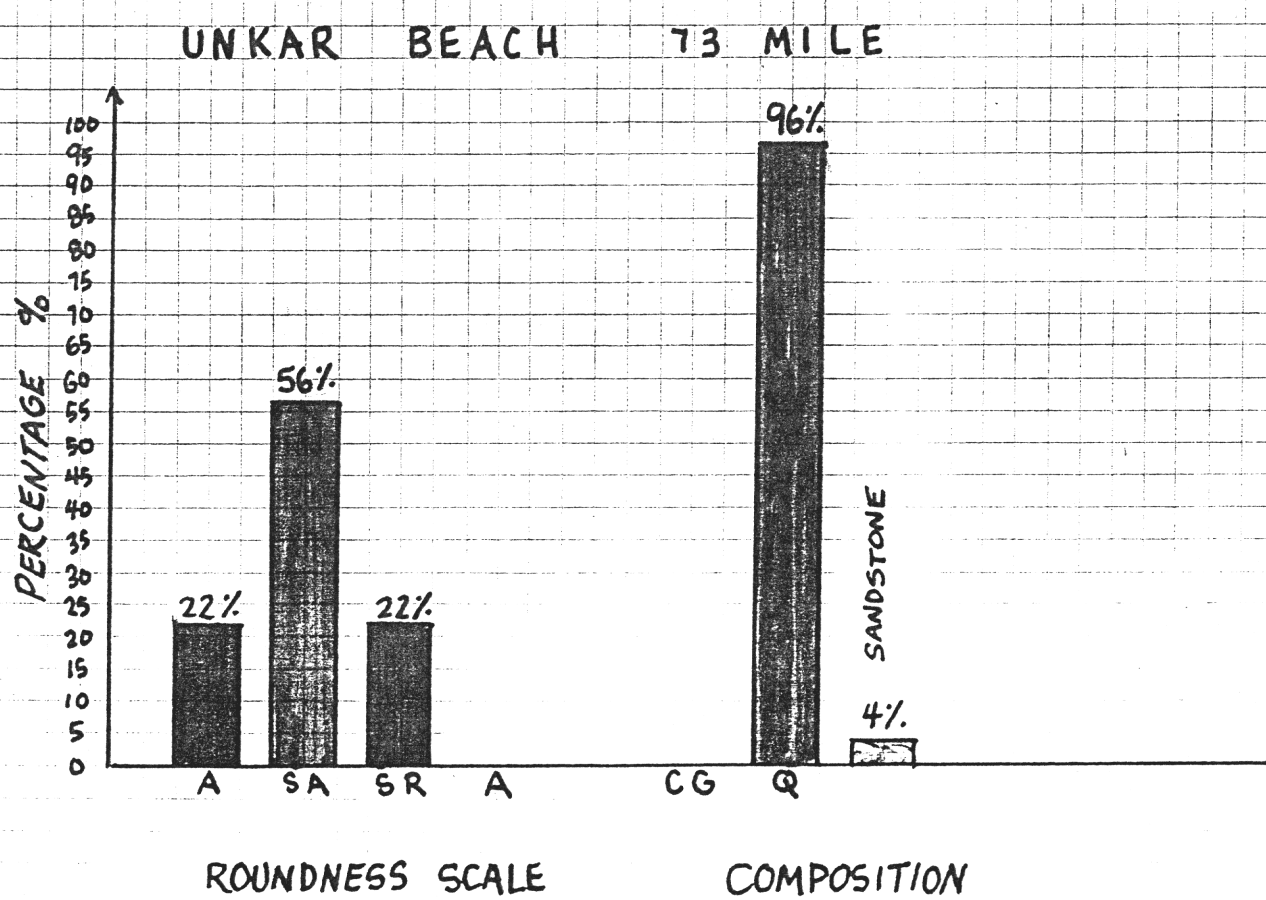
Graph 3-4


22 MILE RIGHT BANK DUNE 22 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
24%
36%
34%
6%
QUARTZ
2%
90%
OLIVINE
2%
SANDSTONE and QUARTZITE
6%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

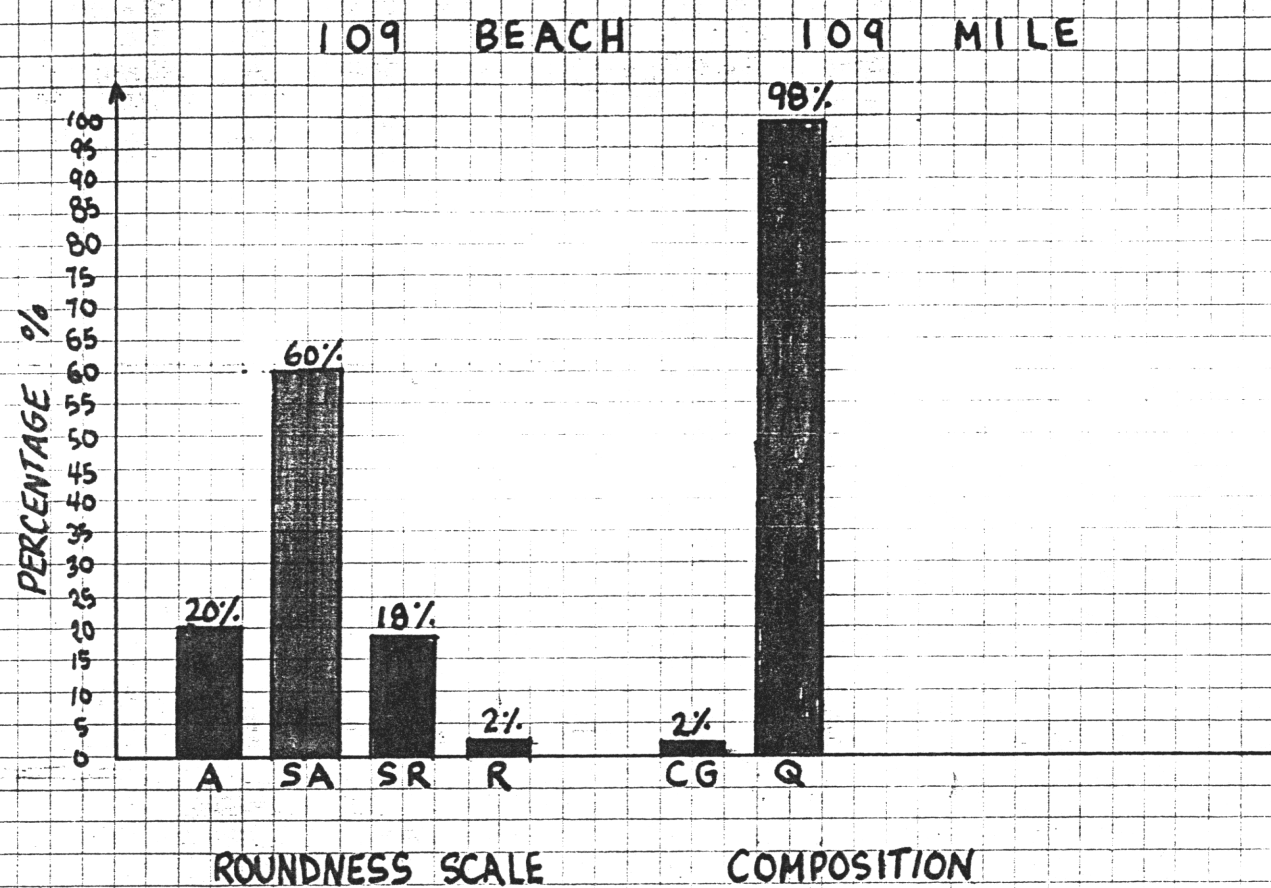

22-MILE RIGHT BANK BEACH 22 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
30%
38%
30%
2%
QUARTZ
2%
86%
SANDSTONE and QUARTZITE
12%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

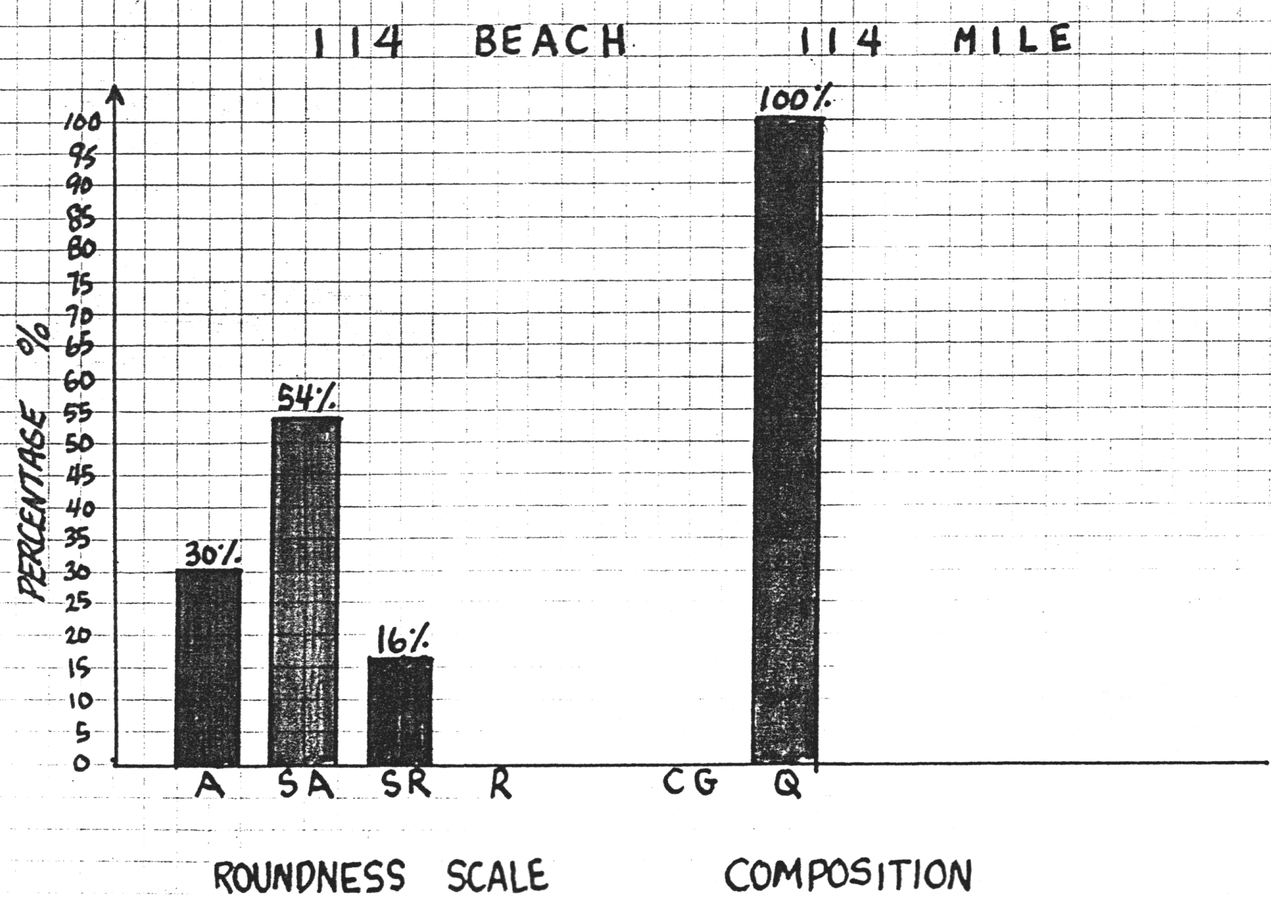
Graph 3-5


NANKOWEAP BEACH 52 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
28%
44%
28%
2%
86%
2%
10%
QUARTZ
OLIVINE
QUARTZITE
A
SA
SR
A
CG
Q
ROUNDNESS SCALE
COMPOSITION

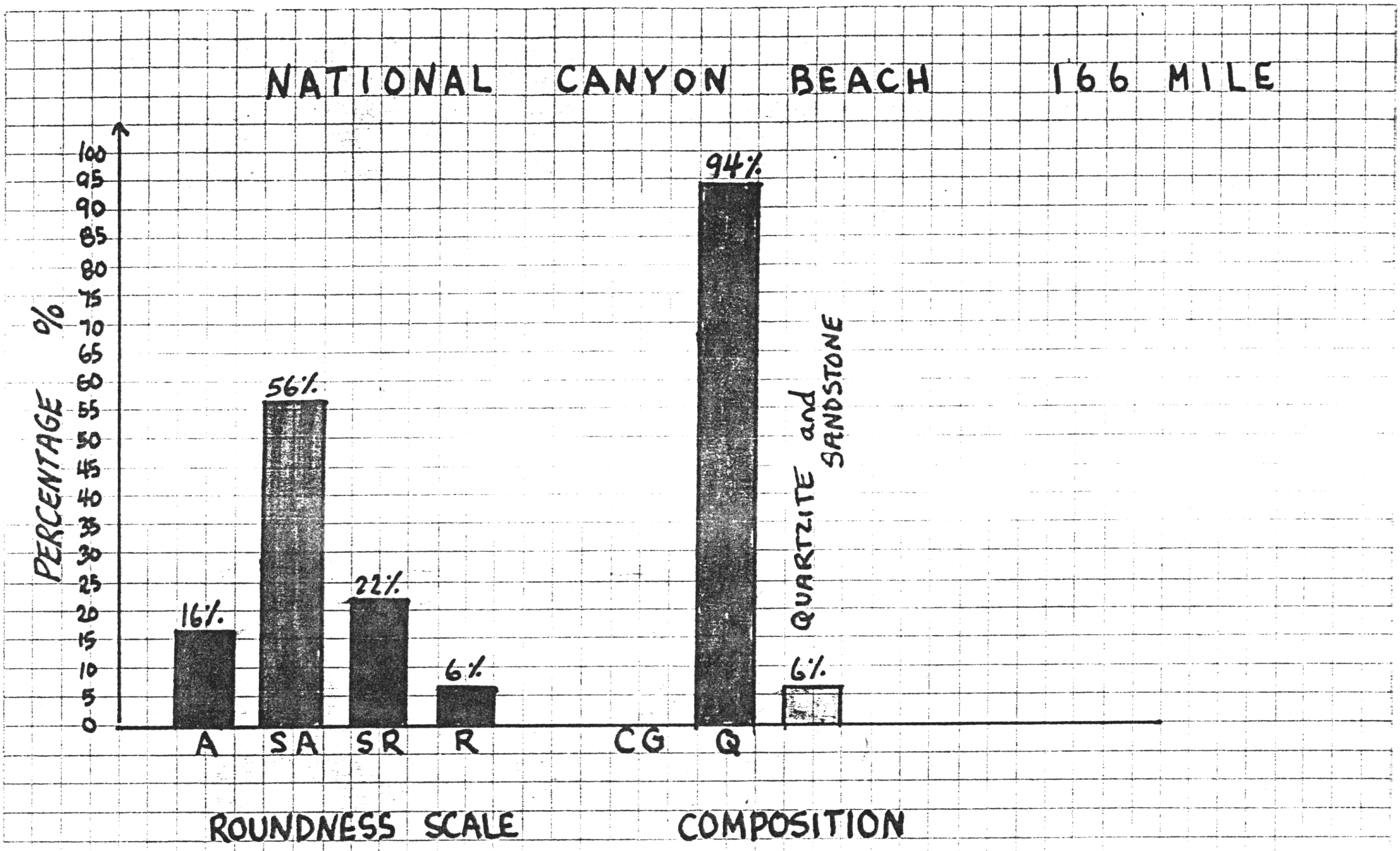

UNKAR BEACH 73 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
22%
56%
22%
96%
4%
SANDSTONE
A
SA
SR
A
CG
Q
ROUNDNESS SCALE
COMPOSITION

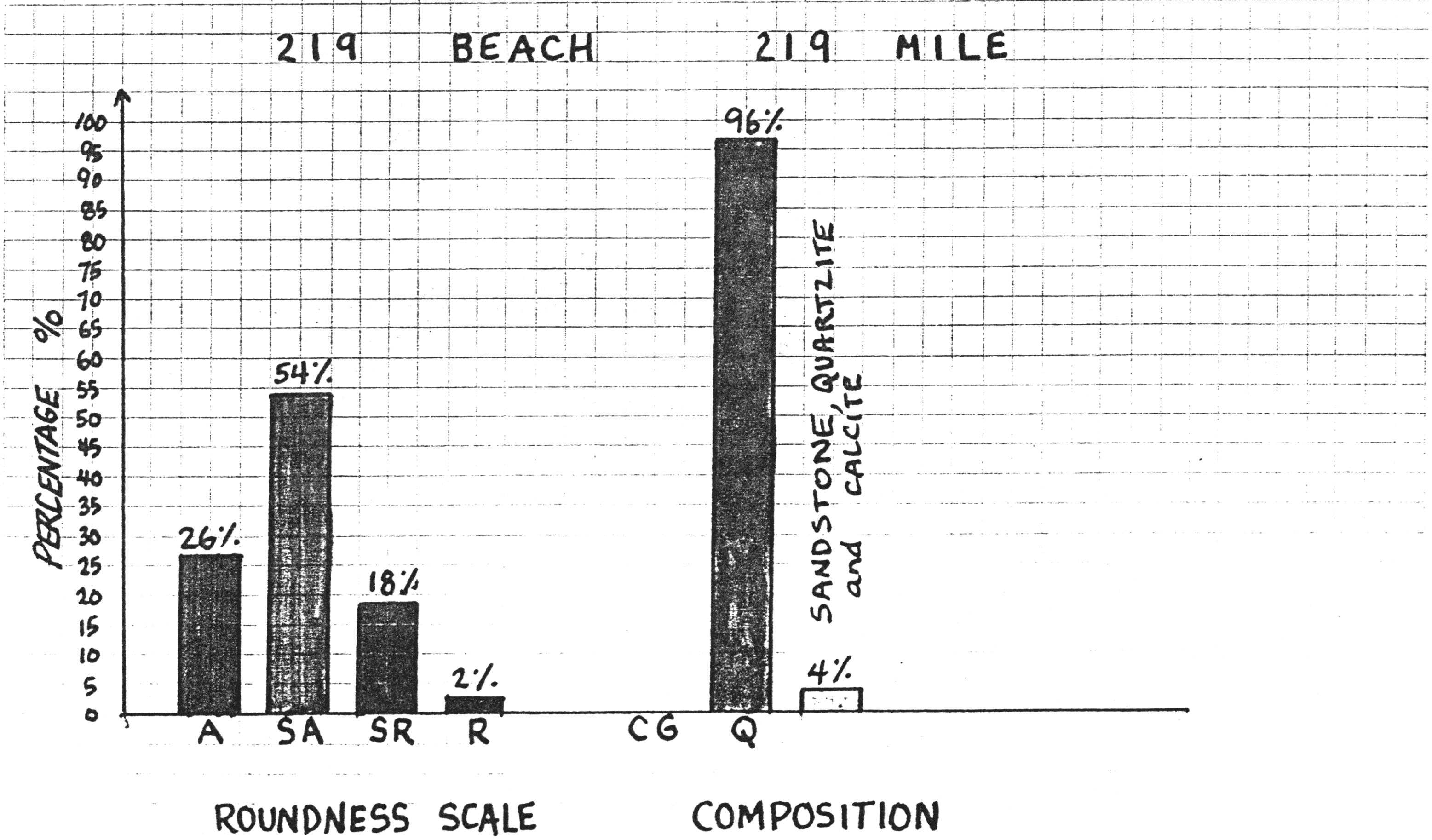
Graph 3-6


109 BEACH
109 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
98%
60%
20%
18%
2%
2%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

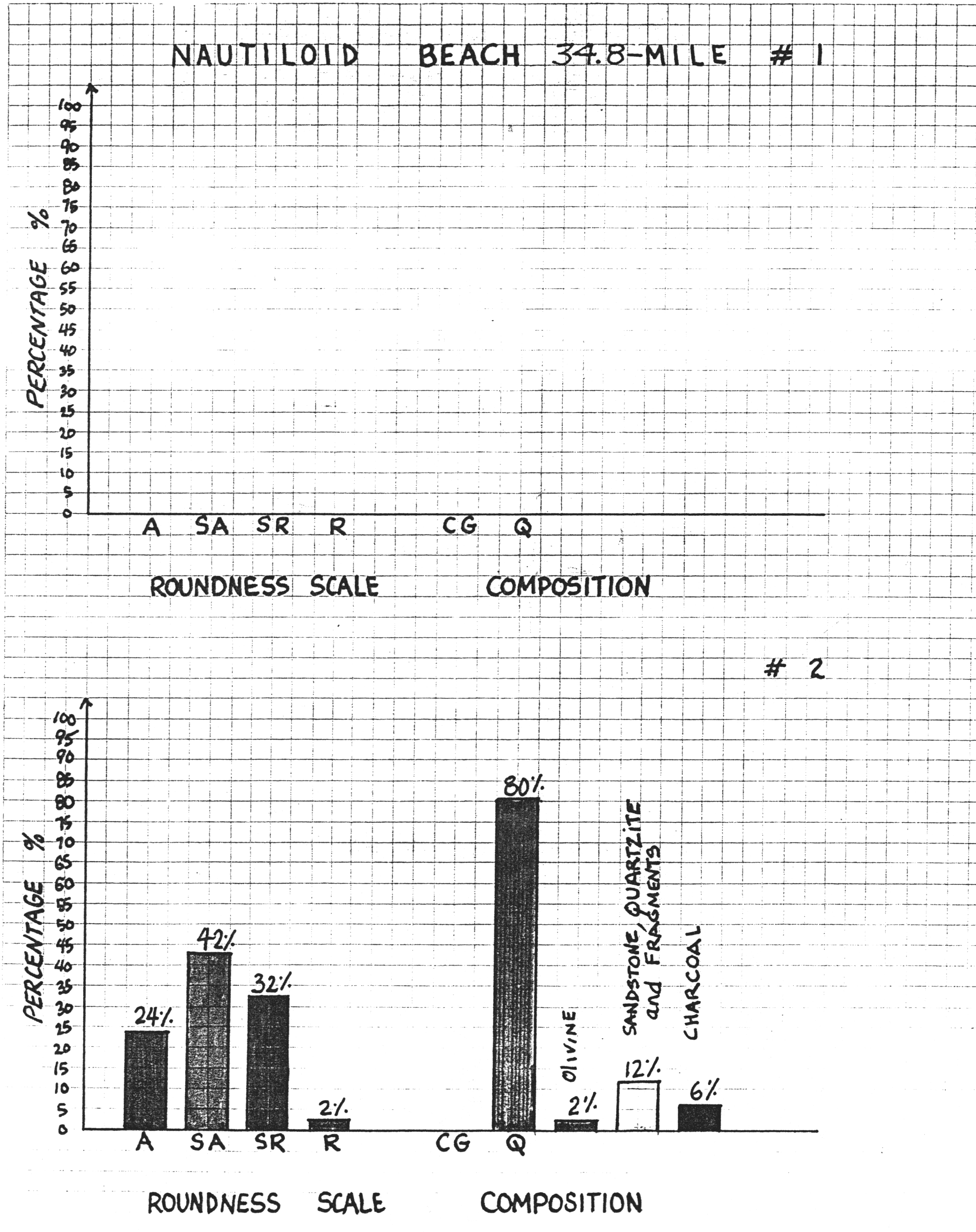

114 BEACH
114 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
100%
54%
30%
16%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

Graph 3-7

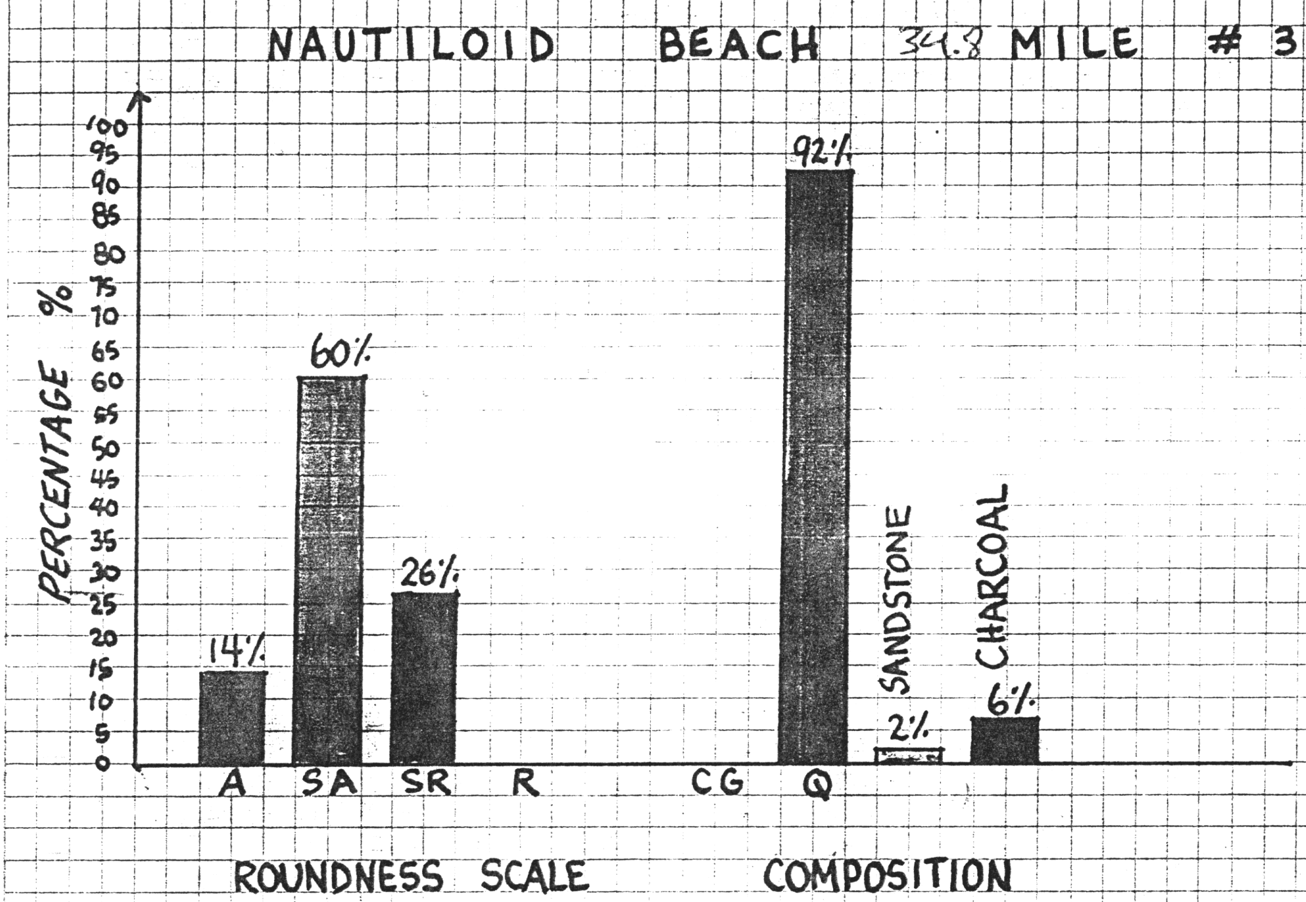

NATIONAL CANYON BEACH 166 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
16%
56%
22%
6%
94%
6%
QUARTZITE and SANDSTONE
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

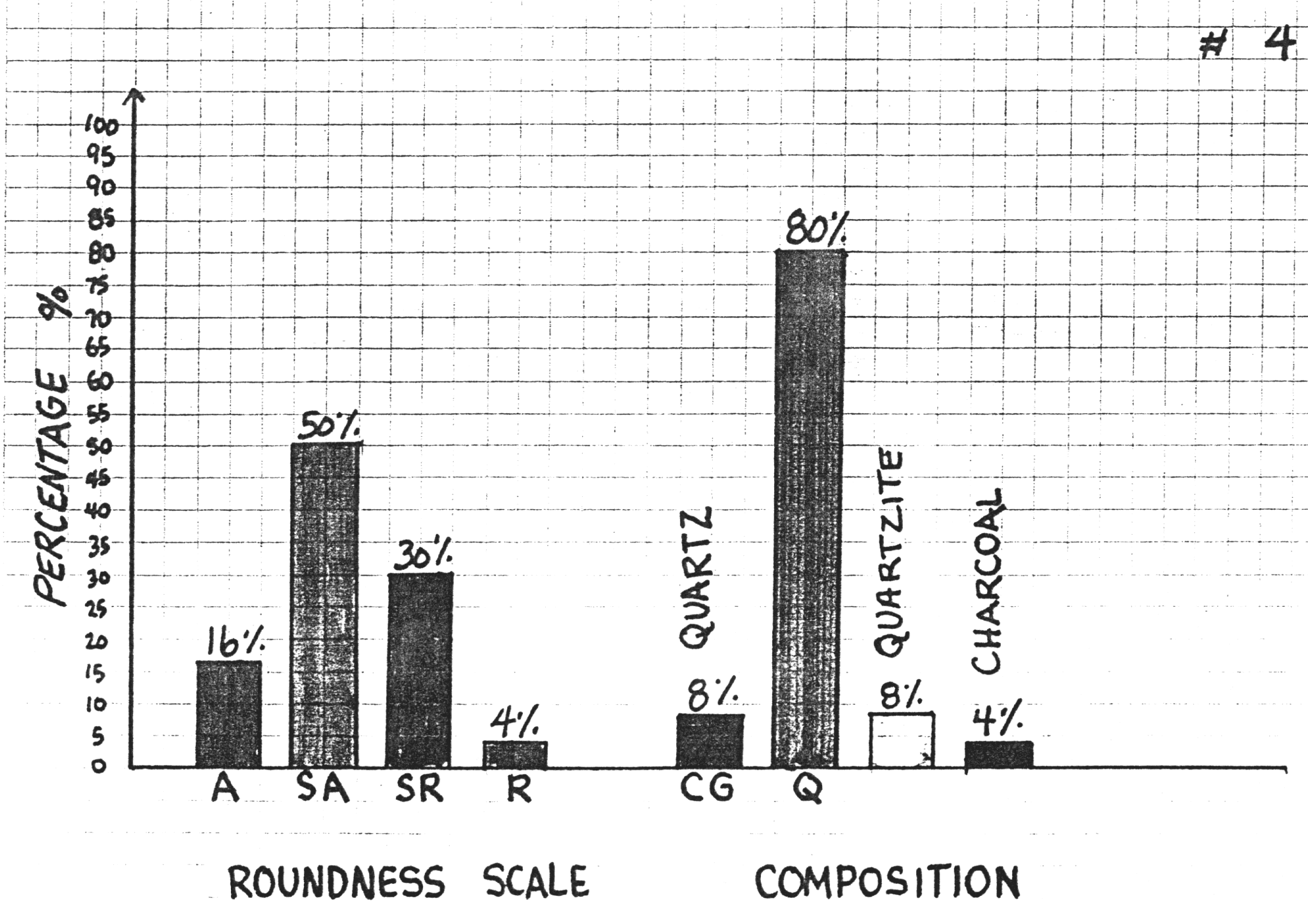

219 BEACH 219 MILE
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
26%
54%
18%
2%
96%
4%
SANDSTONE, QUARTZITE and CALCITE
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

Graph 3-8

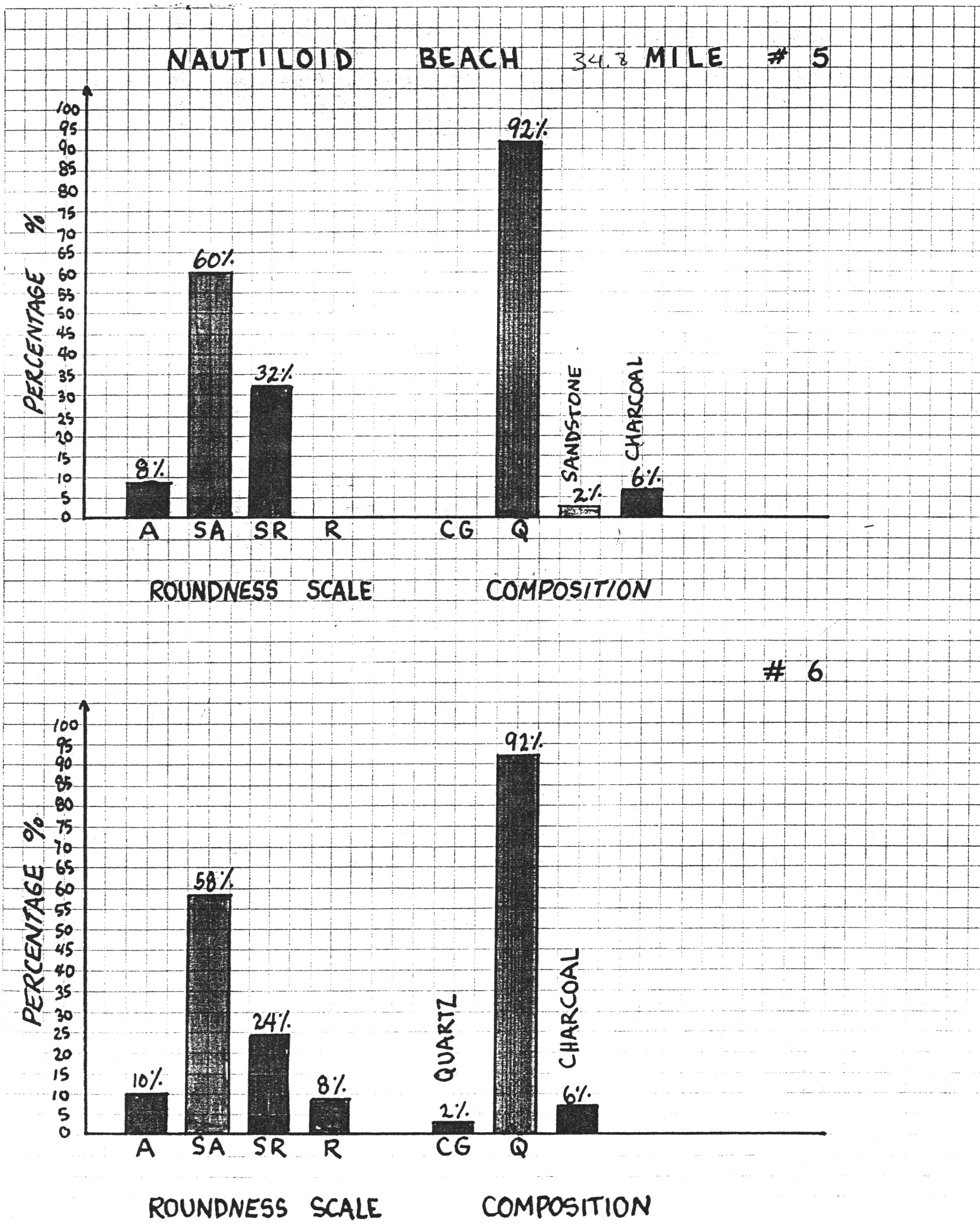

NAUTILOID BEACH 34.8-MILE #1
PERCENTAGE %
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
A SA SR R CG Q
ROUNDNESS SCALE
COMPOSITION
2
PERCENTAGE %
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
24%
42%
32%
2%
80%
OLIVINE
2%
SANDSTONE, QUARTZITE and FRAGMENTS
12%
CHARCOAL
6%
A SA SR R CG Q
ROUNDNESS SCALE
COMPOSITION

Graph 3-9

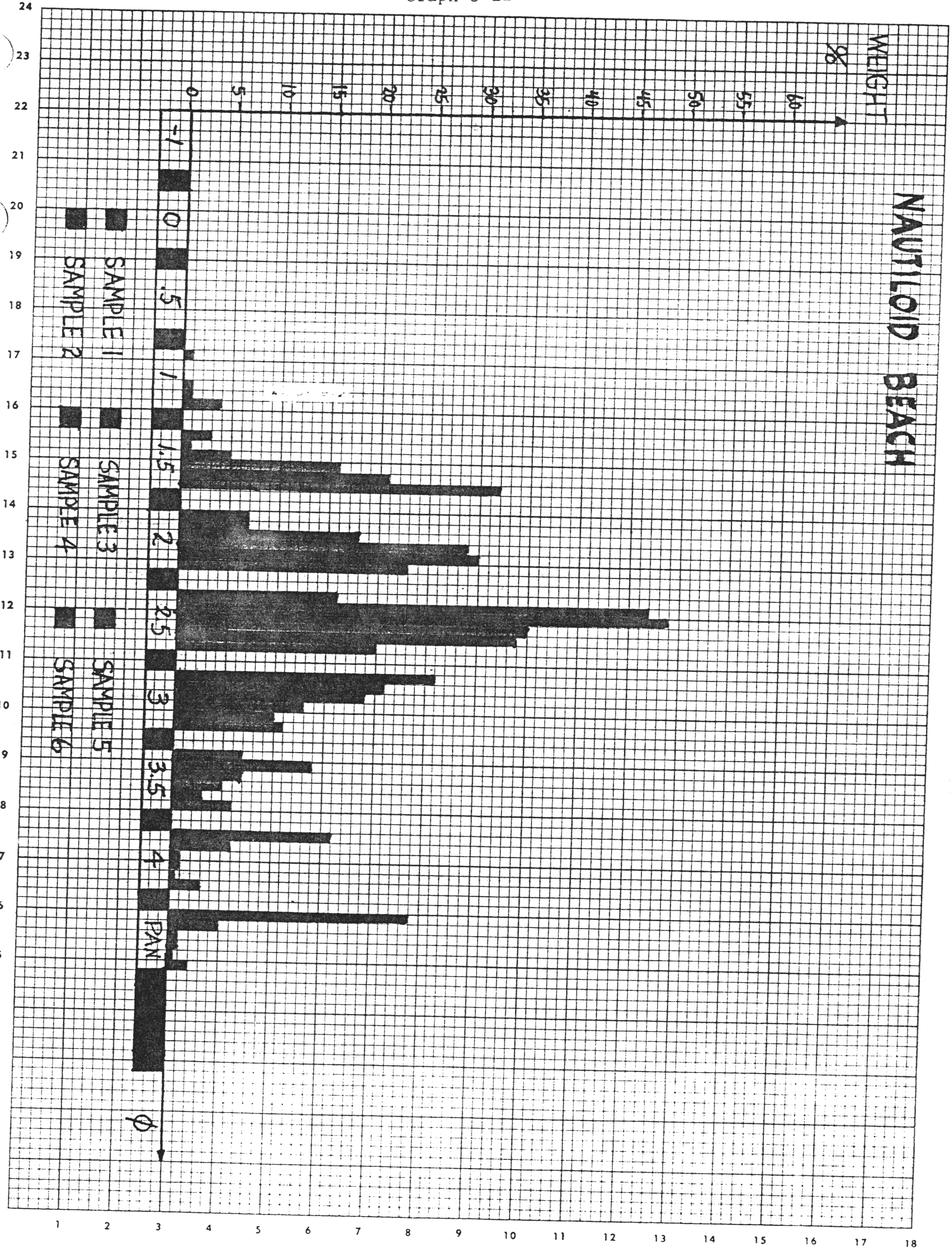

NAUTILOID BEACH 34.8 MILE # 3
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
14%
60%
26%
92%
SANDSTONE
2%
CHARCOAL
6%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION


4
PERCENTAGE %
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
16%
50%
30%
4%
QUARTZ
8%
80%
QUARTZITE
8%
CHARCOAL
4%
A
SA
SR
R
CG
Q
ROUNDNESS SCALE
COMPOSITION

Graph 3-10


NAUTILOID BEACH 34.8 MILE # 5
PERCENTAGE %
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
8%
60%
32%
92%
SANDSTONE
2%
CHARCOAL
6%
A SA SR R
CG Q
ROUNDNESS SCALE
COMPOSITION
6
PERCENTAGE %
100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
10%
58%
24%
8%
QUARTZ
2%
92%
CHARCOAL
6%
A SA SR R
CG Q
ROUNDNESS SCALE
COMPOSITION

Graph 3-11


NAUTILOID BEACH
WEIGHT %
0 5 10 15 20 25 30 35 40 45 50 55 60
-1 0 .5 1 1.5 2 2.5 3 3.5 4 PAN
φ
SAMPLE 1
SAMPLE 2
SAMPLE 3
SAMPLE 4
SAMPLE 5
SAMPLE 6

1983

BEACH SAND GRAIN SIZE ON THE COLORADO RIVER IN GRAND CANYON

by

Frank B. Lojko (Project Coordinator), Besty Burmaster,

George Spears, Wayde Nelson, Dale Dancis and Betty Byars.

INTRODUCTION

Beach sand samples were taken from 24 beaches in the Grand Canyon during a ten-day period from July 29 to August 7, 1983. The 68 samples were analyzed for grain size as a means of determining sand mean size, deposition and resistance to erosion. This report presents the results of the grain size analysis, comparison of data with the 1982 sand grain study, and field measurements and observations.

SAMPLING TECHNIQUE

Six types of sites were sampled as follows:

1. random surface samples collected at beaches and campsites
2. random surface samples collected at measured transect sites
3. surface samples collected at prescribed sites previously sampled for comparison basis
4. spot samples collected from trenches of river bars and beaches
5. profile samples collected from eroded and exposed sand banks
6. random samples collected at high deposited dunes on beaches

Beach samples (60-80 gm) were collected in small plastic vials at or near the surface of the beach or special deisgnated research study areas. The sample sites selected were those that appeared to have relatively little disturbance by human traffic. The campsite samples on the higher part of the beach were collected from randomly selected sites along a metric tape transect, or at last year's transect sites, within the campsite areas. Due to the 1983 high water and consequent flooding of beaches along the Colorado River, only ten of last year's 27 sampled beaches could be compared and sampled with this year's study (Table 4-1). On the ten beaches, only four out of 13 sites were sampled at the same spot as in 1982 (Table 4-1).

The 68 samples collected were sieved through a standard set of 3-inch-diameter sieves graduated in ½ Ø sizes. Each sample was shaken by hand for 10 minutes using a clamping device that held two sieve sets together.

Each size fraction was weighed using on Ohaus triple beam balance. The results were tabulated and are summarized in Table 4-2. The samples collected were saved for future reference and study.

SAND SIZE ANALYSIS

The sand samples measured range from fine- to medium-grained size sand with one in the very fine-grain size (Fig. 4-1, Table 4-1). The mean grain size is generally between 1.5 Ø (3/8 mm diameter) and 3.0 Ø (1/8 mm diameter) (Fig. 4-1). There are 20 medium-grained samples, 43 fine-grained samples, and four samples on the fine- to medium-grain size boundary (2.00 Ø size). A preliminary examination of the grain composition indicates mainly quartz.

The purpose of collecting two or more samples at any one site is to establish a comparison base. Because of local flooding, erosion of beaches and the 1983 high water level of the river, sampling was done mainly along measured transect lines, approximately parallel to the river. The data obtained and the comparison with previous studies of beaches revealed some interesting results. The mean phi size, or mm size, of the beach sands was significantly larger in samples taken

SAND ANALYSIS - MEAN PHI SIZE

Comparison of Sand samples of 1982 sites with 1983 sites

Mile marker #	Name of Location	Sample site	mean phi size 1982	mean phi size 1983
7.8	Badger Rapids	T-3	2.1	2.2
		T-27	2.0	1.66
20	20 mile beach	T-34	2.38	2.23
29	Shinumo wash	beach	2.3	
		T-19		2.03
43	Anasazi	T-31	3.0	
		C-1		1.86
		C-2		2.00
52	Nankoweap	T-30	2.55	
		Tombolo T-20		1.73
		Tombolo T-40		2.00
73	Unkar	Tamarisk	3.21	
		Willow	3.10	
		T-35		2.28
		T-9		2.31
75	Nevilles	T-6	2.3	
		campsite		2.5
108	Bass	T-4	2.66	
		T-4 (new)		2.9
		T-19 (old)		2.53
132	Stone Creek (Dubendorff)	T-27	2.66	1.9
166	National	Trench 5cm	2.73	
		Trench 10cm	2.50	
		T-38 sec. B		3.03
		T-4 sec. B		2.76
166	Upper National	T-7 sec. A		2.26
		T-40 sec. A		2.00

Table 4-1

MILE NUMBER	REFERENCE AREA SAND SAMPLING SITES	MEAN PHI SIZE Ø	GRAIN SIZI IN MM	WENTWORTH SCALE CLASSI
7.8	Badger T-3	2.2	.218	F.S
7.8	Badger T-27	1.66	.320	M.S.
7.8	Badger T-30	1.96	.260	M.S.
20	20 Mile T-34 B-Sec.	2.26	.210	F.S.
20	20 Mile T-34 A-Sec.	2.23	.218	F.S.
20	20 Mile T-17	2.01	.250	F.S.
29	Shinumo T-19	2.03	.242	F.S.
34.8	Nautiloid T-12	2.13	.226	F.S.
34.8	Nautiloid T-14	2.06	.242	F.S.
43.5	Anasazi C-1	1.86	.280	M.S.
43.5	Anasazi C-2	2.00	.250	MS/FS
52	Nankoweap T-10 #1	2.1	.234	F.S.
52	Nankoweap T-20 #2	1.73	.300	M.S.
52	Nankoweap T-30 #3	1.75	.300	M.S.
52	Nankoweap T-40 #4	2.00	.250	MS/FS
52	Nankoweap (5) below T-20 #7	1.80	.290	M.S.
52	Nankoweap Profile #6 (River Edge below T-10	1.73	.300	M.S.
52	Nankoweap Profile (Front of #5 Tombolo River Edge)	1.83	.280	M.S.
52	Nankoweap River Bar Profile 40 cm #1	1.66	.320	M.S.
52	Nankoweap River Bar Profile 70 cm #2	2.70	.154	F.S.
52	Nankoweap River Bar Profile 109 cm #3	1.78	.290	M.S.
59	Beach 59 T-12	2.13	.226	F.S.
59	Beach 59 (lower beach area new deposit)	2.10	.234	F.S.
61.5+	Below the Mouth of the Little Colorado	2.53	.172	F.S.
65	Lava Canyon Rapids T-6	1.85	.280	M.S.
65	Lava Canyon Rapids T-39	1.73	.300	M.S.
73	Unkar T-9	2.31	.203	F.S.

Table 4-2

MILE NUMBER	REFERENCE AREA SAND SAMPLING SITES	MEAN PHI SIZE Ø	GRAIN SIZE IN MM	WENTWORTH SCALE CLASSIF.
73	Unkar T-35	2.28	.203	F.S.
75	Nevilles	2.5	.177	F.S.
81.5	Grapevine T-9	1.76	.300	M.S.
81.5	Grapevine T-36	1.66	.320	M.S.
81.5	Grapevine (New High Beach)	2.43	.183	F.S.
93.4	Granite Rapid T-4	2.61	.165	F.S.
93.4	Granite Rapid T-8	2.53	.172	F.S.
108	Bass T-4	2.9	.134	F.S.
108	Bass T-8	2.53	.172	F.S.
120	Blacktail Canyon B.S. 1	2.2	.218	F.S.
120	Blacktail Canyon B.S. 2	2.33	.196	F.S.
123	Forster T-6 Sec. A	1.73	.300	M.S.
123	Forster T-6 Sec. O	1.60	.330	M.S.
123	Forster Eolian Deposits	2.03	.242	F.S.
123	Forster - Old High River Bank	2.8	.144	F.S.
123	Forster Beach Surface CS-2 Rod 12	2.36	.196	F.S.
123	Forster 7 cm Profile X-S CS-2 Rod 12	2.28	.203	F.S.
123	Forster 38 cm Profile X-S CS-2 Rod 12	2.36	.196	F.S.
123	Forster 63 cm Profil~~e X-S Top~~ (Grasses)	2.45	.183	F.S.
123	Forster Profile/Old Root Zone	2.26	.210	F.S.
123	Forster Profile 30 cm Below Root Zone	2.35	.196	F.S.
123	Forster X-Bedding Profile A left X-S	1.83	.280	M.S.
123	Forster X-Bedding Profile A right X-S	1.76	.300	M.S.
132	Dubendorff (Stone Creek) T-10	2.03	.242	F.S.
132	Dubendorff (Stone Creek) T-27	1.90	.270	M.S.
136	Deer Creek Falls T-3	2.11	.234	F.S.
136	Deer Creek Falls T-5	2.68	.154	F.S.

MILE NUMBER	REFERENCE AREA SAND SAMPLING SITES	MEAN PHI SIZE Ø	GRAIN SIZE IN MM	WENTWORTH SCALE CLASSIF
137	Ponchos Kitchen T-5	2.00	.250	MS/FS
137	Ponchos Kitchen T-34	1.88	.240	M.S.
166	National T-4 Sec. B	2.76	.149	F.S.
166	National T-38 Sec. B	3.03	.121	V.F.S.
166	National T-7 Sec. A	2.26	.210	F.S.
166	National T-40 Sec. A	2.00	.250	MS/FS
180	Beach 180 T-11	2.21	.218	F.S.
180	Beach 180 T-35	2.3	.203	F.S.
209	Granite Park T-6	2.28	.203	F.S.
209	Granite Park (Dune)	2.1	.234	F.S.
212	Pumpkin T-3	2.3	.203	F.S.
212	Pumpkin T-38	2.2	.218	F.S.
220	Beach 220 T-20	2.6	.165	F.S.
220	Beach 220 T-40	2.11	.234	F.S.

KEY: V.F.S. - ve[illegible] sand

F.S.

M.S.

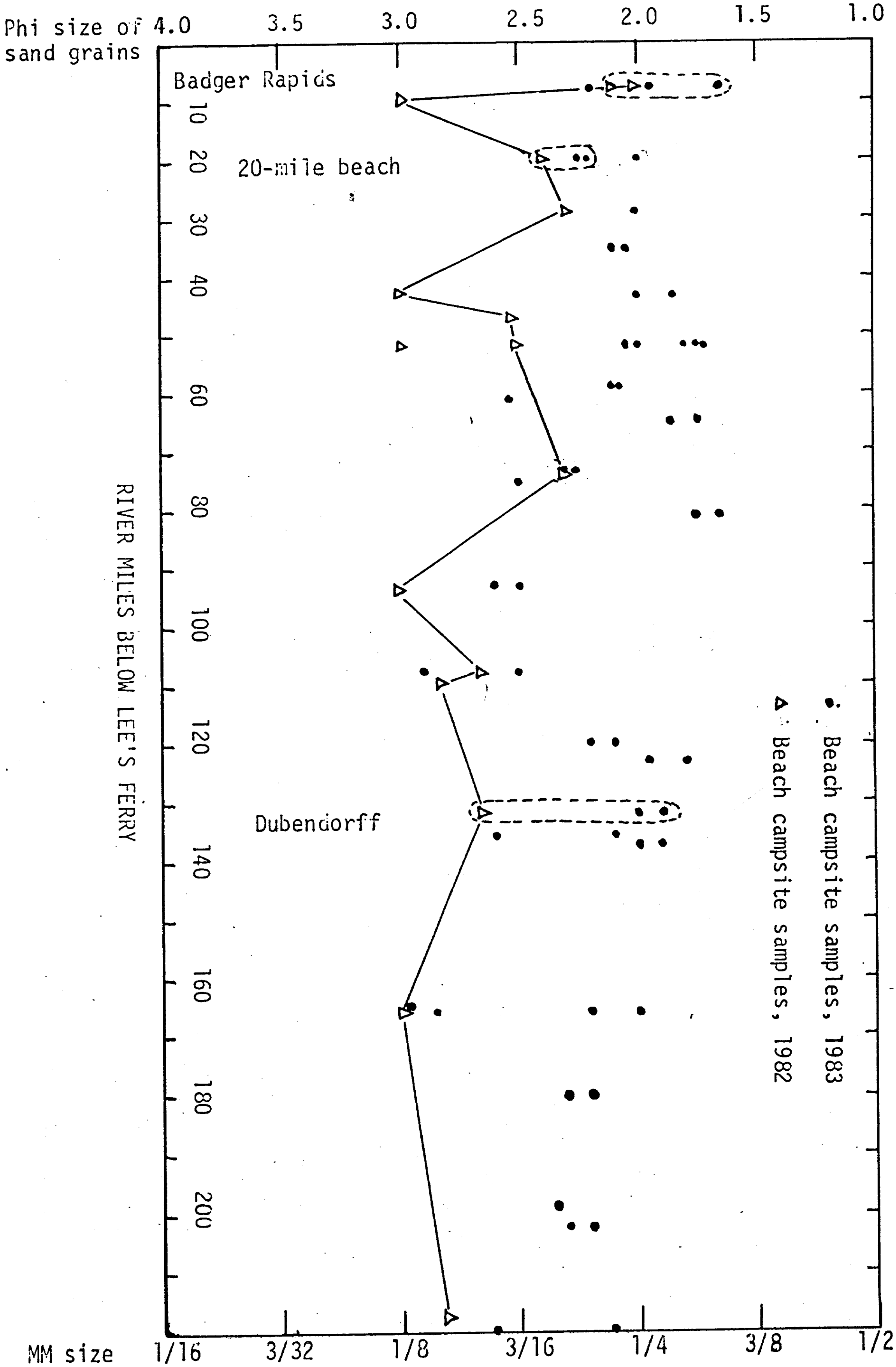


Figure 4-1. Mean sand grain size of beach campsite samples, 1982 and 1983. Circled sample plots are those taken from same meter square quadrat both years.

closer to the water edge. The 1982 study also indicated that size of sand grains to beach samples near the water was larger compared to sand grain size at campsites more distant from the river. The 1982 sand study comparison of 18 sites indicated 11 beach sites sampled were larger in mm size than campsites. The 1983 sand study of samples collected along a skewed transect line (one not parallel to the river bank) indicated that a sample collected closer to the river was larger in mm size than a sample at the upper end of the transect. The ten beach locations studied in 1983, compared to the same ten beaches of 1982, indicated the mean sand grain sizes were basically larger in 1983.

There were four samples taken in the 1983 sand study from the same identical spot sampled in the 1982 sand study. The data indicates that 1982 samples had a 2.28 phi size or 0.203 mm diameter mean size compared to 1983 samples with a 1.99 phi size or 0.250 mm mean size. Three out of four sites sampled in 1983, compared to 1982, show an increase from fine-grained sand to medium-grained sand; the other sample showed no significant change (Table 4-1).

SUMMARY

The use of data, evidence and scientific observations collected from the two sand studies provides a scenario to the depositional and erosional processes of the Colorado River. The grains sampled are predominantly quartz. The grains are mostly moderately to well-sorted. Beach sands along the Colorado River in the Grand Canyon are generally medium-to-fine-grained, as compared to last year's study, wherein the beach sands were fine- to very fine-grained. The change in particle size can be attributed to erosion and deposition processes. A water current velocity of 22 to 25 cm/sec in the river at the sample sites would be sufficient to initiate erosion of any beach sands sampled in the Grand Canyon. The turbulent currents and fast moving flood waters can cause beaches to erode, or to gain sediment from the river. The evidence that beaches were eroded, that beaches were shifted, that sediments were reworked and that new beaches were established by the receding high flood waters, can be supported by data collected in the sand study.

CONCLUSIONS

There are many unanswered questions regarding the effects of the 1983 flood waters of the Colorado River. Does the river replenish and reestablish beaches in the Grand Canyon adequately? Are there sufficient external contributing factors which provide sediment from other sources beyond the river system? How finite are the resources associated with the complexities of the river and its surroundings? How has the "flood" and heavy rains in the Grand Canyon region provided additional sediment sufficient to sustain the pristine environment, exotic species, and conditions noted in the recent past history of the Colorado River?

These questions and circumstances must be addressed through continued intensified studies of sand sediment, sedimentary structures of beaches and depositional/erosional processes at work. The Colorado River system and the Grand Canyon need further study and monitoring for adequate mangement of this unique resource.

CHANGES IN BEACH PROFILES ALONG THE COLORADO RIVER IN GRAND CANYON 1974-1983

by

S. S. Beus, B. Burmaster, B. Byars, D. Dancis, P. Hasenbuhler, and J. Pauls

INTRODUCTION

This report presents results of topographic profile measurements made in the late summer of 1983 on selected campsite beaches along the Colorado River in Grand Canyon. The purpose of this study is to compare present beach profiles with those taken in preceding years (1974, 1975, 1980, 1982) as a means of determining changes on the beaches--either erosion or deposition--owing to human use, fluctuation in river level, wind or flash flooding, or other factors.

The initial data base for these studies was provided mainly by Howard (1975) who established semipermanent benchmarks at some 20 beach campsites in Grand Canyon in 1974 and 1975. From one to three topographic profiles were measured by tape and transit surveys at each of the beaches (total of 45 profiles). The lines of traverse for the profiles were oriented approximately perpendicular to the beach and river bank trend and generally extended from the campsite area of the beach to the water's edge or beyond. Some of the beaches were resurveyed in 1980 (Dolan, 1981) and two were resurveyed in 1982 (Beus and others, 1982).

In the summer of 1983 (July 29-August 7; September 15) we resurveyed 28 profiles at 18 of the original 20 beaches. Some were still under water owing to the unusually high water release from Glen canyon dam (36,000-43,000 cfs). In addition three profiles were measured and a plane table map prepared for a newly deposited beach campsite at Forster Canyon (mile 122.8). The surveying was done with a telecsopic transit, rod and steel tape. Three profiles where original survey sites were partially submerged were done with a hand-held Brunton compass. Table 5-1 presents a list of the beach profile data available.

TABLE 5-1. BEACH PROFILES SURVEYED

River Mile	Name	No. of Profiles Measured 1974	1975	1980	1982	1983
L18.2	Upper 18-mile Wash		2			2
L19.3	19-mile Wash		2	1		2
L34.7	Nautiloid Canyon	2	2			2
R53.0	Lower Nankoweap	3	3	1		1
R61.8	Mouth of Little Colorado	1		1		1
L65.5	Tanner Mine	2		2		2
R72.2	Unkar Indian Village	1	1	3		2
L81.1	Grapevine	2		2		2
L87.1	Lower Suspension Bridge		2	1		
L93.2	Upper Granite Rapids	2		1		2
R109.4	109-mile	2				1
R112.2	Walthenberg Canyon	1		1		1
R120.1	Blacktail Canyon	2		2	1	1
L122.8	Forster Canyon (New Survey)					3
L124.4	Upper 124½-mile Canyon	2				1
R131	Bedrock Rapids	2		2		2
R151.6	The Ledges	2	2			1
L166.5	National Canyon		2	1		1
R180.9	Lower Lava Falls Rapids	2		2		2
L190.2	190-mile		1	1		
L208.8	Granite Park	2	2	2	1	2

1974, 1975 data from Howard (1975)

1980 data from Dolan (1981)

1982 data from Beus and others (1982)

1983 data from this report

RIVER DISCHARGE RATES

In the past 20 years, since the completion of Glen Canyon dam, the flow of water through Grand Canyon has been carefully regulated by the release of water through the dam. The tributaries downstream of the dam contribute only a small and generally insiginifcant amount to the river volume. Discharge rates at Glen canyon dam have generally fluctuated between about 28,000 cfs for a high to about 5,000 cfs for a low. Commonly the discharge rates fluctuate daily in response to power generation and reservoir level requirements. The only exception to this flow regimen was a high water release in June, 1980, of about 50,000 cfs at the time Lake Powell, behind Glen Canyon Dam, was filled to design level for the first time.

In the summer of 1983 unusually high runoff filled Lake Powell above design level by early June and produced an exceptional "spill" through Glen Canyon dam. The discharge rate at the dam approached 100,000 cfs for a few days in late June. During July the rate decreased gradually from about 80,000 to 40,000 cfs with only very minor daily fluctuations. Table 5-2 summarizes the discharge rates discussed. Most of the 1983 beach profile surveys were taken in late July and early August immediately after the "spill" and while the discharge rate was maintained at between 40,000 and 36,000 cfs. Surveys at 18.2-mile and 19.3-mile were done September 15, 1983, when the discharge rate was about 28,000 cfs.

TABLE 5-2. DISCHARGE RATES OF COLORADO RIVER THROUGH GRAND CANYON. DISCHARGE RATES ARE IN CUBIC FEET PER SECOND (CFS)

	Mean High	Mean Low	Maximum High
Pre-dam annual	80,000	4,000	220,000 (1921)* 300,000 (1884)*
Post-dam daily	20,000	5,000	50,000 (1980)
June 1983	80,000		100,000
July 1983	55,000		87,000

*Highest recorded floods

	Minimum	Maximum	Mean daily
July 29, 1983	43,437	44,192	43,930
July 30	43,511	44,192	43,980
July 31	43,562	44,391	43,935
August 1	36,813	44,065	40,570
August 2	36,311	37,129	36,840
August 3	36,687	37,700	36,990
August 4	36,060	37,954	36,950
August 5	36,311	37,446	36,830
August 6	36,186	37,319	36,865
August 7	35,558	37,954	36,830

RESULTS OF 1983 PROFILE MEASUREMENTS

The high waters of the 1983 summer floods inundated all the campsite beaches examined in this study. At most beaches the maximum high flood level was clearly marked by new sand deposits, rarely by erosional cutbanks, and in some by buried or uprooted vegetation. Sands on all the beaches have clearly been reworked; most beaches were either built up or eroded down from pre-1983 levels. Table 5-3 presents a summary of topographic changes in the beach profiles measured. The beach profiles are shown in Figures 5-1--5-32.

Many (18) of the beach profiles exhibit a net gain in sand sediment in 1983 as compared to 1974-1975 levels. Profile CS2 at 18-mile wash shows an addition of nearly 10 vertical feet of sand to the outer beach. At Nautiloid Canyon (mile 34.7) the profile at CS2 showed a net gain of about 2 1/2 feet of sand deposited along the entire profile (Fig. 5-6). At Granite Park (mile 208.8) CS2 profile shows 3-4 feet of sedimentation along the traverse (Fig. 5-32). At Blacktail Canyon (mile 120.1) the bench mark for the beginning of CS2 is now buried under approximately 6 feet of sand, so much so that we were unable to dig it out in the time available. Parts of a few beaches are entirely gone, notably CS1 at 18-mile which has lost four feet of sand as the river eroded down to the loose talus rock floor beneath the beach (Fig. 5-1).

The beach at upper Granite (mile 93.2) has experienced both major erosion and major deposition from the 1983 high water. The inner beach has been built up 2 1/2 to 4 feet at both profiles whereas the outer beach has been removed and eroded back 10-20 feet (Figs. 5-15,16,). A few beach profiles such as those at Bedrock (mile 131), CS2 at Unkar (mile 72.2) and CS1 at Lower Lava (mile 180.9) show very minor to no change in topography.

In summary, of the beaches measured, 13 profiles on 8 beaches had only major increase or build up of beach sand and 3 profiles on 3 beaches had only major erosion or decrease in beach sand. Upper Granite (mile 93.2) experienced

TABLE 5-3. CHANGES RECOGNIZED IN BEACH PROFILES, 1983

Major Changes (several feet) — 3 Buildup (+)
Moderate Changes (1-2 ft.) — 2 Eroded (-)
Minor Changes (< 1 ft.) — 1

River Mile and Beach		Cross Section #	Buildup Outer Beach	Buildup Inner Beach	Eroded Down Outer Beach	Eroded Down Inner Beach	Remarks
L18.2	18-Mile Wash	1	3+	2+			7' sand buildup
		2			3-	2-	Deeply eroded
L19.3	19.-Mile Wash	1	2+		1-		
		2			2-	1-	
L34.7	Nautiloid	1	3+	3+			
		2	3+	3+			
R53.0	Nankoweap	2	?	1+		1+	Mostly under water
R61.8	Little Colorado	1	3+	2+			
L65.5	Tanner Mine	1	2+	2+			
		2	1+			2-	
L72.2	Unkar	1	3+	2+			
		2	1+			1-	Very minor change
L81.1	Grapevine	1	3+	1+			
		2	3+	3+			
L93.2	Upper Granite	1		3+	3-		
		2		3+	3-		
R109.4	109-Mile	1			?	?	Mostly under water
R112.2	Walthenberg	1			?	1-	Mostly under water
R120.2	Blacktail	1		2+	?		Buried Tamarisk
		2	?	3+			5' sand buildup
L122.8	Forster		2+	?			New Survey
R124.3	124½ Mile	2	?	2+			Mostly under water
R131.0	Bedrock	1	0	2+			½ under water
		2		1+		1-	½ under water
R151.6	Ledges	1				?	Mostly under water
R165.5	National	2				?	All under water
R180.9	Lower Lava	1	0	1+			Almost no change
		2		3+			1/3 under water
L209.8	Granite Park	1	2+	1+			
		2	3+	3+			

major buildup and major erosion of parts of the beach. Three beach profiles exhibit almost no topographic change and 3 beaches were still too submerged to adequately measure. On balance it appears that loss of beach sand by erosion was more than compensated for by addition of beach sand by deposition on the higher and inner parts of the beaches (Fig. 5-34).

DISCUSSION

It appears that most of the topographic changes in beach profiles can be attrributed to the 1983 high water. A comparison of profiles CS2 at 19-mile, CS2 at Grapevine (81.1), CS2 at Upper Granite (93.2), CS2 at Blacktail (120.1), and CS2 at Lower Lava (180.9) indicates that between 1974 or 1975 and 1980-82 the beach topography remained almost unchanged, whereas significant changes show up when the 1983 profile data are compared with those of previous years. One exception to that is CS2 at Granite Park (208.8). Here the 1982 profile showed an 8-foot retreat of the outer beach shoreface between 1974 and 1982 but the 1983 profile indicates a major buildup of beach sand (3-4 feet higher and 15-20 feet riverward) between 1982 and 1983.

What is the source of sand for the major beach buildups observed? Most sediment transported by the Colorado River is now settled out in Lake Powell before the river enters Grand Canyon. Downstream tributaries such as the Paria River, Little Colorado, and Kanab Creek supply some additional sand but probably only about 10% of the amount carried through Grand Canyon by the river before Glen Canyon dam. The river must be redistributing the sand from the existing beaches. The sand supply may be locally augmented by sediment from tributaries, flash floods, and perhaps by reeentraining sand that had accumulated on the river bed. It seems likely that the total sand supply in the river corridor through Grand Canyon must eventually be reduced from the present level to some lesser amount as sediment transport continues, especially during high water "spills." Research currently underway by the U.S. Geological

Survey at five sampling sites within Grand Canyon and Marble Canyon should provide more quantitative data regarding the sediment transport regimen of the river.

It is clear that the high water "spill" releases in 1983 have significantly altered many of the campsite beaches in Grand Canyon. What is not so clear is the long range effects of such high water releases and the subsequent operation of other processes on the new sand surfaces now present on all the beaches. The newly deposited higher level beach sands are mainly fine to very fine grained and are somewhat unstable and easily subject to erosion by natural processes and trampling by campers. At three beaches where newly deposited sands had constructed additional higher level campsite areas--Nautiloid (34.7), Anasazi Bridge (45.3) and upper Unkar (72.2)--flash floods had removed a substantial portion of the new and old beaches between August 1, 1983, and September 16, 1983, when we observed and photographed them again (Figs. 5-33A,B).

CONCLUSIONS

Change in Grand canyon beaches is inevitable whether by natural erosion processes, variation in high and low water releases from Glen Canyon dam or activities of campers. Future high water "spills" can be expected to provide ther most significant rapid changes in the beaches. These changes will involve flooding of the campsite areas together with additional deposition on some beaches and erosion on others. Flash floods from tributary canyons can also produce rapid changes locally. The slower processes of wind deflation, rain wash and heavy campsite use may be expected to have a gradual wearing away effect on the beaches. The long range effects of these processes will be cumulative and may be expected to eventually result in a net loss of sand in the river corridor of Grand Canyon.

RECOMMENDATIONS

1. The 20 beaches originally surveyed should be monitored by profile measurements for several more years, particularly following major events such as flash floods and high water "spills."

2. Some of the original 20 beaches and some additional campsite beaches having heavy camper use should by monitored by topographic profiles selected to coincide with or cross sites of heavy foot traffic associated with camping activities.

3. Some selected campsite beaches should be mapped carefully by plane table methods and checked frequently to assess more quantitatively the net gain or loss of beach sand through time.

4. Further examination should be made of bed rock, canyon topography and river currents associated with selected beaches to assess the question of why some beaches were eroded and others significantly built up by the 1983 high water.

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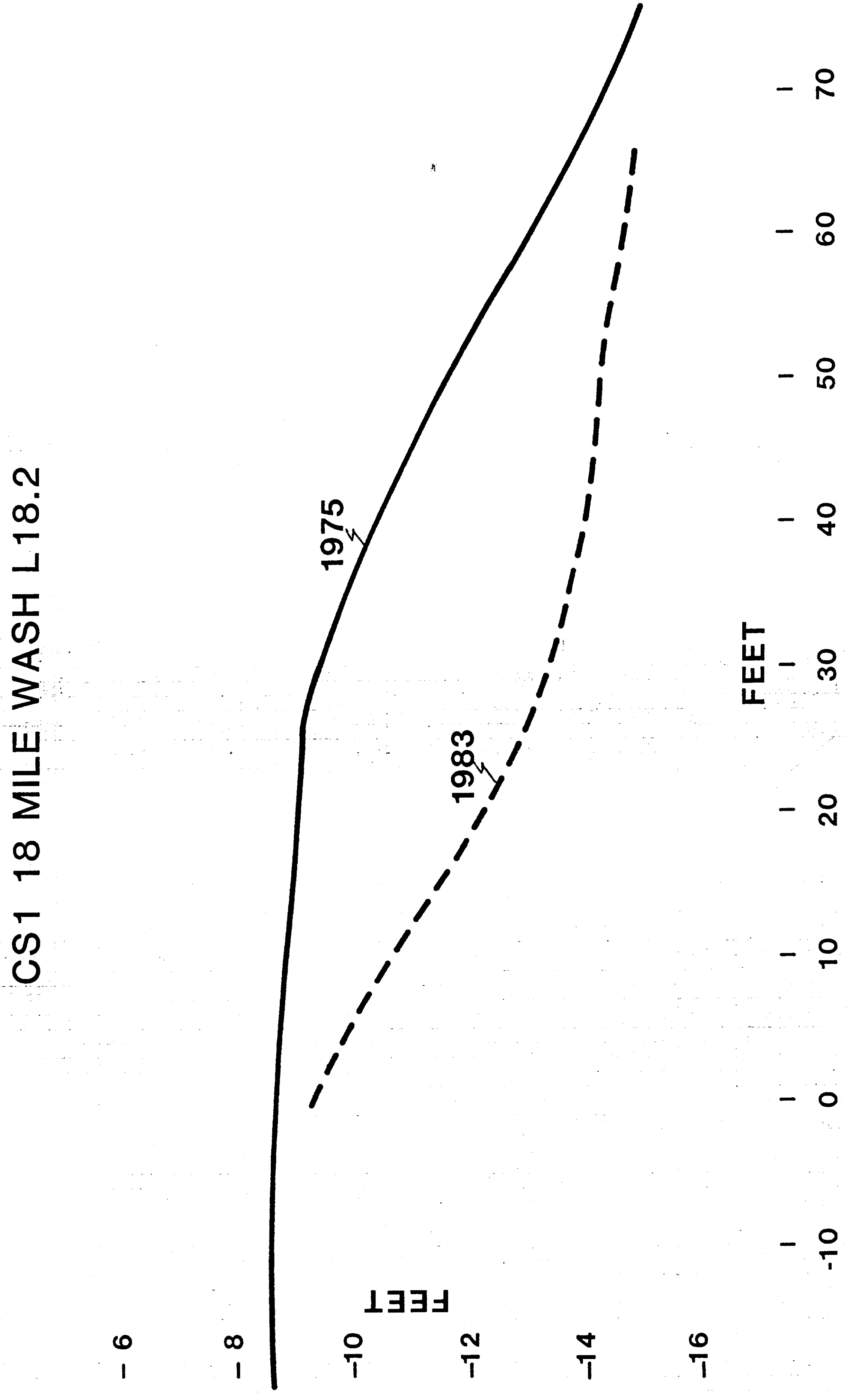

Figure 5-1. Beach cross-section profile 1 at 18-mile Wash

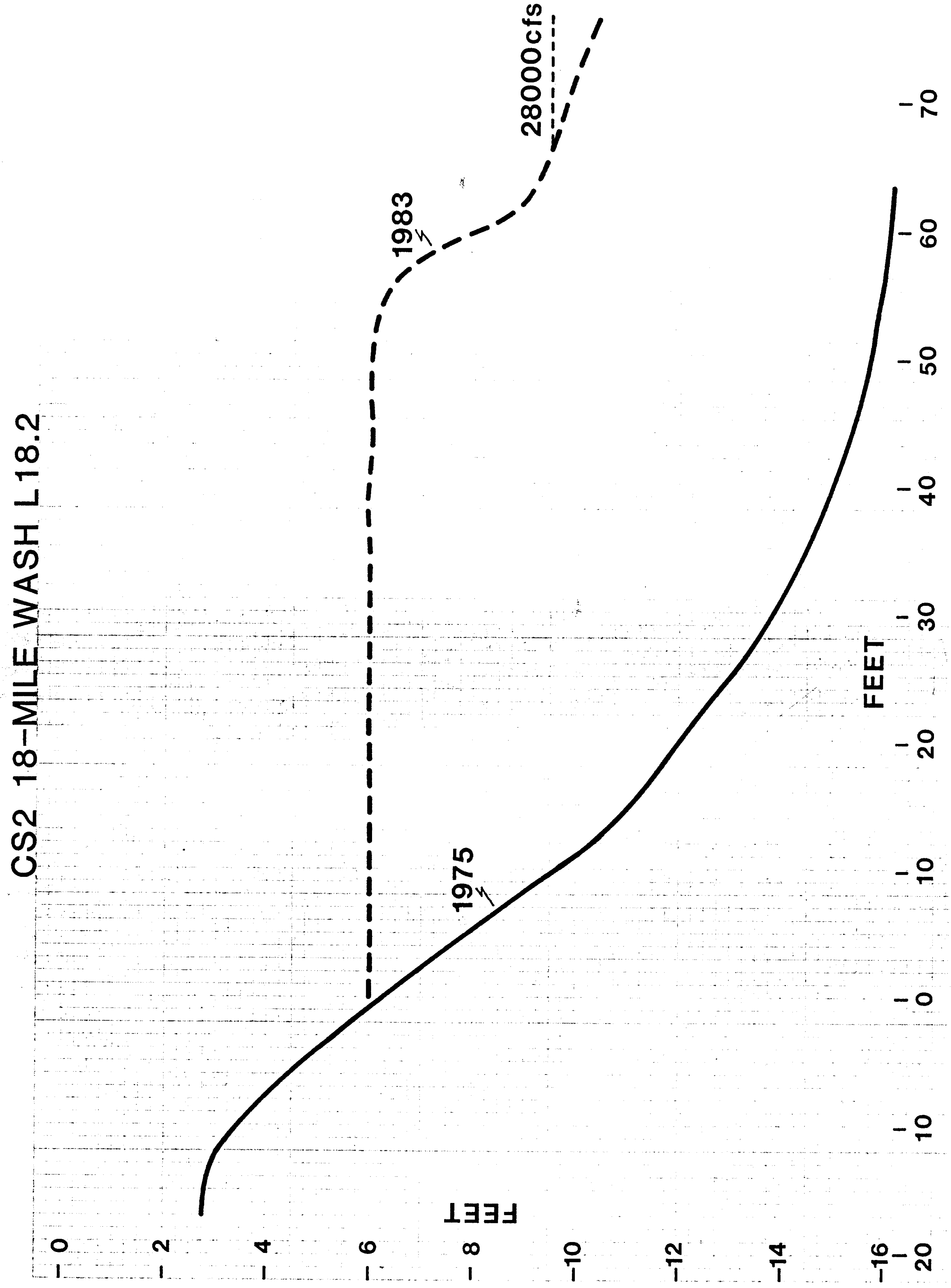

Figure 5-2. - Beach cross-section profile 2 at 18-mile Wash

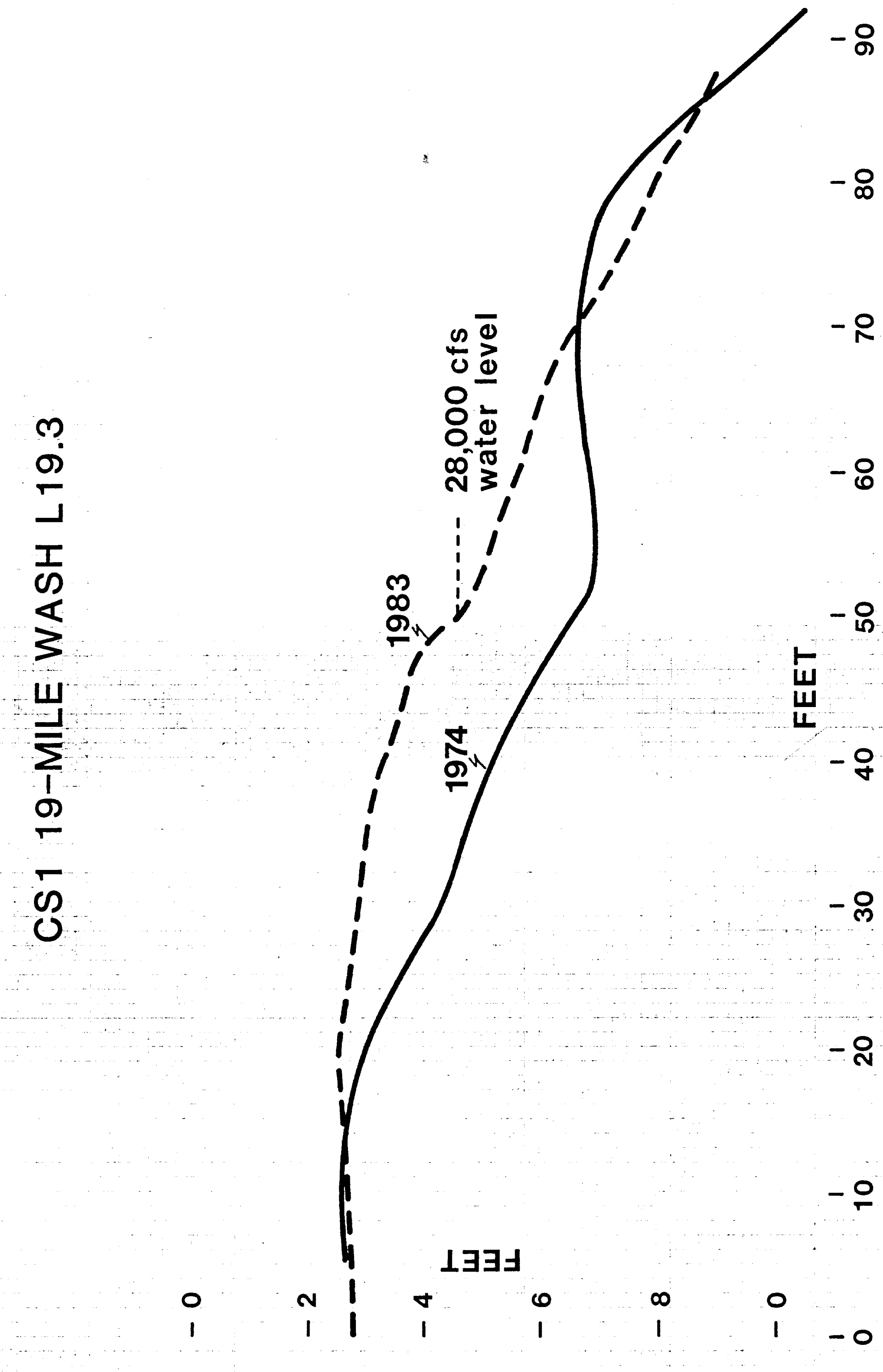

Figure 5-3. Beach cross-section profile 1 at 19-mile Wash

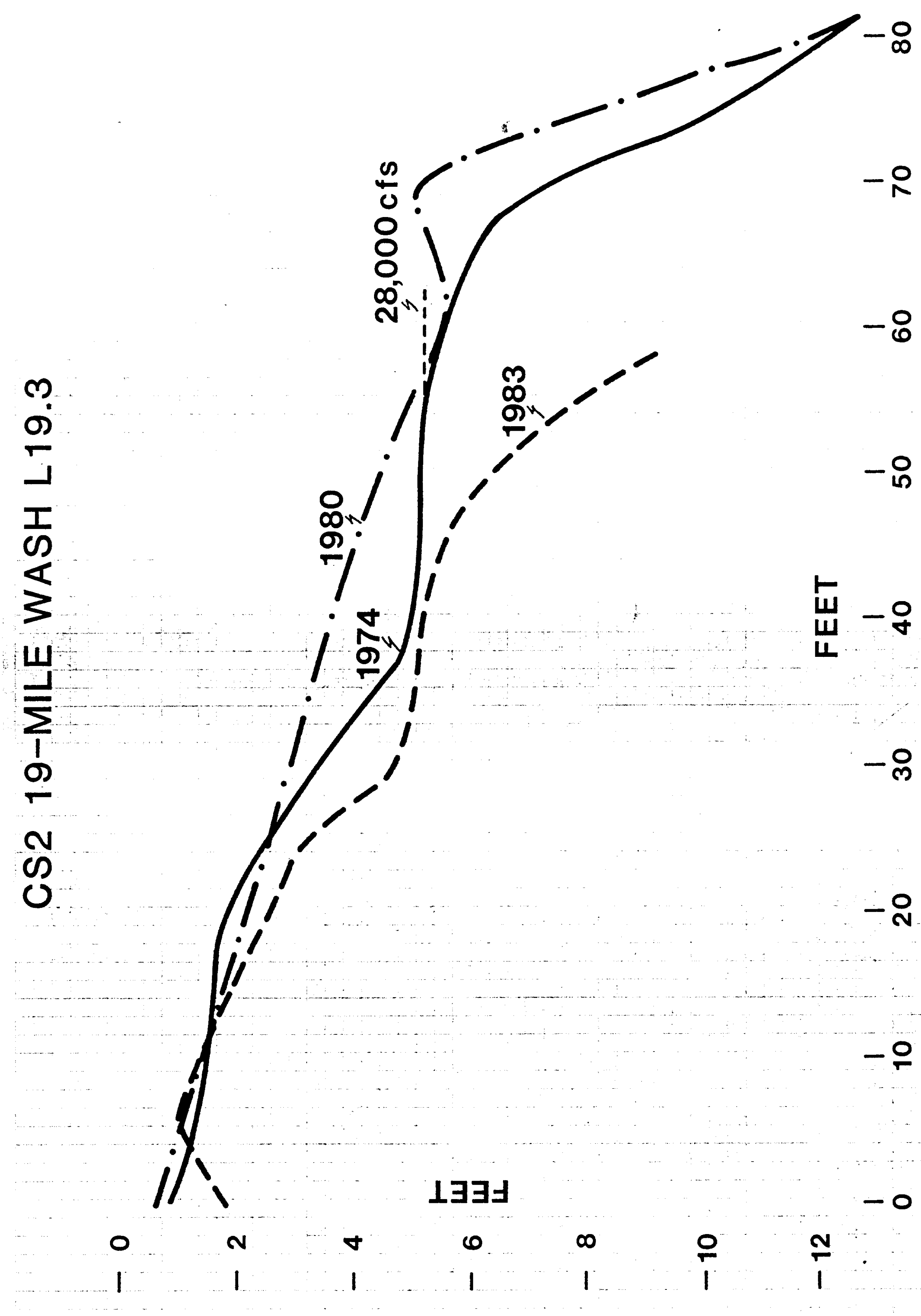

Figure 5-4. Beach cross-section profile 2 at 19-mile Wash

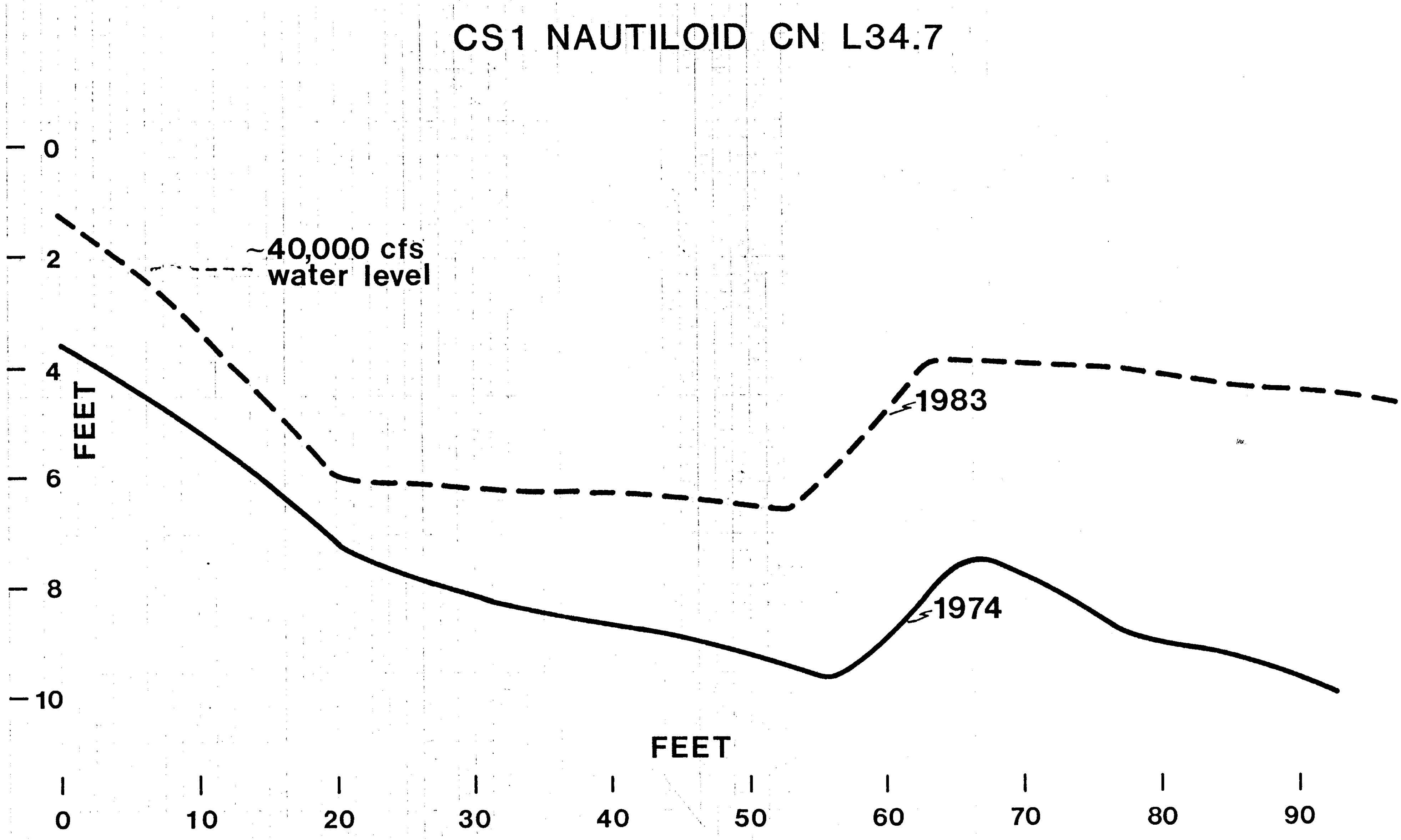

Figure 5-5. Beach cross-section profile 1 at Nautiloid Canyon

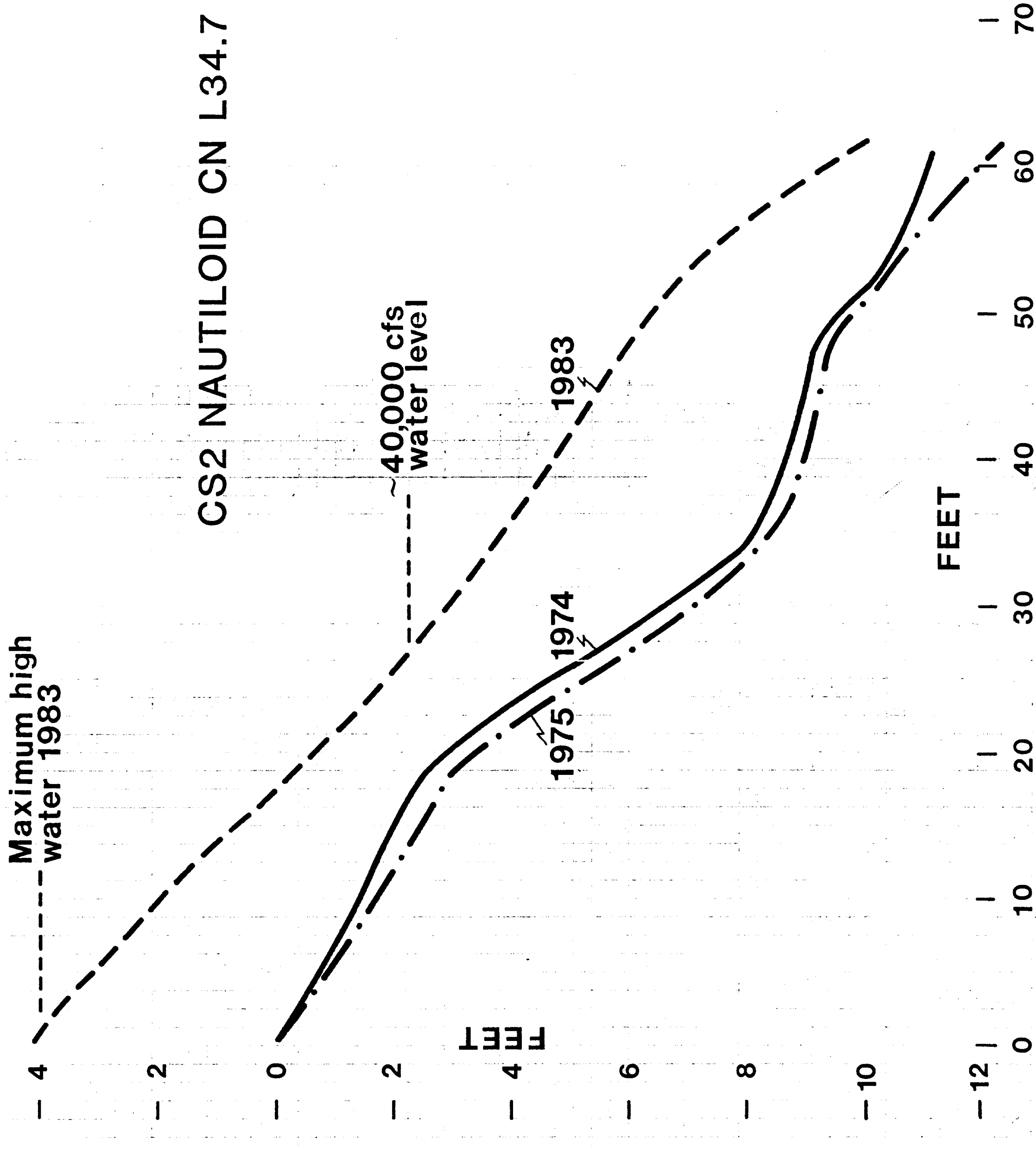

Figure 5-6. Beach cross-section profile 2 at Nautilo-d Canyon

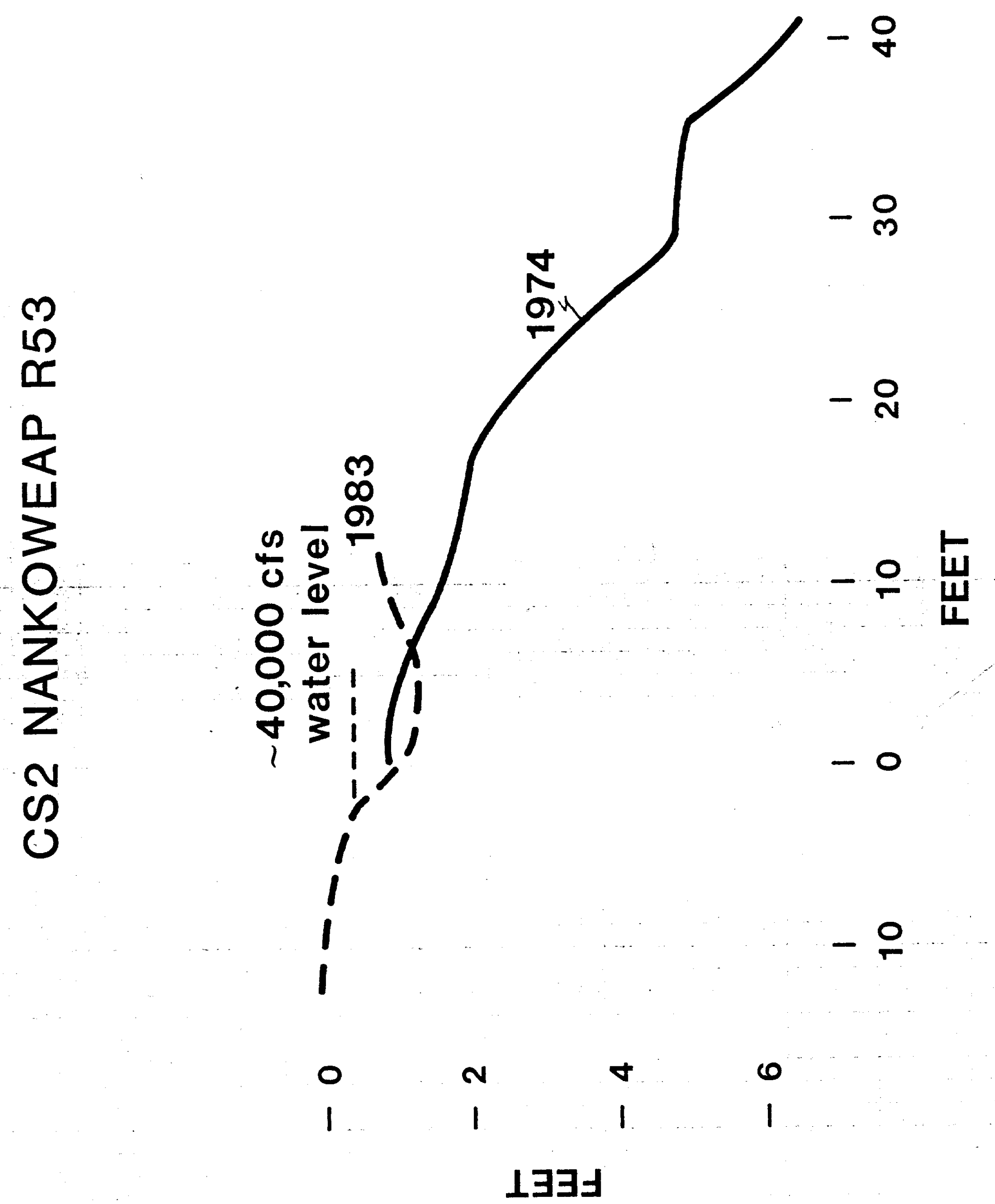

Figure 5-7. Beach cross-section profile 2 at Lower Nankoweap

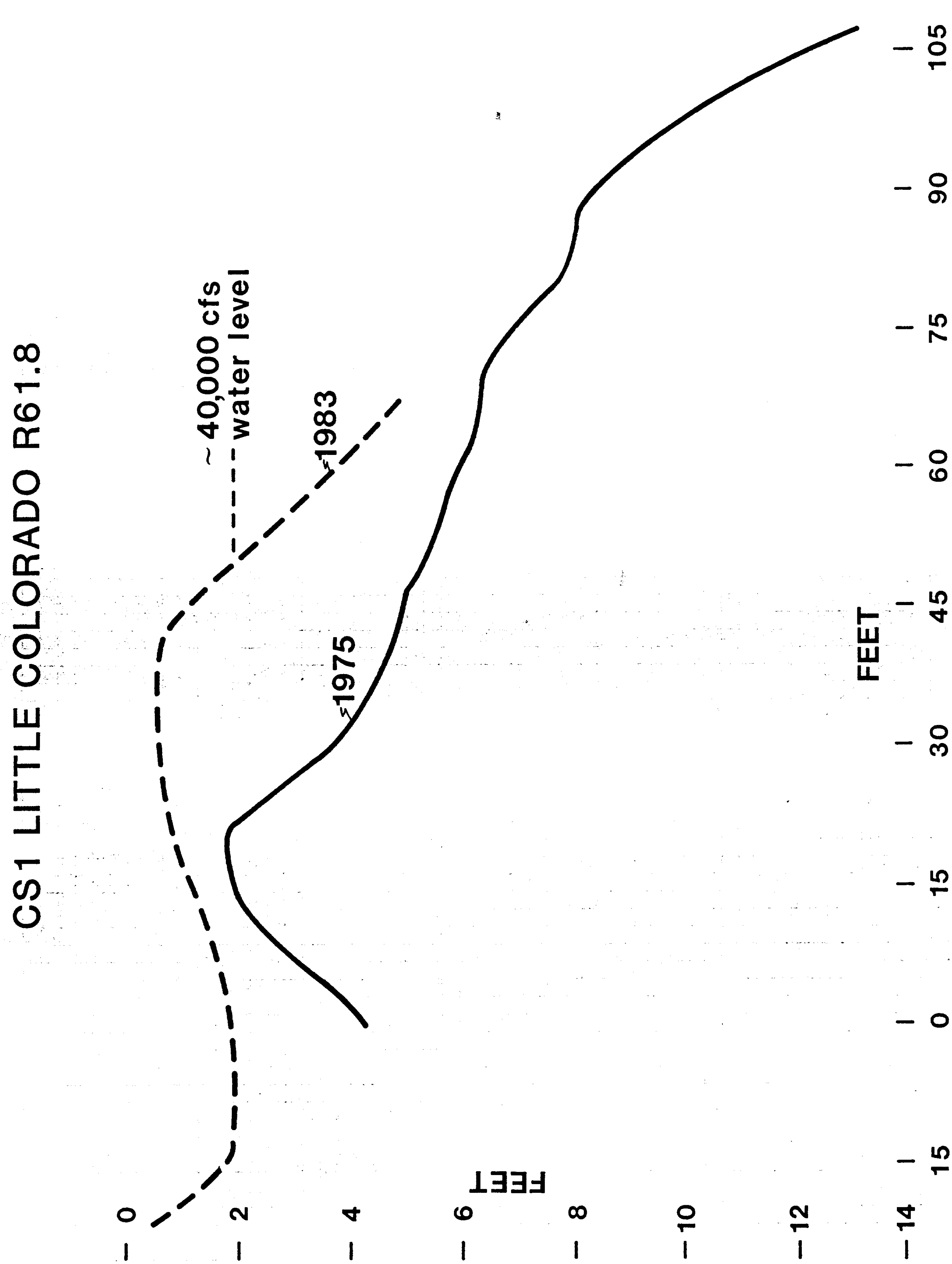

Figure 5-8. Beach cross-section profile 1 at Little Colorado

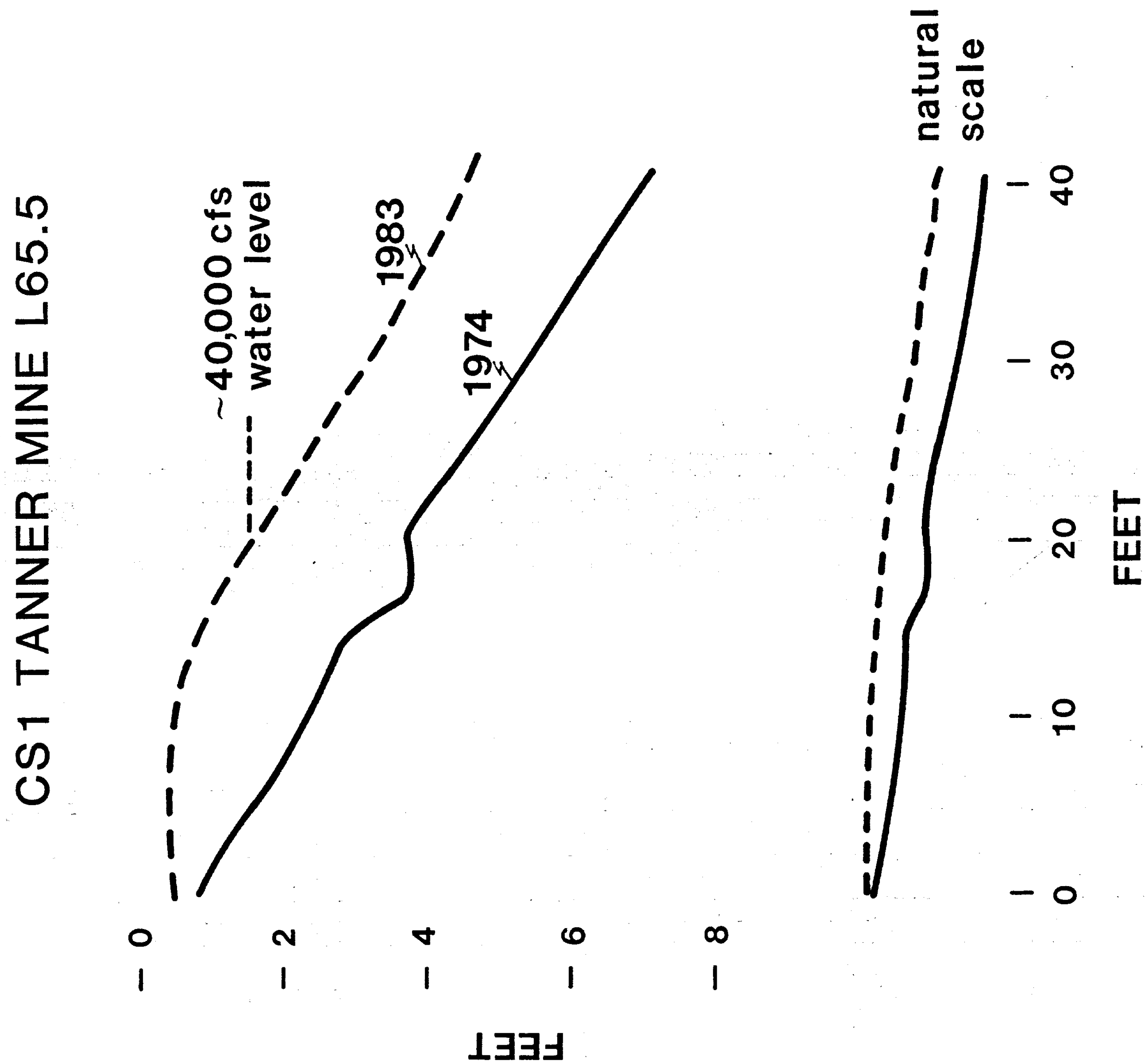

Figure 5-9. Beach cross-section profile 1 at Tanner Mine

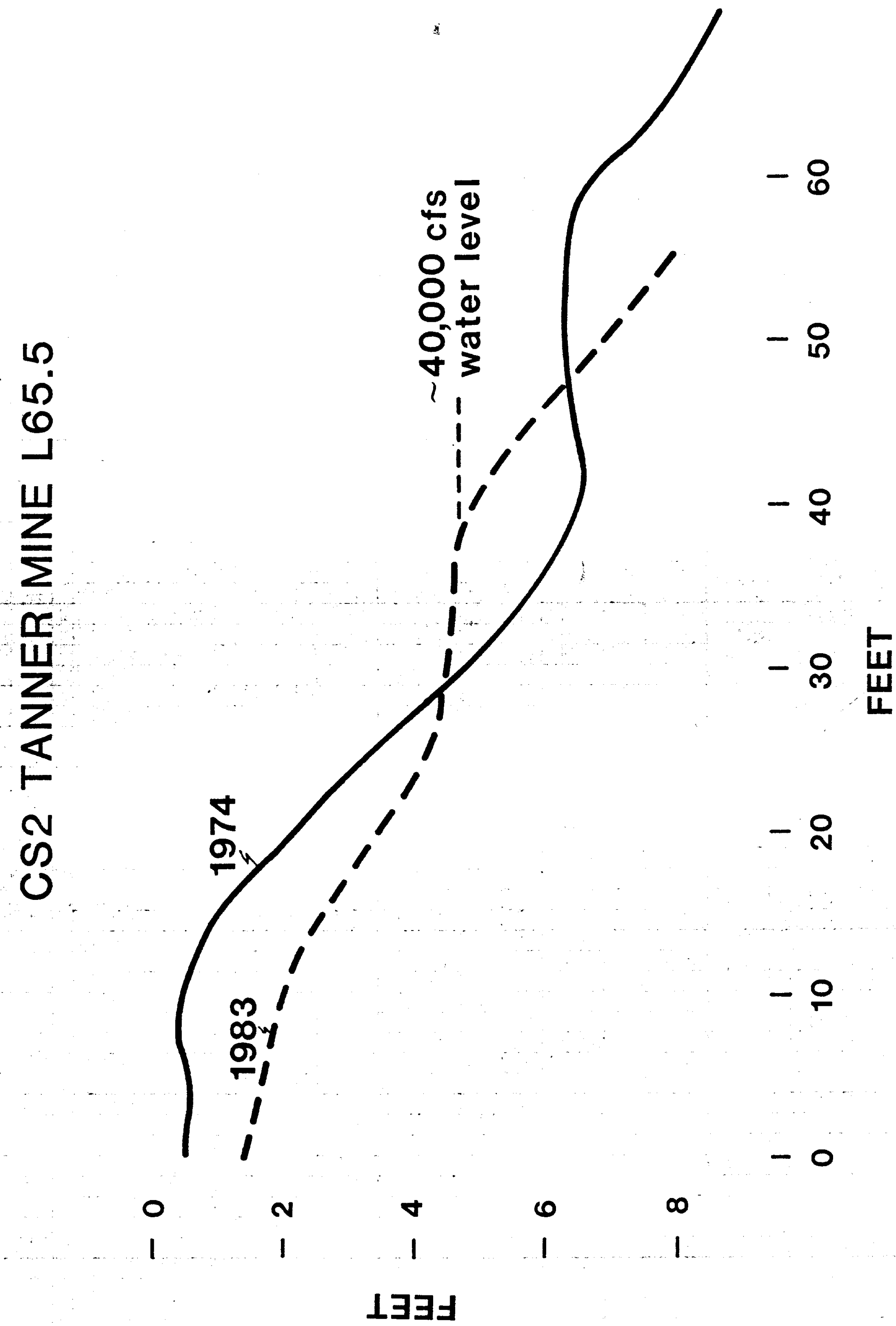

Figure 5-10. Beach cross-section profile 2 a Tanner Mine

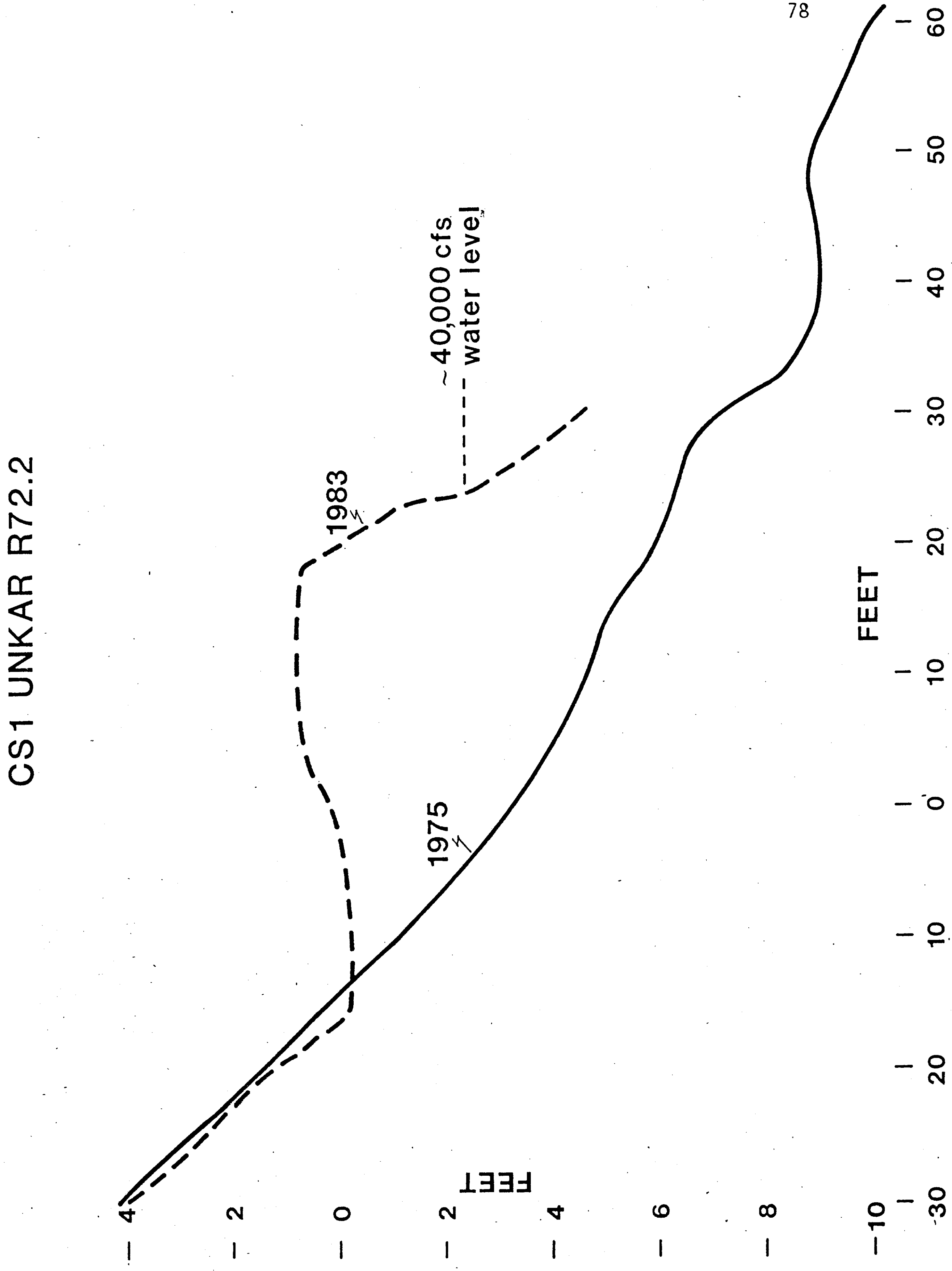

Figure 5-11. Beach cross-section profile 1 at Unkar

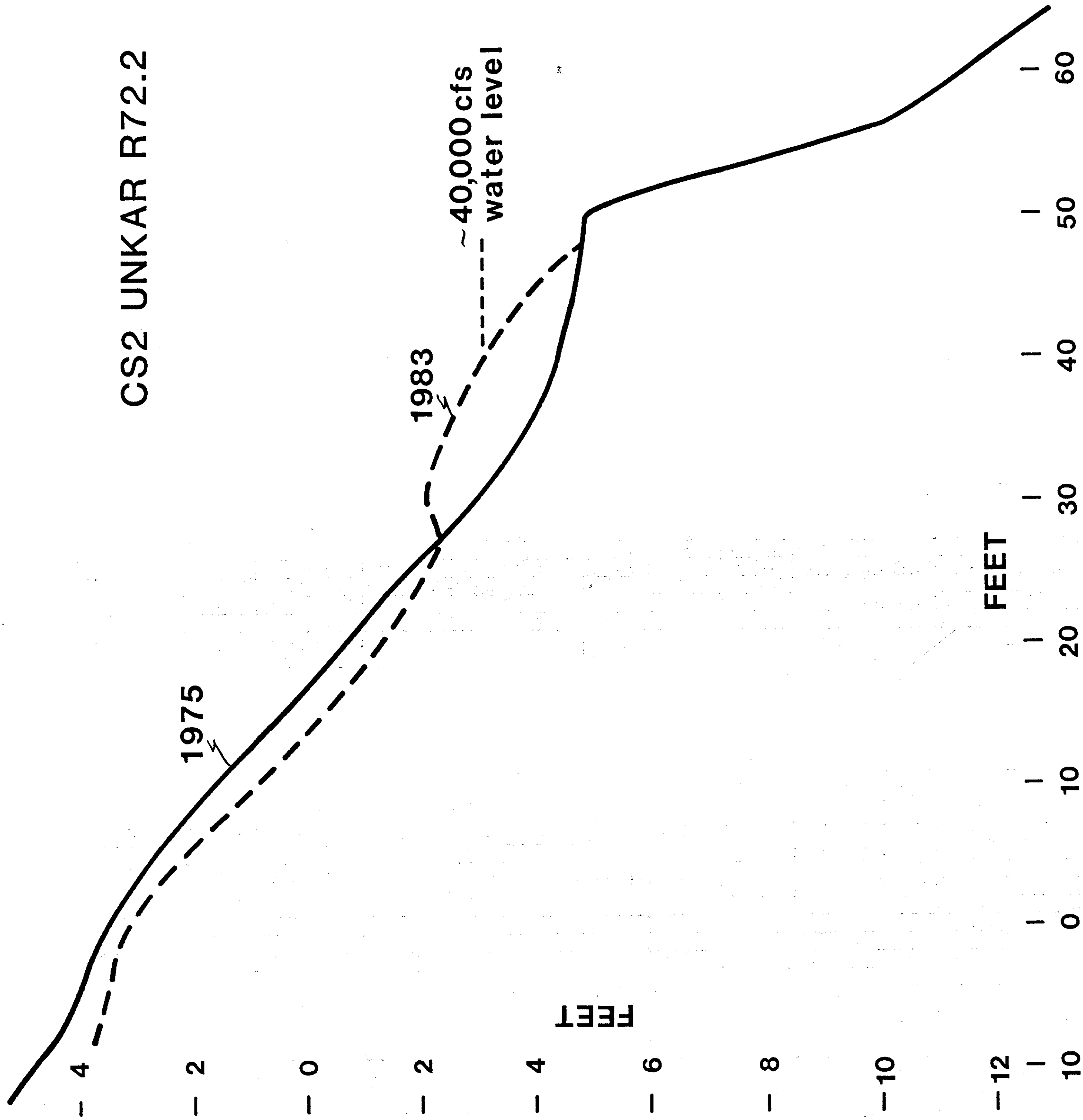

Figure 5-12. Beach cross-section profile 2 at Unkar

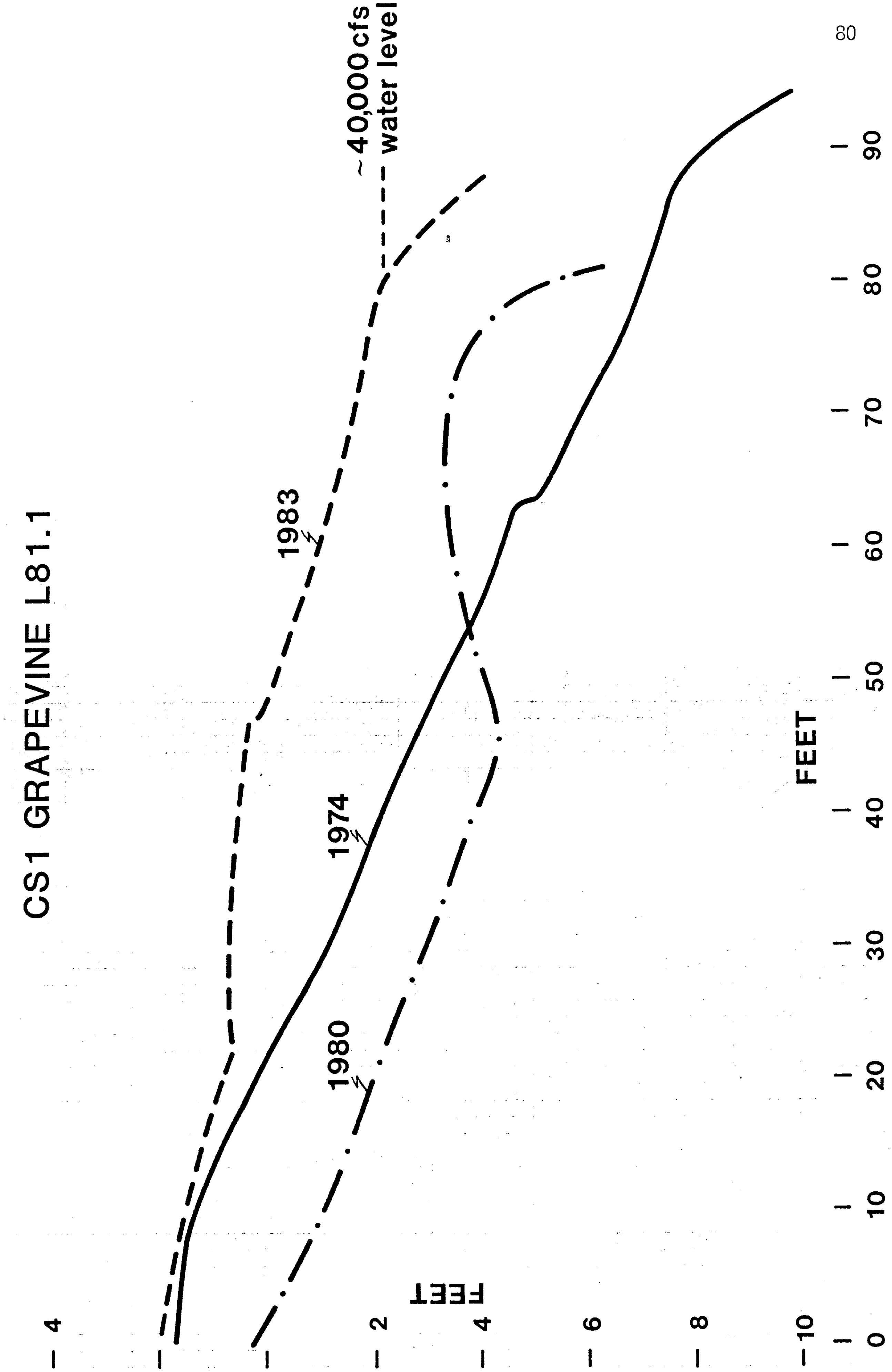

Figure 5-13. Beach cross-section 1 at Grapevine rapids

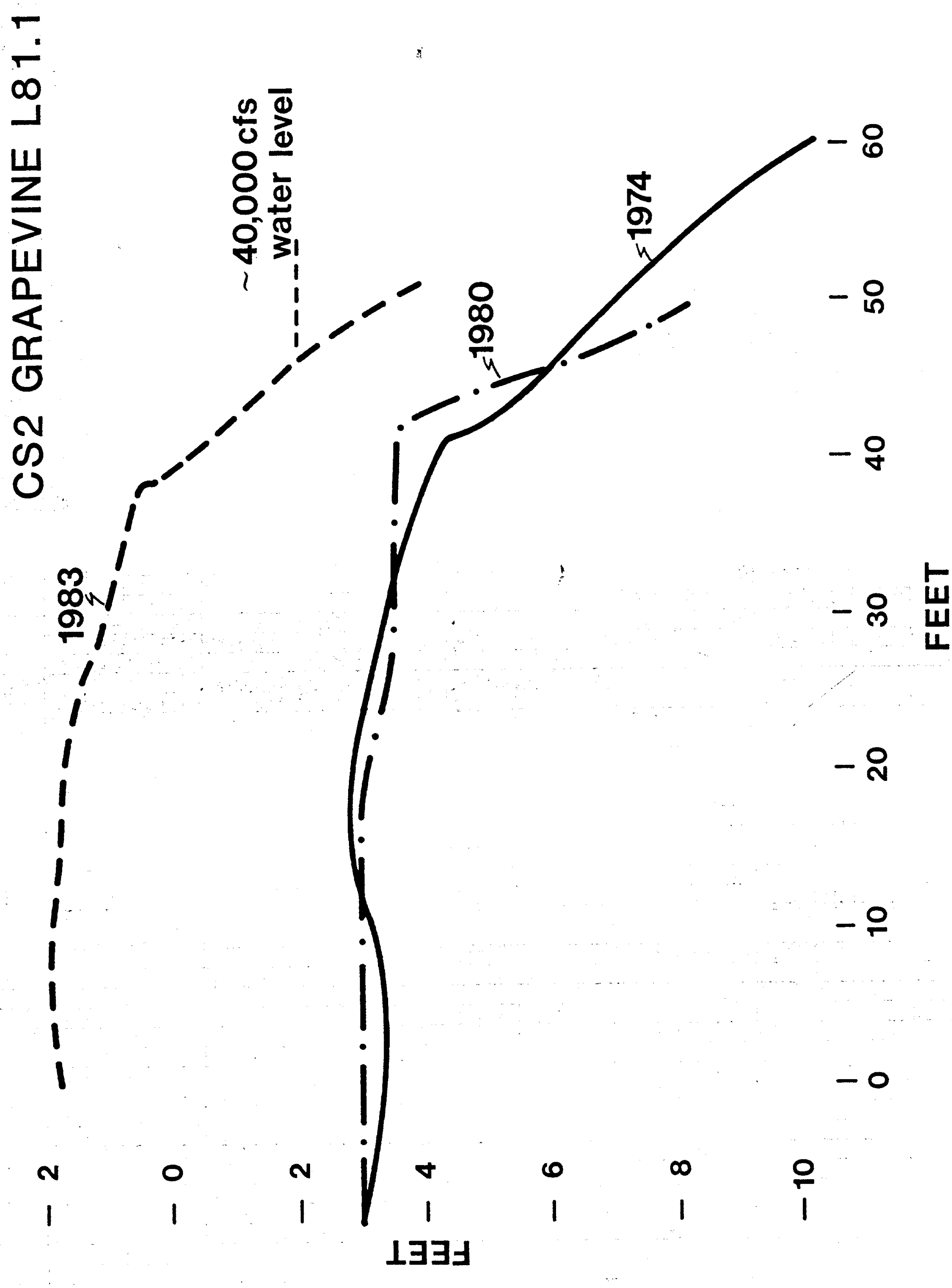

Figure 5-14. Beach cross-section profile 2 at Grapevine Rapids

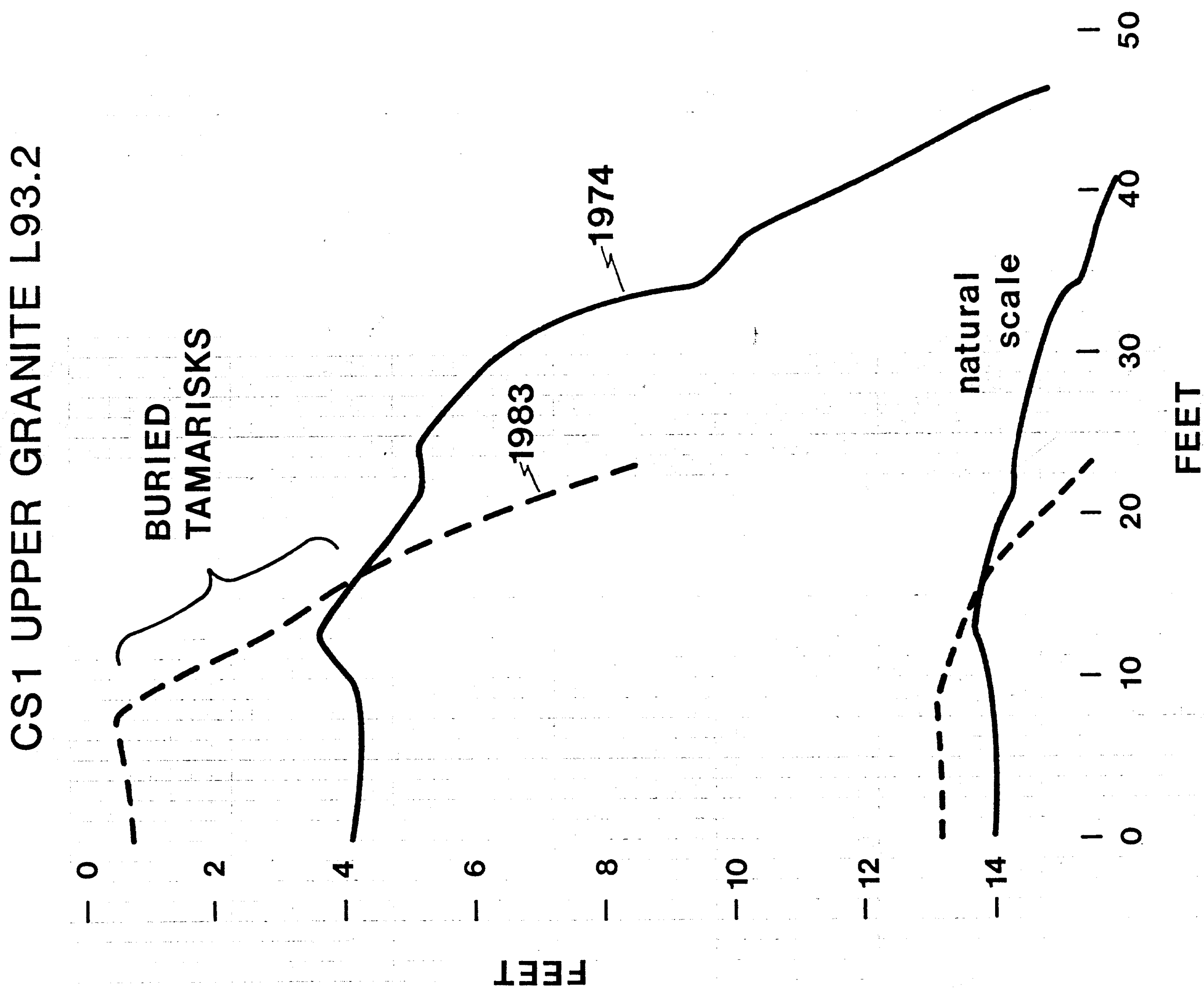

Figure 5-15. Beach cross-section 1 at Upper Granite

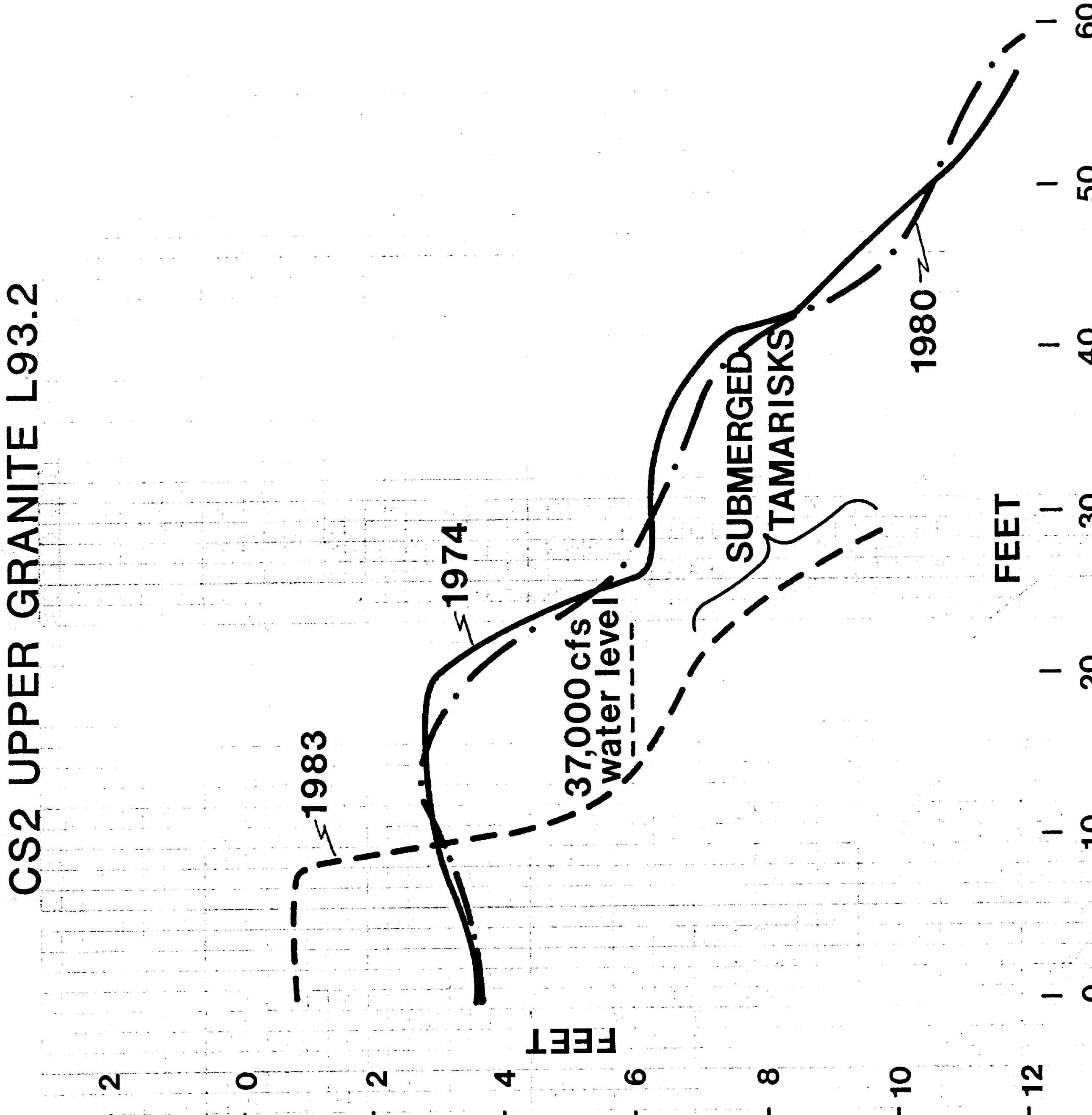

Figure 5-16. Beach cross-section 2 at Upper Granite

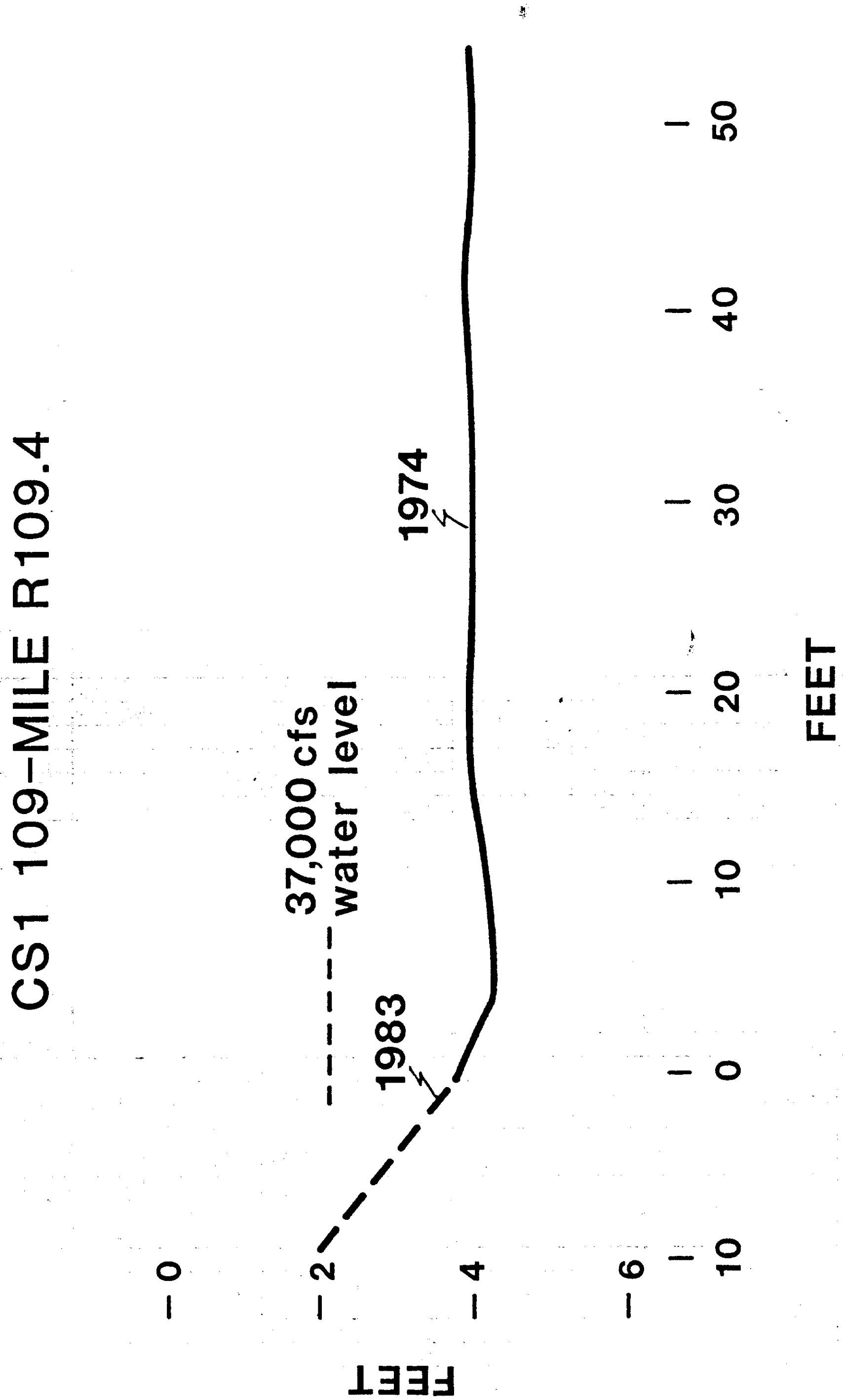

Figure 5-17. Beach cross-section profile 1 at 109-Mile

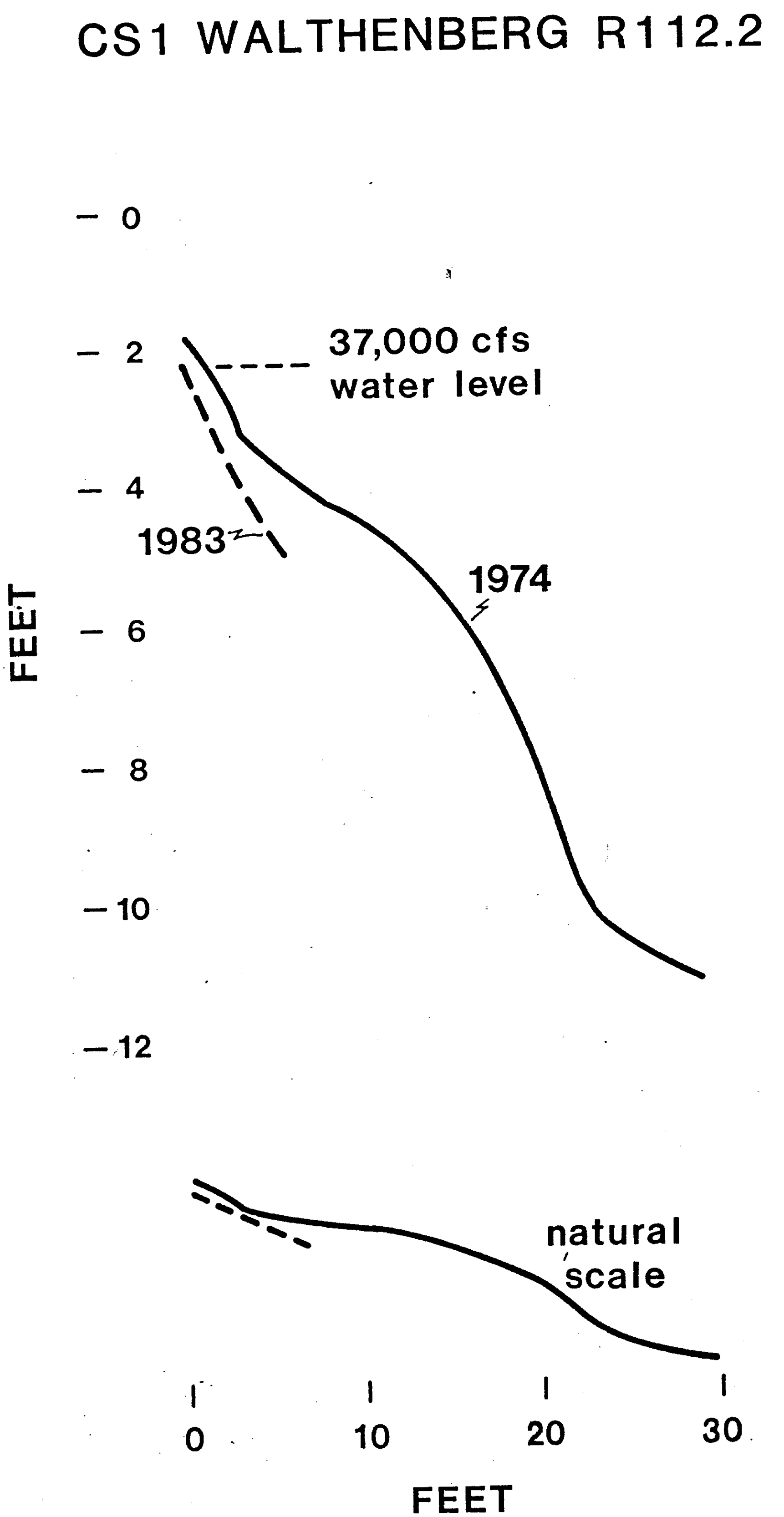

Figure 5-18. Beach cross-section profile 1 at Walthenberg

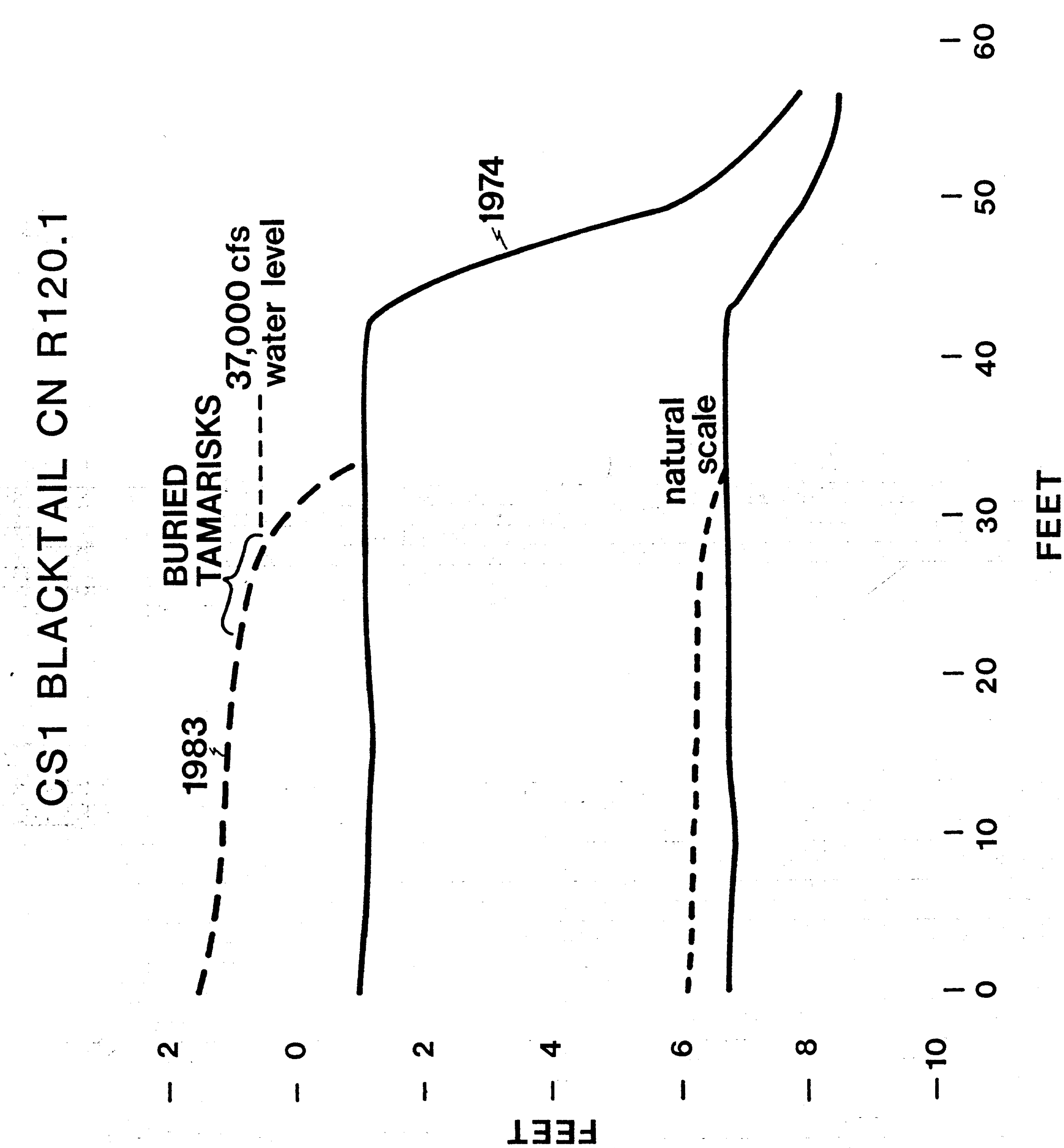

Figure 5-19. Beach cross-section profile 1 at Blacktail Canyon

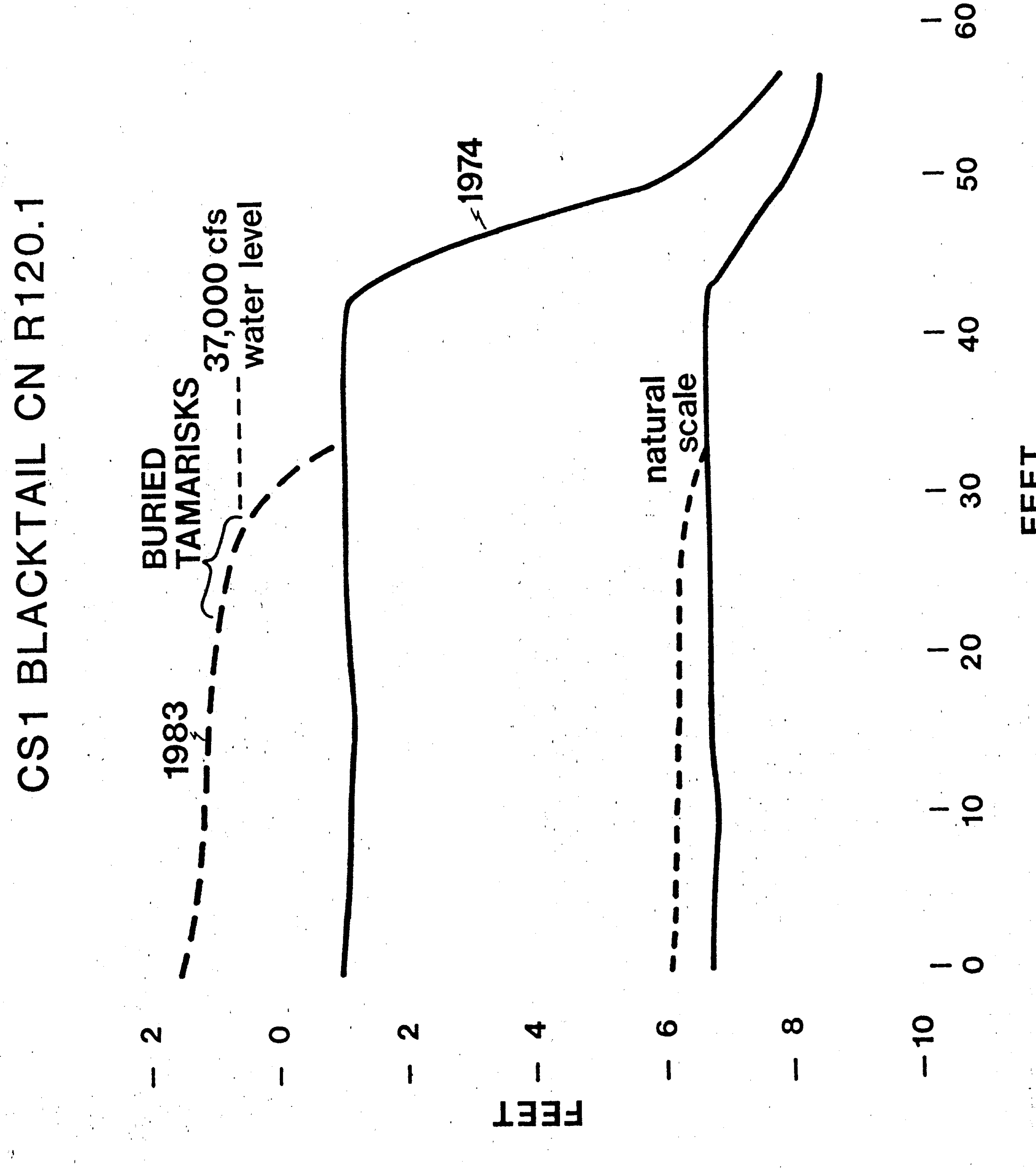

Figure 5-19. Beach cross-section profile 1 at Blacktail Canyon

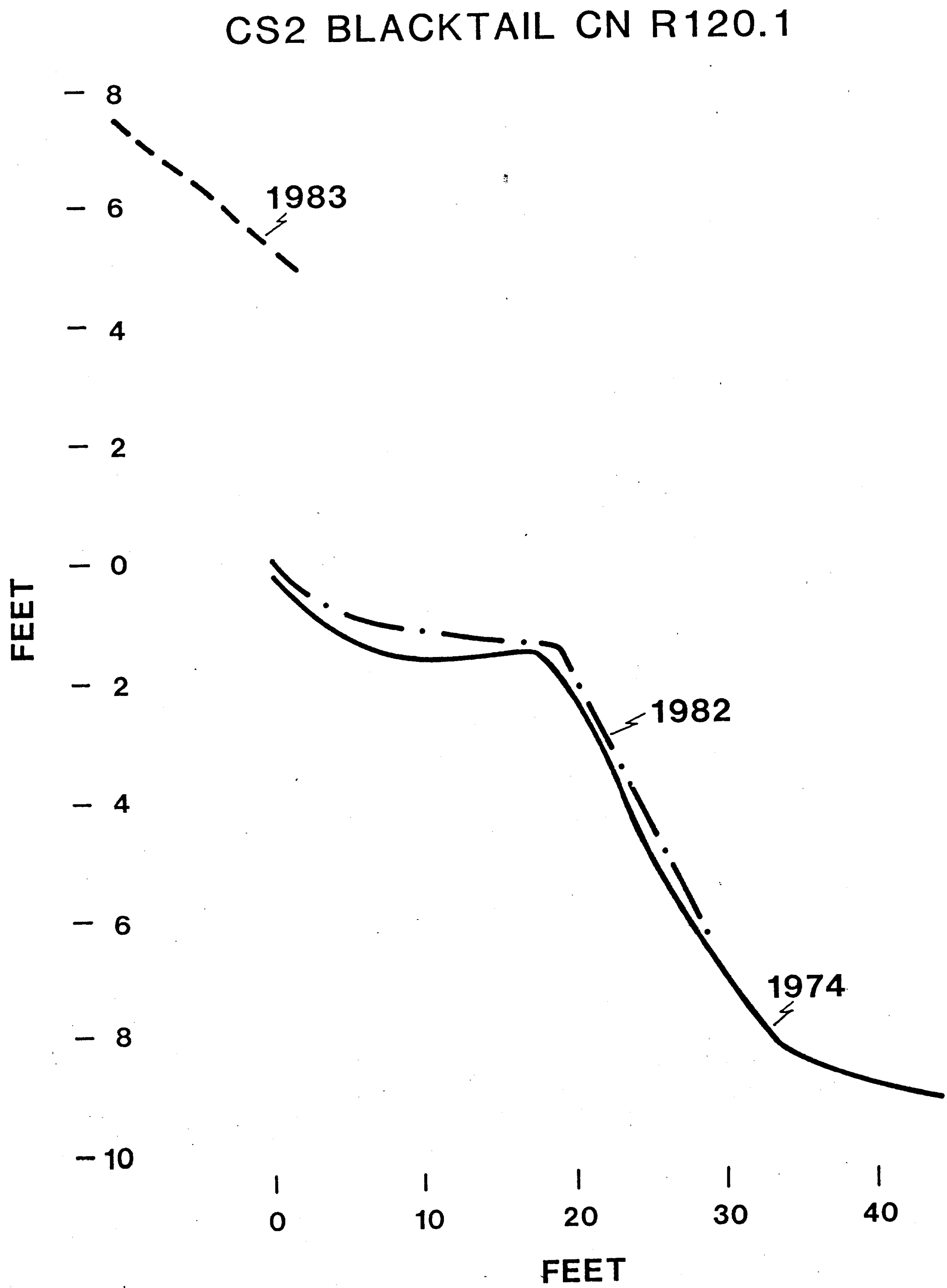

Figure 5-20. Beach cross-section profile 2 at Blacktail Canyon

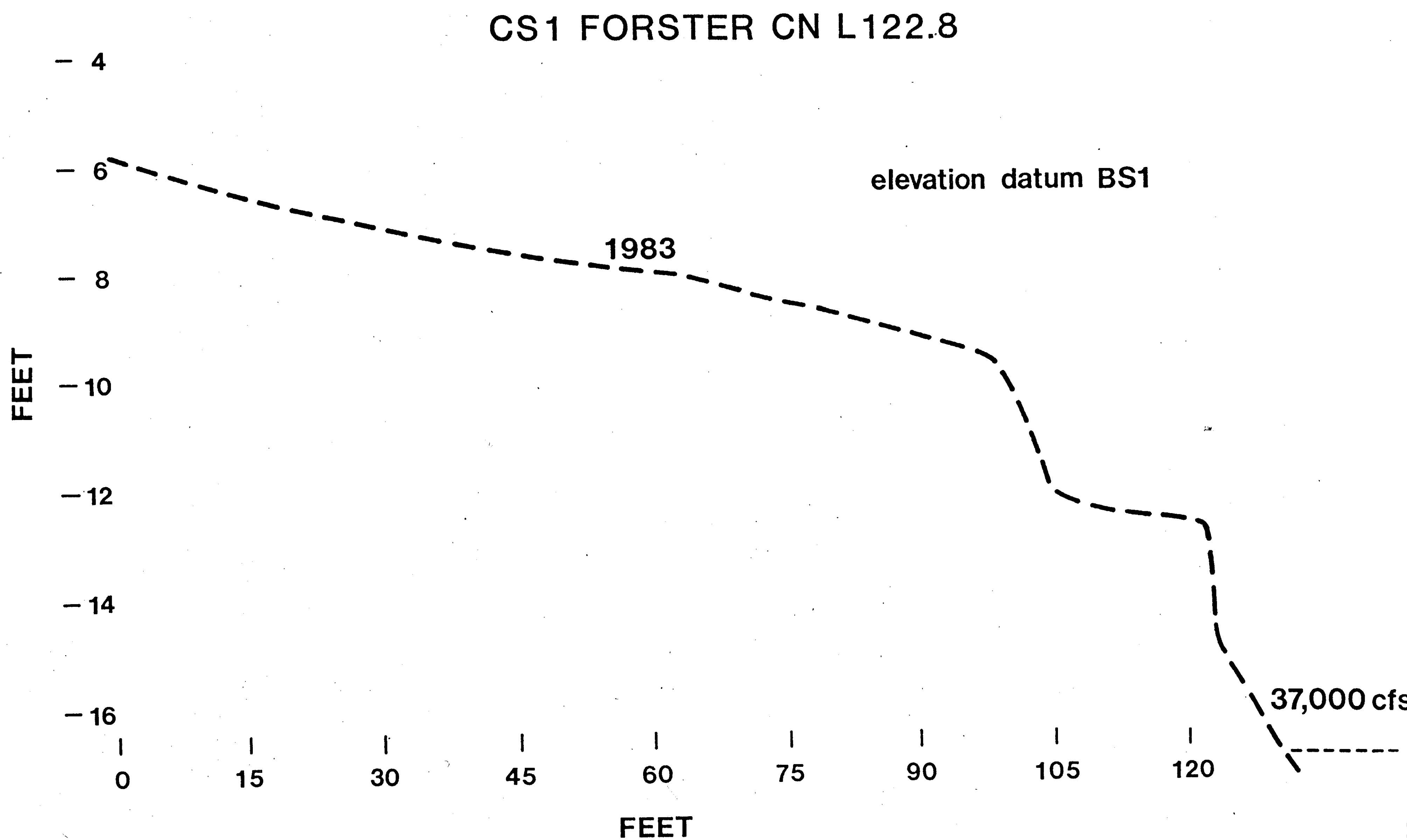

Figure 5-21. Beach cross-section profile 1 at Forster Canyon

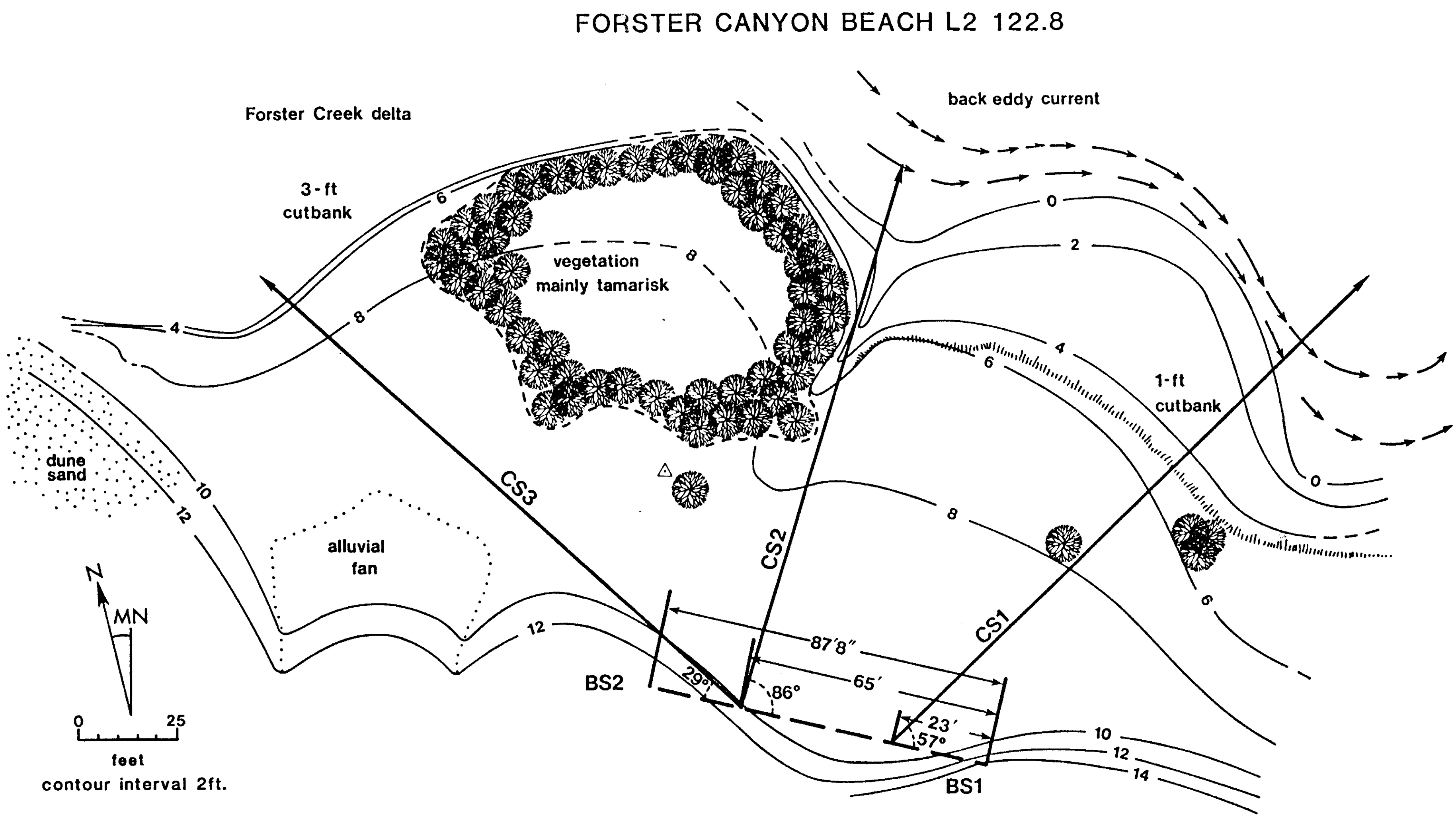

Figure 5-22. Plane Table Map of Forster Canyon Beach, August 1983.

BEACH PROFILE LOCATION SHEET

~~Fossil Rapids~~ Fonster Creek

Date established Aug. 4, 1983 Mile L 122.8

Base station #1 Tan pitted Limestone boulder — Photo ✓ — Perm. mark Spike

Base station #2 Tan bedded boulder — Photo ✓ — Perm. mark Depression at high point of rock

Base Station #3 ________ — Photo ________ — Perm. mark ________

Elevation datum BS 1 - Spike — Photo # ________

Length of base line #1 87' 8" from BS1 to BS2
Base line orientation S 78½°E from BS1 to BS2

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

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

Cross section #1: 23' from BS1 toward BS2
at an angle of 57° (counter) clockwise from direction of BS1

Cross section #2: 63' from BS1 Toward BS 2
at an angle of 53° (counter) clockwise from direction of BS1

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

Comments New beach Surface 1983

CROSS-SECTION DATA SHEET

MILE: 122.8 L

CAMPGROUND NAME: Forster Canyon

CROSS-SECTION NUMBER: 1

SURVEY DATE: Aug. 4, 1983

ORIGINAL SURVEY? ✓

RESURVEY NUMBER:

FROM	TO	ROD READING Feet	DISTANCE Feet/Inches	ANGLE Degrees	COMMENTS
CS1	HI	4.56			
	BS1	0	23'0"	+3°17'	Datum
	Std. 1	5.45	19.9"		
	2	6.72	64'0"		
	3	8.40	98' 10½"		Top of break in Slope
	4	10.66	105'1"		
	5	11.42	121'10"		
	6	11.00	123'4"	-1°5'	
	7	11.00	129'8"	-2°4'	Waters edge ~ 37,000 cfs
	8	11:00	155'4"	-3°0'	
	9	11:00	186'3½"	-4°4'	

Comments:

CROSS-SECTION DATA SHEET

MILE: 122.8 L
CAMPGROUND NAME: Forster Canyon
CROSS-SECTION NUMBER: CS 2
SURVEY DATE: August 4, 1983
ORIGINAL SURVEY? ✓
RESURVEY NUMBER:

FROM	TO	ROD READING Feet	DISTANCE Feet/Inches	ANGLE Degrees	COMMENTS
CS2	HI	4.63	–		Instrument Ht.
"	BS1	0.27	63'0"		Elevation datum
	1	5.74	5'10"		Dune-beach boundary
	2	6.20	32'9½"		
	3	6.63	67'8½"		Top of gully
	4	9.08	86'0"		Bottom of gully
	5	7.10	90'1½"		
	6	8.82	102'7½"		
	7	10.79	107'0"		
	8	11.45	125'¾"		
	9	10.00	127'4½"	−2°10'	Water edge ~ 37,000 cfs
	10	~~14.41~~ 10.00	144'1"	−3°7'	
	11	10.00	178'6½"	−3°	
CS3	HI =	4.63	Same position as CS2		
	1	8.04	151'7"		Top edge of cutbank
	2	10.94	154.1		Top of old beach sfc in cutbank
	3	11.00	156'1½"	−0°35'	Base of cutbank
	4	11.00	169'7½"	0°33'	On stream bed
	5	6.21	100'0"	0	flat beach surface

Comments: CS2 is at an old high water mark
1983 high water mark is 7' South 4' above CS2

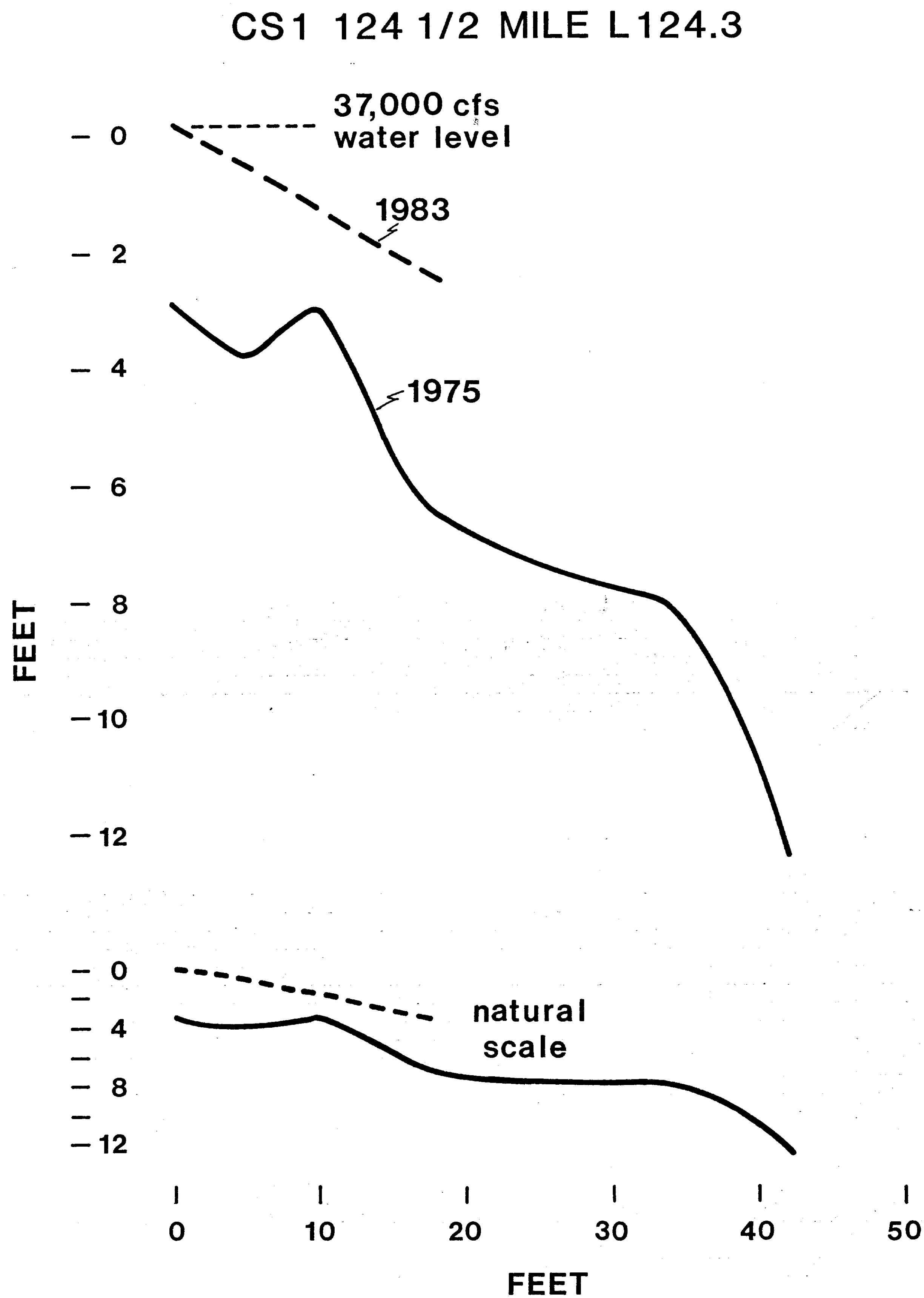

Figure 5-24. Beach cross-section profile 2 at 124 1/2-Mile Canyon

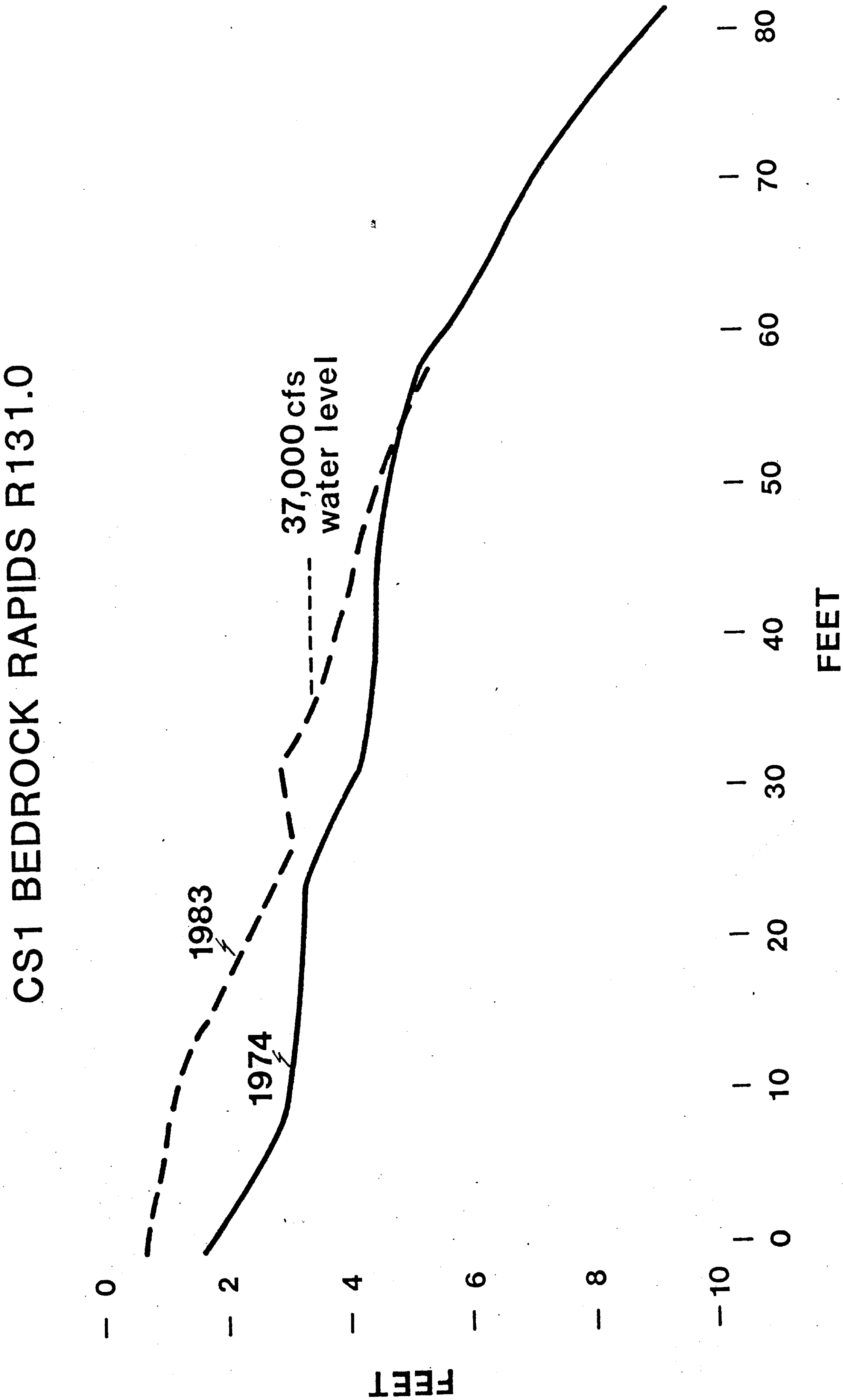

Figure 5-25. Beach cross-section profile 1 at Bedrock Rapids

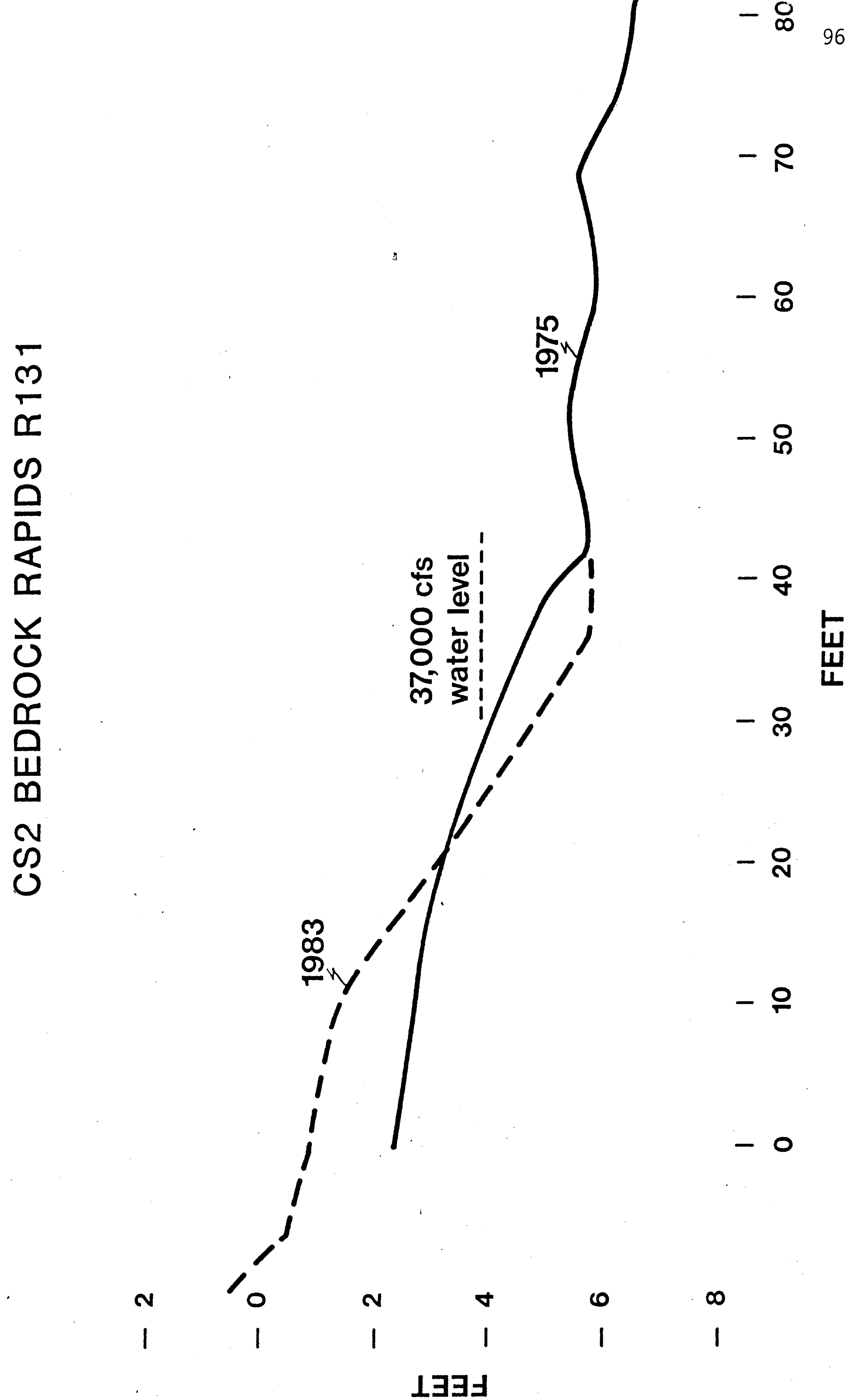

Figure 5-26. Beach cross-section profile 2 at Bedrock Rapids

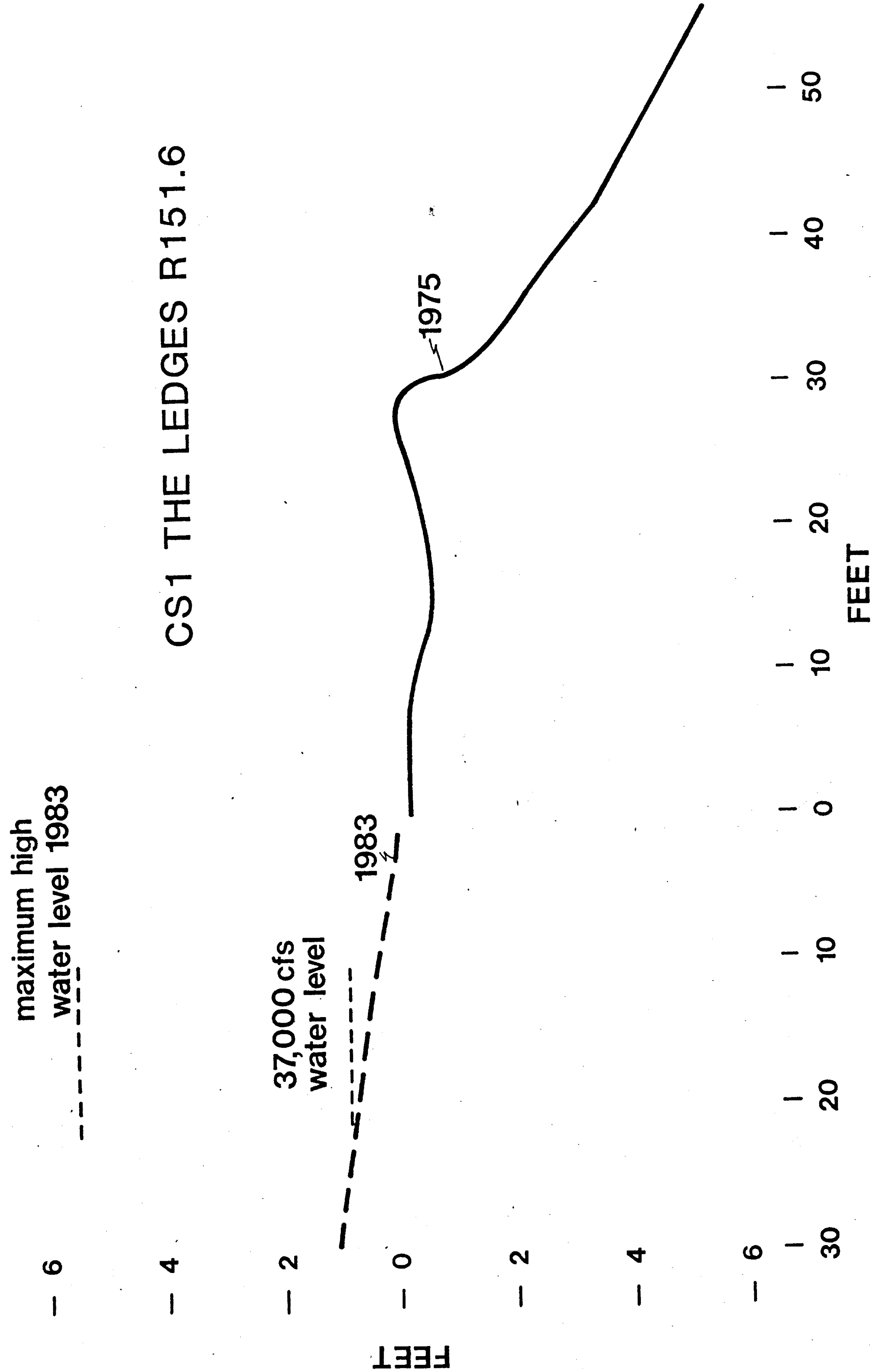

Figure 5-27. Beach cross-section profile 1 at the Ledges

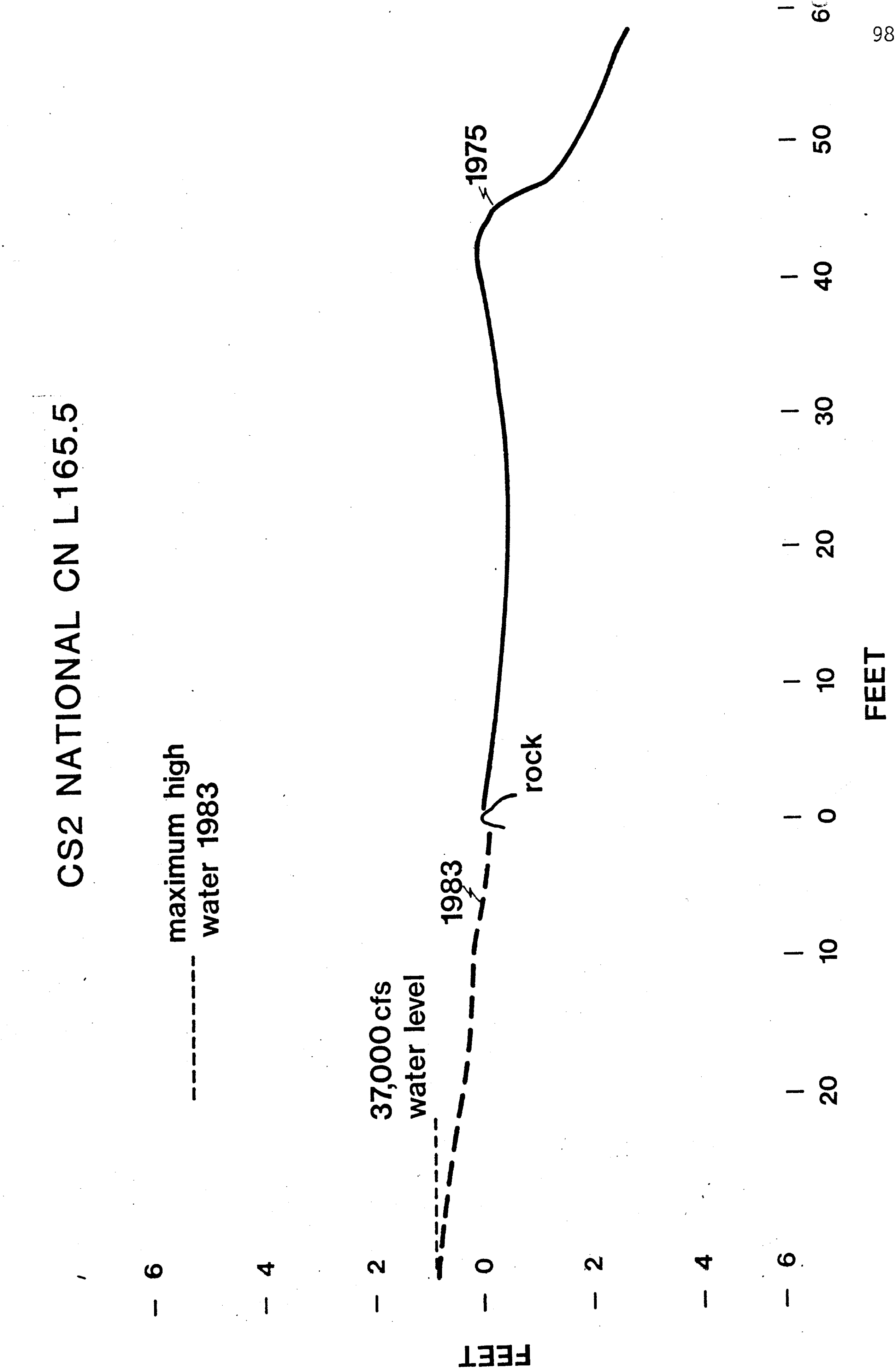

Figure 5-28. Beach cross-section profile 2 at National Canyon

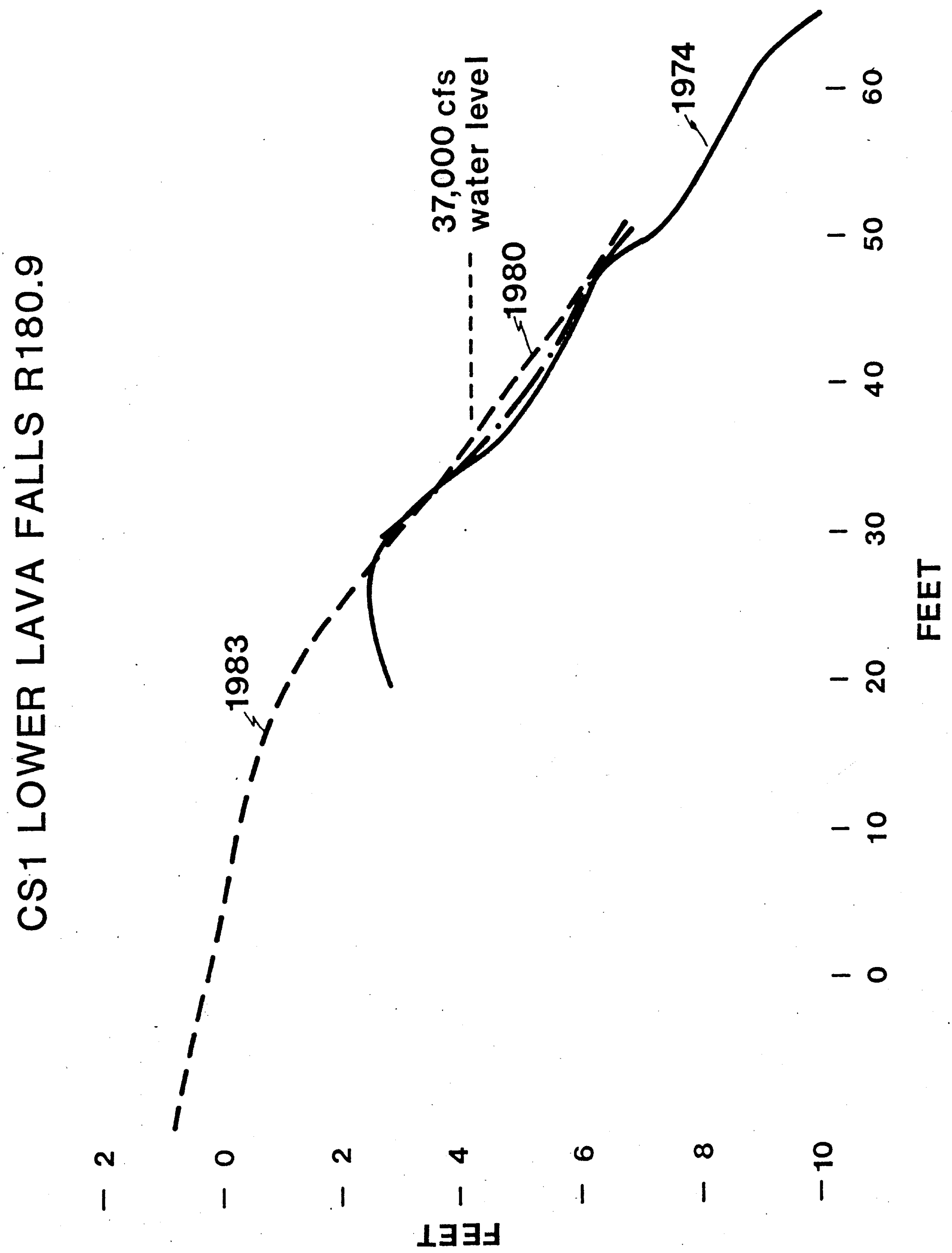

Figure 5-29. Beach cross-section profile 1 at Lower Lava Rapids

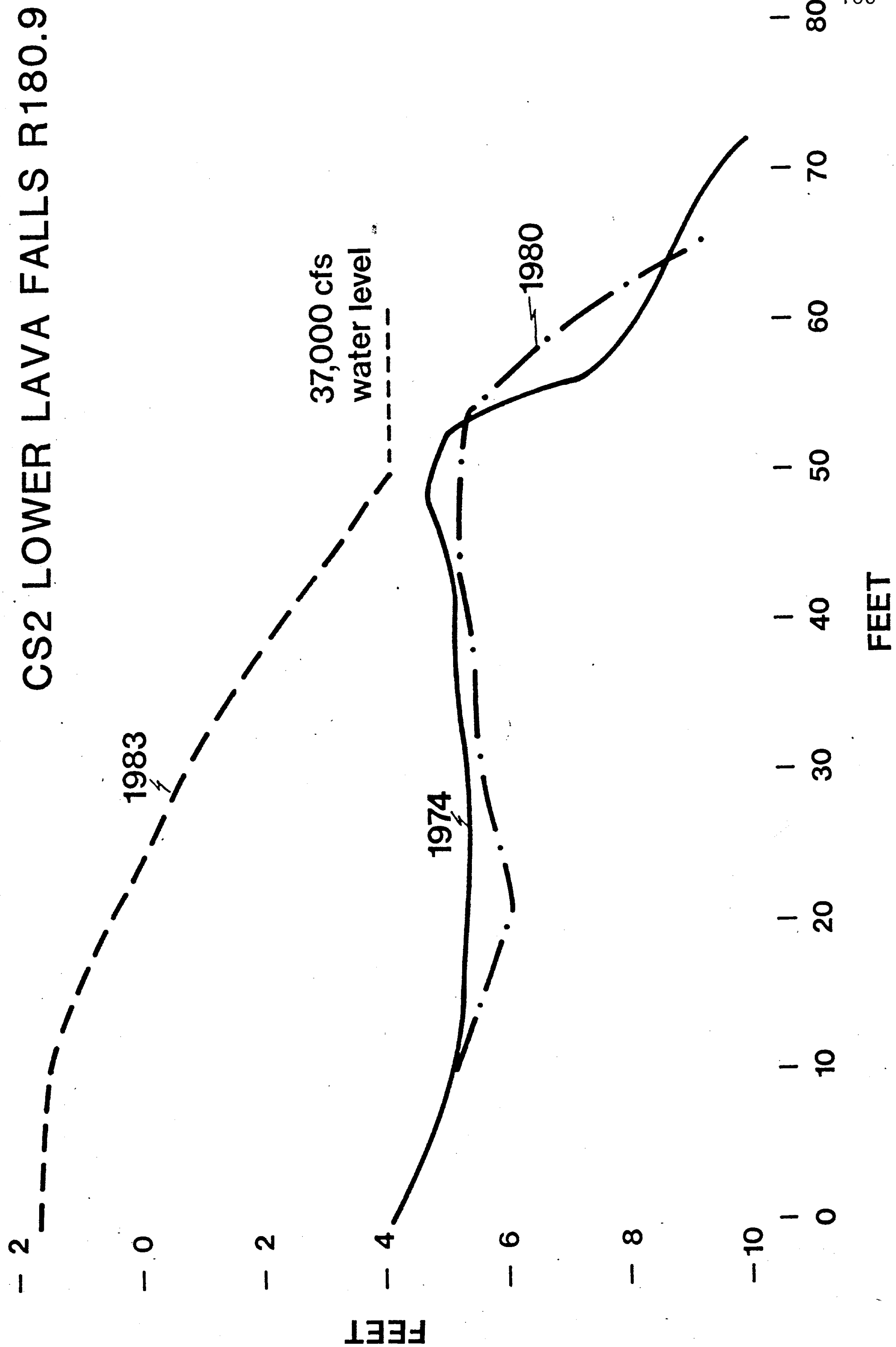

Figure 5-30. Beach cross-section profile 2 at Lower Lava Rapids

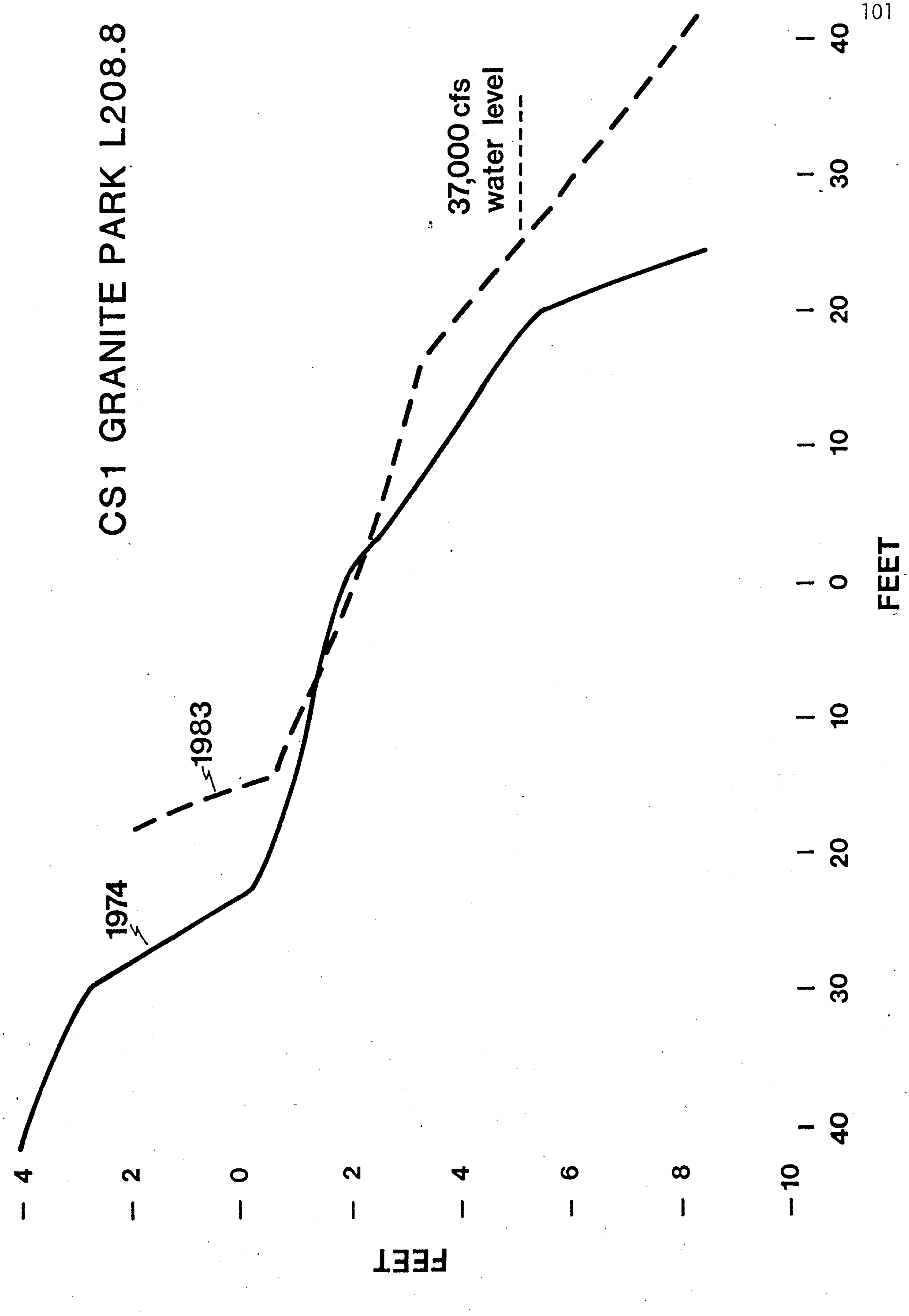

Figure 5-31. Beach cross-section profile 1 at Granite Park

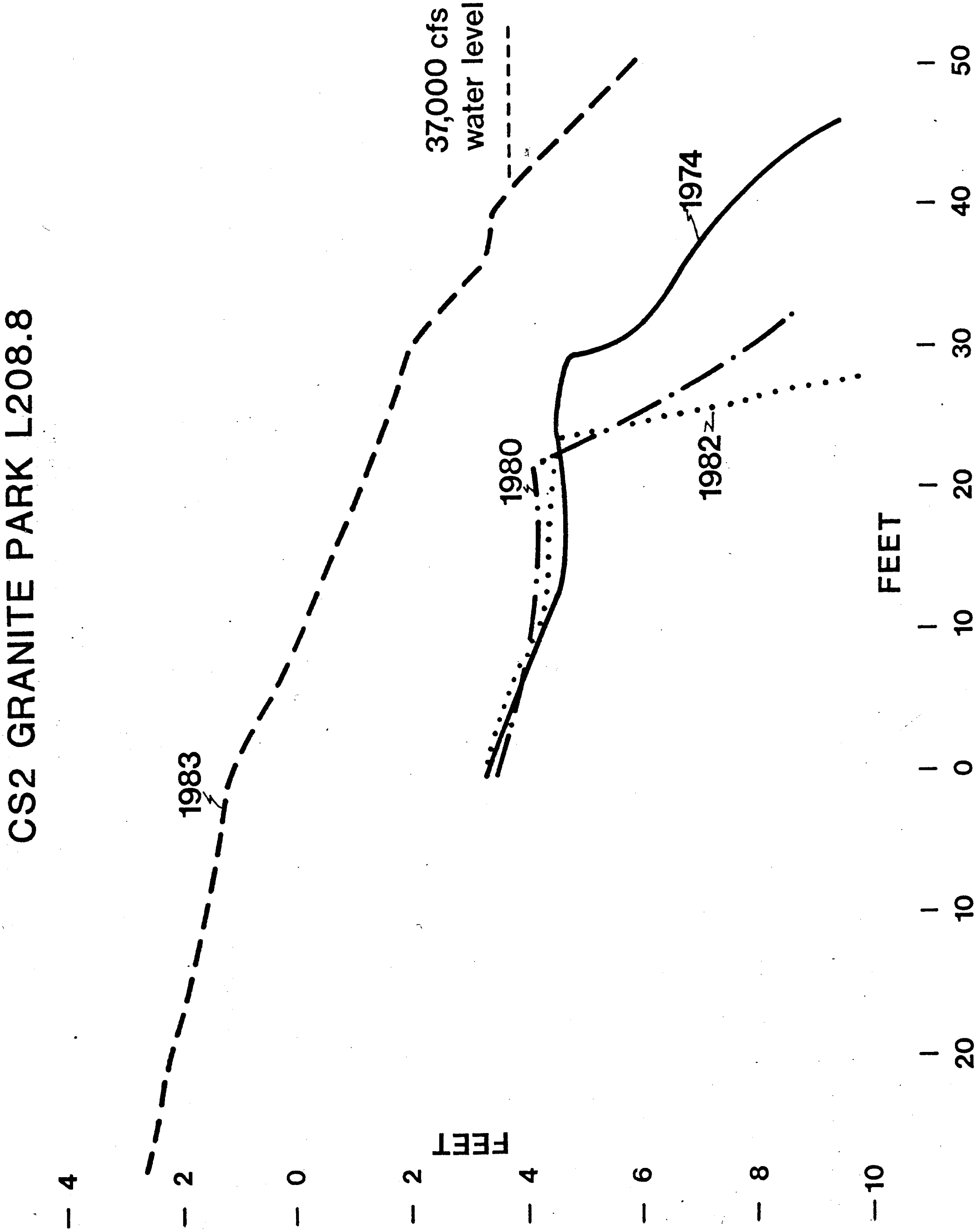

Figure 5-32. Beach cross-section profile 2 at Granite Park

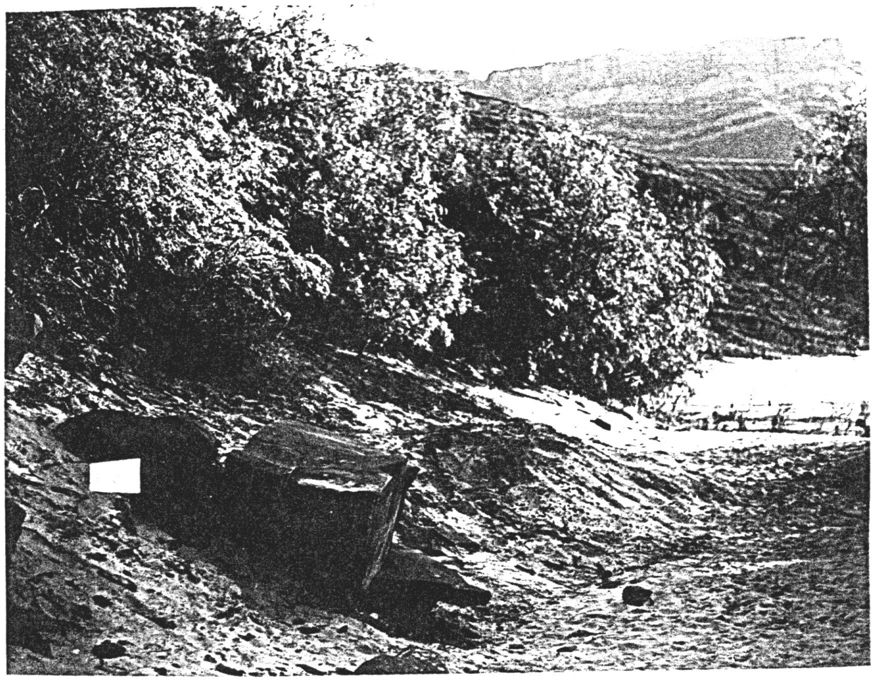

Figure 5-33A. Unkar beach, R 72.2, view towards BS 3 from BS 2, looking towards the north. Taken late July, 1983, before the flash flood.

Figure 5-33B. Unkar beach, nearly same view as A above, taken in September, 1983, after the August flash flood. Note sand removal, exposed talus blocks and downed tamarisk trees.

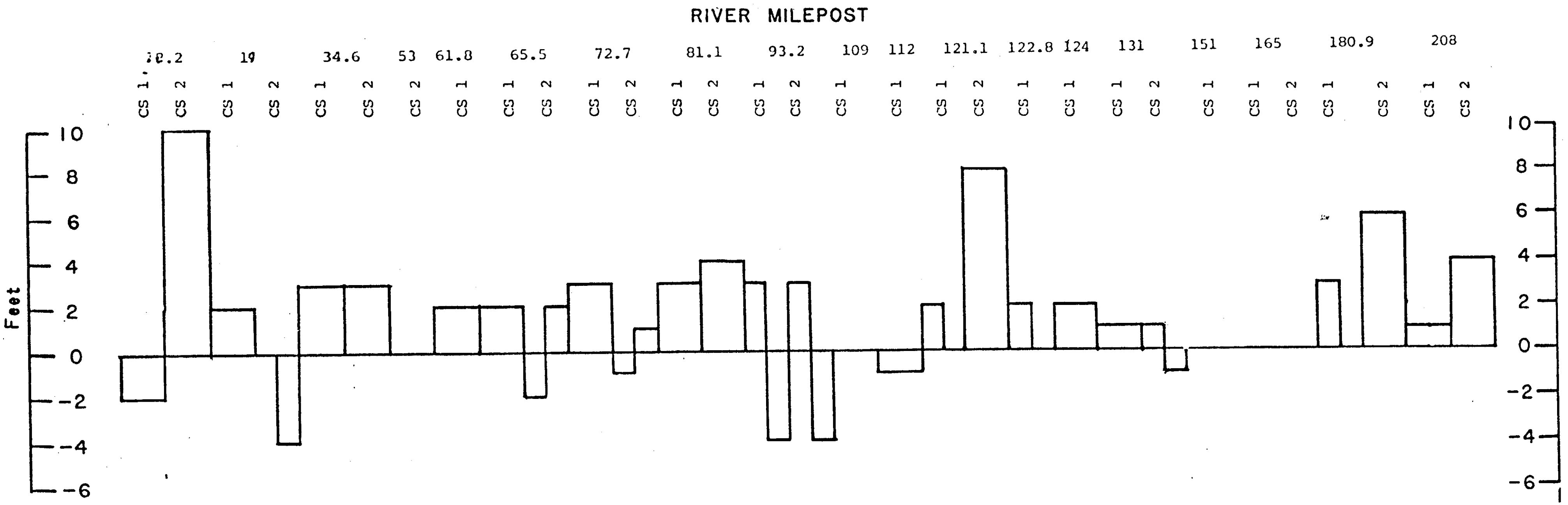

Figure 5-34. Plot of gain and/or loss of beach sand as measured in vertical feet; 19 beaches (including newly surveyed Forster Beach at L 122.8). CS numbers are cross-sections at individual beaches. The 0 base line marks the beach surface position prior to summer 1983.

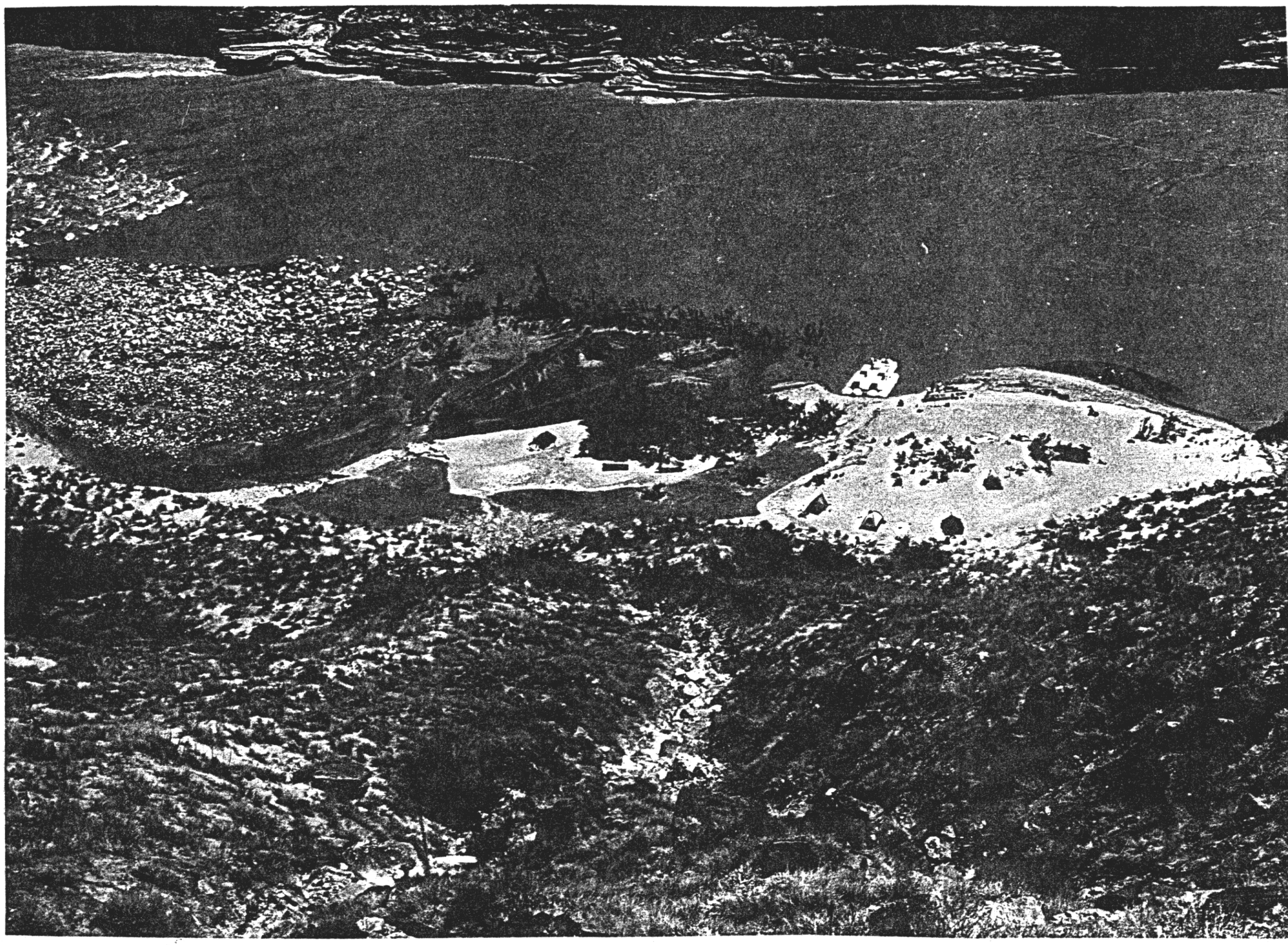

Figure 5-35. View of new beach deposits at Forster Canyon, L 122.8

REPORT ON VEGETATION DAMAGE ALONG THE COLORADO RIVER

by

DALE DANCIS

Summer, 1983

assisted by

Betty Byars

Patrick Hasenbuhler

Frank Lojko

Robert Minicucci

Shirley Pauls

Loreli Wood

INTRODUCTION:

In June, 1983 record flows from the Colorado River caused intense flooding in Grand Canyon National Park. These flood conditions have not been seen since Glen Canyon Dam was built in 1963.

Four students, Bob Minicucci, Shirley Pauls, Loreli Wood and I were interested in determining the amount of vegetation damage along the river's edge. We decided to make this our summer field project for Geology 538. Under the supervision of Dr. Steven Carothers and Dr. Stanley Beus we floated down the river for ten days starting on August 1. Within this time period we surveyed 28 beaches.

METHODS:

A. Zonation of beach:

Each beach was divided into three zones.

1. The 90,000 c.f.s. (cubic feet/second) zone was determined by the records of this year's maximum flow during the flood. Debris is commonly left by the river as it recedes. We took this debris deposit as an indication of the height of the flooding. We assumed that vegetation above this mark was undamaged by the flood.

2. The 40,000 c.f.s. zone was the height of the river during the ten day trip. This was determined by checking the discharge rate at Lee's Ferry Ranger Station. To mark this zone we used the water's edge.

3. The 60,000 c.f.s. zone was assumed to be intermediate between the 90,000 c.f.s. zone and the 40,000 c.f.s. zone.

B. Area surveyed:
Twenty-eight beaches were selected to coincide with those chosen by two other survey teams from Northern Arizona University. A 50 meter strip, parallel to the water flow was studied in each of the zones, (40,000, 60,000, and 90,000 c.f.s.) on each of the beaches. The strips were approximately 5 feet wide as estimated by the outsretched arms of the surveyor.

C. Selection of vegetation for study:

The survey was limited initially to the most abundant species. As we progressed down the river, additional species were added to those surveyed. By the end of the trip there were 21 species under study.

D. Grading the damage:

Each tree was examined for the severity of damage. They were graded according to the following scale:

1: Dead tree
2: 75%-almost dead, few signs of remaining growth as shown by some leaves
3: 25%-tree mostly healthy, lots of growth as shown by few dead branches
4: Healthy tree

E. Plant count:

When possible, actual counts were made. In many instances, the growth of a species (ie. Tamarix chinensis, salt cedar) was too luxurious for individual counting. In those cases we made estimates of the mumber of trees. The accuracy of this approach was validated early in the study by actual counting.

F. Statistics:

The relative damage in the 90,000 c.f.s. zone and the 40,000 c.f.s. zone was compared statistically using the chi-square method. The analysis was limited to Tamarix and Salix, (true willow). The data from all the beaches were pooled to gain sufficient numbers for analysis.

RESULTS:

In Table 6-1 will be found the names of the beaches surveyed and their mile numbers below Lee's Ferry.

Figure 6-1 presents the distribution of species according to the beach on which they were found. In all there were 5,756 plants that were evaluated. Tamarix and Salix accounted for 3,466 or 60% of all the trees counted. The next two most common species were Baccharis and Prosopis (Mesquite) which accounted for only 56% (10%) and 160 (.03%) respectively.

Table 2 presents the incidence of dead Tamarix trees in the 40,000 c.f.s. zone on the individual beaches.

Table 6-3 indicates the amount of damage that was done to the four most common trees, Tamarix chinensis (salt cedar), Salix (true willow), Baccharis (seep willow) and Prosopis (Mesquite). The amount of damage suffered by the four most common trees is presented according to the flood zone. The data from all the beaches are pooled and the severity of damage to each tree is rated on a scale of 1-4. The absolute numbers of trees in each grade and the ratio to the total number are shown.

The results were analyzed by chi-square (Table 6-5) More severe damage was observed for the three most populous trees in the 40,000 c.f.s. zone then in the 90,000 c.f.s. zone and the difference was highly significant.

To test statistically the effect of the flooding, we decided to compare the zone which would have suffered maximal impact (40,000 c.f.s.) to that which would have escaped (90,000c.f.s.). We then selected the ratio of dead trees to total trees for each species as providing the clearest index of damage. Comparison of these ratios in the two zones for the three most populous trees using the chi-square indicated highly significant differences. ($p < .001$)

We used the same approach to investigate the proportion of healthy trees in the two zones, for both Tamarix and Baccharis. There was a highly significant increased proportion of healthy trees in the 90,000 c.f.s. zone. No statistical difference was found for Salix, (true willow).

DISCUSSION:

Because of the absence of previous control data, we decided to use the 90,000 c.f.s. zone as our control study area. The 90,000 c.f.s. zone, the area above the flooding, was compared to the 40,000 c.f.s. zone, the area of maximum flooding. Although observations were made in the 60,000 c.f.s. zone, these data were not analyzed because it was an intermediate zone. We felt that a clearer, more easily interpreted answer would come out of analyzing the difference between the 40,000 c.f.s. and the 90,000 c.f.s. zones.

Before combining the data collected from all the beaches, the numbers of dead *Tamarix* trees in the 40,000 c.f.s. zone were compared beach by beach. An interesting clustering of dead trees along the river suggested that another factor besides submersion might be reasonable. Several beaches just below the Glen Canyon Dam had a high density of dead *Tamarix* trees. The beaches directly below Lava Falls were similarly affected. We may speculate that the stream velocity increased significantly in these two areas and destroyed large populations of *Tamarix*. There may be other geological factors which influenced the amount of damage found on these beaches.

Another major assumption is that the amount of damage observed to healthy and partly dead trees is a result of flooding. Dying and other natural processes such as disease or aging are assumed to be the same in both the 90,000 c.f.s. zone and the 40,000 c.f.s. zone.

In reviewing the results for the three most populous trees, there was consistantly a higher proportion of dead trees in the 40,000 c.f.s. zone (Table 6-3). For Tamarix and Baccharis it approximated a two-fold increase and a 37% increase for Salix (true willow). It was evident that considerable damage to these two could be attributed to the flooding.

Statistical analysis to confirm that these were not chance findings was performed with the chi-square. The analysis were done of the ratio of dead trees to the total as well as the healthy trees to the total. These two classes were selected as most likely to provide clear answers.

For the Tamarix, Baccharis and Salix, the confidence level for a difference in the proportion of dead trees in the 40,000 c.f.s. zone was at the $p < .001$. Similar results were obtained with the converse approach, the proportion of healthy trees in the two zones with p values of $< .001$ for Tamarix and Baccharis. There was no statistical difference for Salix.

SUMMARY:

The effect of flooding along the Colorado River in June, 1983 was estimated by surveying the vegetation on 28 beaches along 220 miles of the river's course.

The incidence of dead *Tamarix* trees in the zone of maximal flooding (40,000 c.f.s. zone) was high in two clusters of beaches, just below the dam and below Lava Falls. These observations suggest that the velocity of flow contributed importantly to the damage.

The amount of damage inflicted was estimated by comparing the incidence of dead trees in the 40,000 c.f.s. zone (maximal flooding) with the 90,000 c.f.s. zone (minimal flooding) for the three most populous trees. The incidence was increased about two fold for the *Tamarix* and *Salix* and about 36% for the *Baccharis*. The increases were highly significant.

Figure 6.1: Distribution of Species by Beach

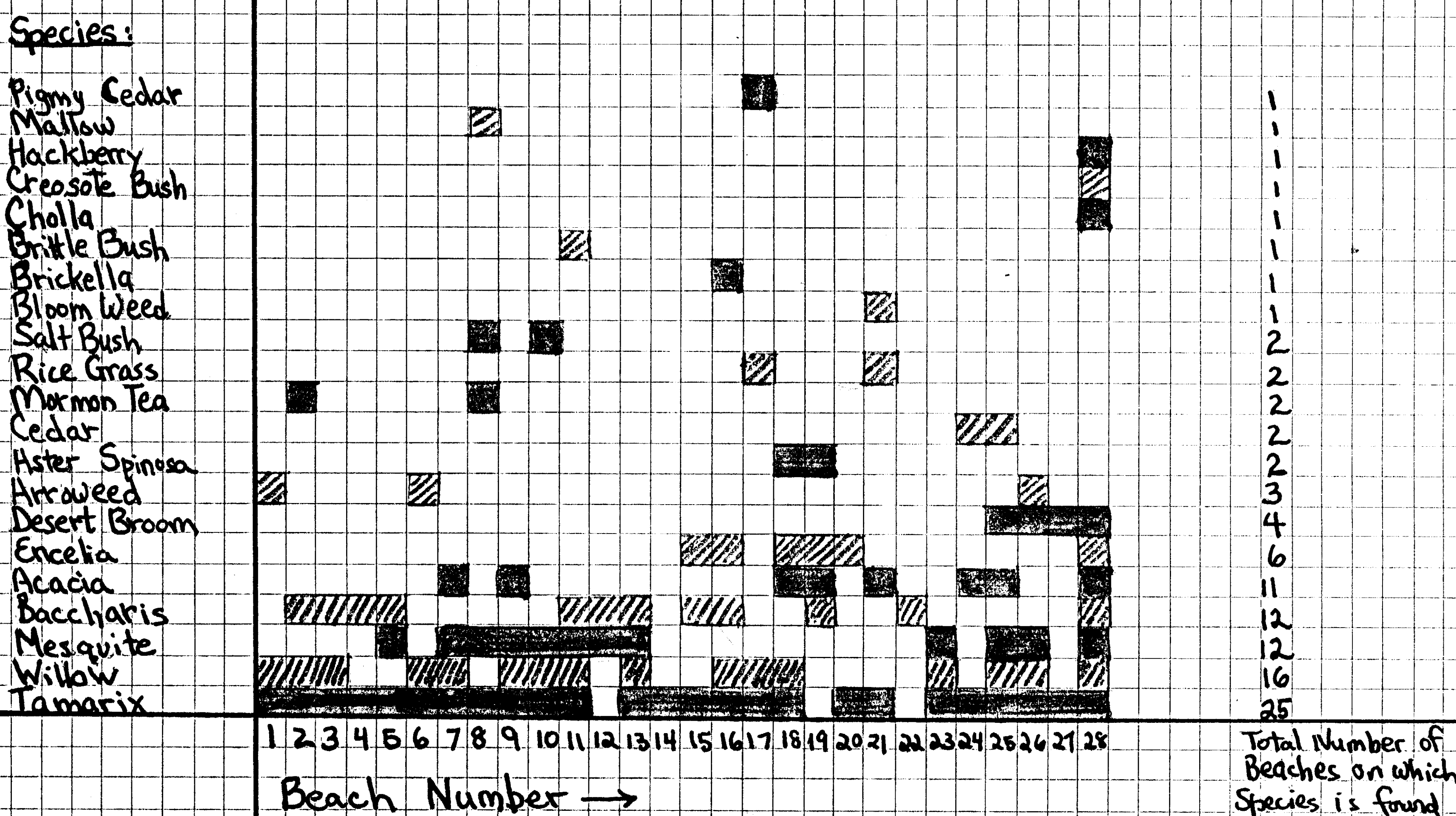

Table 6-1:

BEACHES SURVEYED

The beaches that were surveyed are listed according to the mile number away from the dam.
L.B.= Left Bank
R.B.= Right Bank

Beach Number	Beach Name	Mile Number	Riverbank
1	Badger Creek	8	L.B.
2	Mile 19 Beach	19	L.B.
3	Shinomo Wash	29	L.B.
4	Nautaloid Beach	34	L.B.
5	Anasazi Beach	44.5	L.B.
6	Nankoweep (Lower)	52	R.B.
7	Awatubi Beach	58	R.B.
8.	Little Colorado	62	R.B.
9	Lava Canyon	65.5	L.B.
10	Unkar (Upper)	72	R.B.
11	Nevilles Beach	75	L.B.
12	Grapevine Rapid	81.1	L.B.
13	Granite Beach	93.3	L.B.
14	Lower Bass	108	R.B.
15	Beach between Shinimo and Lower Bass	109.8	
16	Blacktail Canyon	120.1	R.B.
17	Forster Beach	123	L.B.
18	Fossil Canyon	124.5	L.B.
19	Bedrock Beach	130.2	R.B.

Table 6-1(Continued)

Beach Number	Beach Name	Mile Number	Riverbank
20	Dubendorf Beach	131.8	R.B.
21	Deer Creek Beach	136	L.B.
22	Poncho's Kitchen	137	L.B.
23	Ledges Camp	151	L.B.
24	National Camp (Upper)	166	L.B.
25	Lava(Lower)	180	R.B.
26	Granite Park	209	L.B.
27	Pumpkin Bowl	212	L.B.
28	Mile 220 Beach	220	R.B.

Table 6-2:

TAMARIX

Ratio of dead *Tamarix* trees to total number of *Tamarix* in 40,000 c.f.s. zone.

Beach Number	Ratio of Dead:Total	Percent dead
1	10:40	25%
2	21:45	47%
3	29:31	94%
4	2:25	8%
5	0:30	0%
6	0:40	0%
7	0:16	0%
8	0:20	0%
9	26:116	22%
10	10:75	13%
11	2:107	2%
12	0:0	0%
13	20:203	10%
14	175:212	83%
15	45:65	69%
16	52:86	64%
17	12:46	26%
18	0:35	0%
19	0:0	0%

Table 6-2 (Continued)

Beach Number	Ratio of Dead:Total	Percent dead
20	1:3	33%
21	0:0	0%
22	0:0	0%
23	1:3	33%
24	110:170	65%
25	11:41	27
26	14:87	16%
27	4:10	4%
28	0:4	0%

Table 6-3:

RELATIVE DAMAGE TO VEGETATION IN THE THREE SURVEY ZONES

This table shows the amount of damage to the four most common trees.
The numbers 1-4 indicate the amount of damage.

1- dead tree
2- 75% almost dead, few signs of remaining growth as shown by some leaves.
3- 25% tree mostly healthy, lots of growth as shown by few dead branches
4- heathy tree

Brackets indicate the proportion of trees so damaged.

SPECIES	DAMAGE CLASS	ZONE 40,000 c.f.s.	60,000 c.f.s	90,000 c.f.s.
TAMARIX:				
	1	445 (.31)	63 (.12)	63 (.17)
	2	518 (.36)	145 (.28)	43 (.11)
	3	432 (.30)	259 (.50)	195 (.59)
	4	55 (.04)	49 (.09)	75 (.20)
	Total:	1450	516	376
				Total: 2,342
SALIX: (True Willow)				
	1	184 (.26)	110 (.37)	12 (.12)
	2	222 (.31)	33 (.11)	1 (.01)
	3	173 (.24)	75 (.25)	78 (.75)
	4	141 (.20)	82 (.27)	13 (.13)
	Total:	720	300	104
				Total: 1,124

Table 6-3(Continued)

SPECIES	DAMAGE CLASS	ZONE 40,000c.f.s		60,000c.f.s.		90,000c.f.s.	
BACCHARIS	1	106	(.95)	92	(.75)	234	(.70)
	2	4	(.04)	23	(.19)	38	(.11)
	3	1	(.01)	7	(.06)	32	(.10)
	4	1	(.01)	0	(.00)	29	(.09)
	Total:	112		122		333	
						Total:	567
PROSOPIS (Mesquite)	1	1	(.2)	3	(.07)	0	(.00)
	2	4	(.8)	4	(.09)	17	(.15)
	3	0	(.00)	35	(.78)	29	(.26)
	4	0	(.00)	3	(.07)	64	(.58)
	Total:	5		45		110	
						Total:	160

Table 6-4:

TAMARIX:

# of live Tamarix trees:

	Flooding 40,000c.f.s.	Control 90,000 c.f.s.	Total
Healthy:	55	75	130
Damaged:	1395	301	1696
Total:	1450	376	1826

Expected incidence of healthy and damaged counts:

"Healthy" rate= Healthy trees/total= 130/1826= .071
Expected # healthy (40,000 c.f.s.): 1450 x.071 =102.95

Expected # healthy (90,000 c.f.s.): 376 x.071 =26.7

Expected Counts:

	Flooding	Control	Total
Healthy:	102.95	26.7	129.65
Damaged:	1347.05	349.3	1696.35
Total:	1450	376	1826

O-E=
102.95-55=47.95
75- 26.7=48.3

$48-.5=(47.5)^2 = 2256.25$

1/102.95+1/26.7+1/1347.05+1/349.3 =

.0097+.037+.0007+.0028 =.0502

2256.25 x .0502 =113.26
1 degree of freedom
p = > .001

Table 6-5:

APPENDIX

Formula for Chi-square:

$$x^2(df) = \sum_{\text{all categories}} (O-E)^2/E$$

O= observed count in a category

E= expected count in that category if the null hypothesis is true

---

TAMARIX:

# of dead Tamarix trees:

	Flooding 40,000c.f.s.	Control 90,000c.f.s.	Total
(grade 1) Dead:	445	63	508
(grade 2,3,4) Living:	1005	313	1318
Total:	1455	376	1826

Theoretical mortality rate (Null hypothesis):
Total # of dead trees/ total= 508/1826=.278

Expected mortality (40,000c.f.s.): 1450 x.278=403.1

Expected mortality (90,000c.f.s.): 376 x.278=104.53

Expected Counts:

	Flooding 40,000c.f.s	Control 90,000c.f.s.	Total
Dead:	403.1	104.5	507.63
Living:	1,046.9	271.4	1,318.37
Total:	1,450	376	1,826

O-E=

445-403.1=41.9

$41.9-.5=(41.4)^2=1718.1$

1/403.1+1/104.5+1/1046.9+1/271.4=

.0025+.0096+.0010+.0035=.0166

1718.1 x .0166 = 28.59

1 degree of freedom

$p= < .001$

Table 6-5 (Continued)

SALIX:
(True Willow)
# of dead Salix trees:

	Flooding 40,000 c.f.s	Control 90,000 c.f.s.	Total
Dead:	184	12	196
Living:	536	92	628
Total:	720	104	824

Theoretical mortality rate (Null hypothesis)
Total # of dead trees /total= 196/824= .238

Expected mortality (40,000c.f.s.): 720 x .238 =171.36

Expected mortality (90,000c.f.s.): 104 x .238 =24.75

Expected Counts:

	Flooding 40,000 c.f.s.	Control 90,000 c.f.s.	Total
Dead:	171,36	24.75	196.11
Living:	548.64	79.25	627.89
Total:	720	104	824

O-E=
184 -171.36 = 12.64
12.64 -.5 = $(12.14)^2$ =147.38
1/171.36 + 1/24.75 +1/548.64 +1/79.25 =
.006 +.04 +.002 +.013 =.061
147.38 x .061 =8.10 (1 degree of freedom)
.01>p>.001

Table 6-5 (Continued)

SALIX:

(True Willow)
Of healthy Salix trees:

	Flooding 40,000c.f.s.	Control 90,000c.f.s.	Total
Healthy:	141	13	154
Damaged:	579	91	670
Total:	720	104	824

Expected incidence of healthy and damaged tree counts:
Healthy rate= # of healthy over total = 154/824 =.187

Expected healthy= 720 x .187 =134.64
(40,000 c.f.s.)

Expected healthy (90,000 c.f.s.) =104 x.187 =19.45

Expected Counts:

	Flooding 40,000 c.f.s.	Control 90,000c.f.s.	Total
Healthy:	134.64	19.45	154.09
Damaged:	585.36	84.55	669.91
Total:	720	104	824

O-E=

$134.64-141= (6.36)^2 = 40.45$

1/134.64 +1/19.45 +1/585.36 +1/84.55 =

.007 +.05 +.002 +.012 =.071

40.45 x.071 =2.87
1 degree of freedom
$0.10 > p > .05$

Table 6-5 (Continued)

BACCHARIS:

# of dead Baccharis trees:

	Flooding 40,000 c.f.s.	Control 90,000 c.f.s.	Total
Dead:	106	234	340
Living:	6	99	105
Total:	112	333	445

Theoretical mortality rate (Null hypothesis)
Total # of dead trees/ total= 340/445 =.76

Expected mortality (40,000c.f.s.): 112 x .76 = 85.12

Expected mortality (90,000c.f.s.): 333 x .76 = 253.08

Expected Counts:

	Flooding 40,000 c.f.s.	Control 90,000 c.f.s.	Total
Dead:	85.12	253.08	338.2
Living:	26.88	79.92	106.8
Total:	112	333	445

O-E=

$106-85.12 = (20.88)^2 = 435.97$

$1/85.12 + 1/255.08 + 1/26.88 + 1/79.92 =$

$.012 + .004 + .037 + .012 = .065$

$435.97 \times .065 = 28.34$
1 degree of freedom
$p < .001$

Table 6-5 (Continued)

BACCHARIS:

# of live Baccharis trees:

	Flooding 40,000 c.f.s.	Control 90,000 c.f.s.	Total
Healthy:	1	29	30
Damaged:	111	304	415
Total:	112	333	445

Expected incidence of healthy and damaged tree counts:

Healthy rate= # of healthy over total = 30/445 = .067

Expected survival: (40,000 c.f.s.) 112 x .067 = 7.5

Expected survival: (90,000 c.f.s.) 333 x .067 = 22.3

Expected Counts:

	Flooding 40,000 c.f.s.	Control 90,000 c.f.s.	Total
Healthy:	7.5	22.3	29.8
Damaged:	104.5	310.7	415.2
Total:	112	333	445

O-E=

7.5 -1 =6.5

$6.5 - .5 = (6)^2 = 36$

1/7.5 +1/104.5 +1/22.3 =1/310.7 =

.133 + .010 + .045 + .003 = .191

36 x .191 = 6.88

1 degree of freedom

$.01 > p > .001$

Insect Diversity and Density on Colorado River Beaches, 1983

by

Betty Byars

Introduction

A study to determine insect density and diversity in different vegetative zones on Colorado River beaches in Grand Canyon was undertaken during August of 1982 (Byars, 1982). The results of the study indicated that insect density and diversity was highest in the zone of vegetation (new riparian zone) which has become established since the placement of Glen Canyon Dam.

The present study is essentially a duplication of the 1982 study. During the summer of 1983, water discharges from Glen Canyon Dam were in excess of 90,000 cfs for several days, and flows in excess of 40,000 cfs lasted for at least 2 months. Since the Dam went operational in 1963, flows in excess of cfs have been very rare. The intent of this study was to determine whether or not the high flows of 1983 influenced the insect populations in the new riparian zone. In addition, duplicate samples were taken during this study in the pre-dam riparian zone (old high water line=OHWZ) and compared with the results of 1982.

Methods

It was the original intent of this study to sample the same beaches in 1983 that were sampled during the 1982 study. Many of the 1982 sites had been so modified by the floods that the vegetation was gone. In this case, new study sites were selected wherever samples of the new riparian zone could be found. The insects were collected by sweep netting (200 sweeps per plant) and data recorded by the zone (old and new high water) and/or plant species. The vegetation in the new high water zone consists mostly of native willows (Salix sp.)and the introduced salt cedar or tamarisk (Tamarisk sp.). Each of these species were sampled separately and the data recorded accordingly. In the old high water zone (OHWZ) the vegetation consisted of arroweed (Pluchea sp.), cat-claw (Acacia sp.) and mesquite (Prosopis sp.). All samples in the OHWZ were lumped together. The Desert Scrub zone consisted of a variety of desert plants, but were mostly brittlebush (Encelia sp.), saltbush (Atriplex sp.), Mormon-tea (Ephedra sp.) and others. After the collecting sweeps were made in each of the zones, the insects were immobilized, identified to Family and recorded in a field notebook.

Results and Discussion

The results of the 1982 and 1983 studies are presented in Tables 7-2, and Figure 7-1. Although there were approximately 46% fewer insects collected in 1983 (696, n=19) than there were in 1982 (1300, n=22) there are few conclusions which may be reached relative to the reason why. This study could not determine whether or not the fewer insects in 1983 were a result of flooding or of other natural causes. The average number of insects captured in the willow habitat did decrease by about 50% and the number of families found also decreased by a similar amount when the 1983 data are compared to the previous year. On the tamarisk, however, there was actually a 21% increase in the number of individuals captured per unit effort, and the number of families found during the 1983 sampling period increased by 2 from the previous year.

In the OHWZ community, the capture effort each year was similar, yet the number of families encountered dropped from 11 in

1982 to 6 in 1983. In the desert scrub community, there was an overall decrease in the insect density, from 34.5 insects per sample during the 1982 period while there were only 12.0 insects per sample during the 1983 sampling. Also, in the desert scrub, with three times the sampling (6 compared to 2) during the 1983 period, there was only an increase in the number of families by 1. Thus, in the zone where there should have been no influence of the 1983 floods, that is the desert scrub zone, there was a fairly substantial decrease in the insect density.

Table 7-1. A comparison of the occurrence of insect families on Colorado River vegetation, 1982 and 1983.

Insect Family	Vegetation							
	Willow		Tamarisk		OHWZ		Desert Scrub	
	1982	1983	1982	1983	1982	1983	1982	1983
Acrididae	4	0	12	4	6	2	6	9
Aphidae	3	0	0	0	0	0	1	0
Apidae	1	1	0	14	1	0	0	0
Asilidae	1	1	4	7	1	0	3	5
Bombyliidae	8	0	22	10	0	0	0	1
Cercopidae	0	0	0	4	0	0	0	0
Chrysopidae	1	1	0	0	0	0	0	0
Cicadellidae	9	13	192	112	8	0	23	0
Cicadidae	15	2	46	4	37	14	5	28
Coccinellidae	7	18	36	69	3	12	0	11
Curculionidae	0	0	0	0	0	0	13	4
Elateridae	5	0	0	0	0	0	0	0
Formicidae	0	0	0	1	3	1	0	1
Halictidae	6	1	28	39	5	3	3	9
Hemerobiidae	0	0	1	0	0	0	0	0
Miridae	12	1	8	2	21	1	0	0
Pentatomidae	0	0	5	0	0	0	15	0
Phasmatidae	1	0	0	0	0	0	0	0
Pomplidae	0	0	0	1	0	0	0	0
Sphecidae	7	1	23	2	7	0	0	0

Table 7-1 (Continued)

Tenebrionidae	0	0	0	0	0	0	0	4
Vespidae	1	0	7	9	1	0	0	0
Total Individuals	81	39	384	274	93	33	69	72
Total Families	15	9	12	14	11	6	8	9
Percent Change		-52%		-29%		-65%		+4%
Total Samples	5	5	7	4	8	4	2	6

Table 7-2. Average number of all insects collected per 200 sweeps on Colorado River Vegetation, 1982 and 1983.

Vegetation	Year 1982	1983
Willow	16.2	7.8
Tamarisk	54.8	68.5
OHWZ	11.6	8.2
Desert Scrub	34.5	12.0

Conclusions

There was a general decrease in the number of individual insects in the willow and desert scrub zones when the 1983 data were compared with the 1982 samples. There was an increase in the density and diversity of insects in the tamarisk zone for the same period. The numbers of insects encountered in the OHWZ was approximately the same for both years, however the numbers of families decreased by almost 50% in 1983. No conclusions could be drawn as to the impact of the 1983 flooding on the insects of the riparian vegetation of the Colorado River in Grand Canyon.

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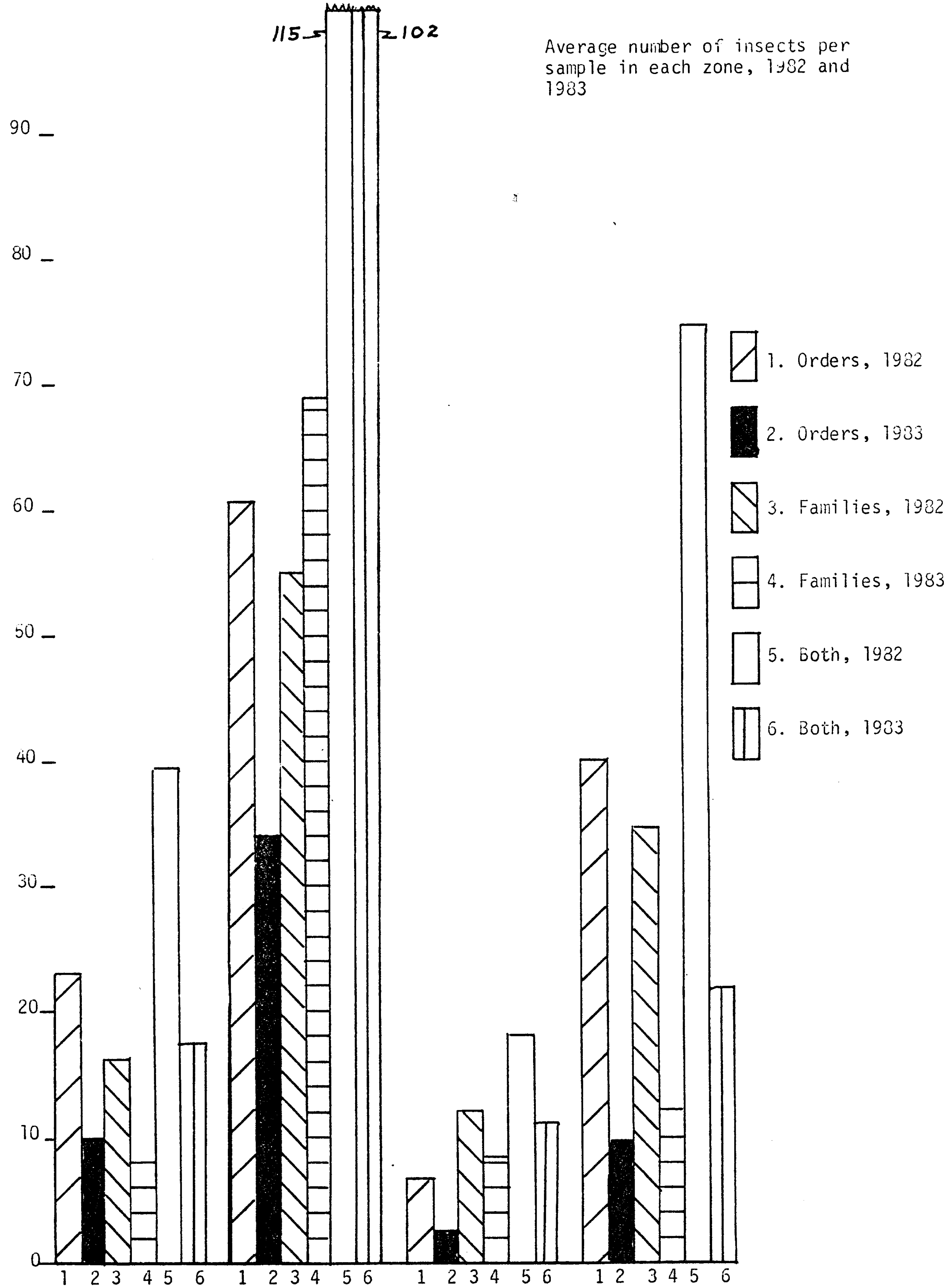

115
102
Average number of insects per sample in each zone, 1982 and 1983
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6 1 2 3 4 5 6
1. Orders, 1982
2. Orders, 1983
3. Families, 1982
4. Families, 1983
5. Both, 1982
6. Both, 1983

Figure 7-1

Further Investigations on Pogonomyrmex Ants on Colorado River Beaches in Grand Canyon

by

Betty Byars

Introduction

Previous investigations on densities of the harvester ant (Pogonomyrmex sp.) in the Grand Canyon have indicated that ant density is highest on beaches which receive heavy human recreational use (Petersen 1982, Hayden et al. 1977).

During this study, harvester ants were observed to determine whether or not there was a quantifiable difference in the kinds of food particles chosen by foraging ants in areas where differing amounts of human use were known. In addition, harvester ant densities (nest density) were recorded to determine if ant density could still be correlated with human use on beaches that had been scoured by the Colorado River floods of 1983.

Harvester Ant Natural History

Four species of harvester ants, P. californicus, P. desertorum, P. maricopa and P. rugosus have ranges that include the Grand Canyon (Cole 1968). The biology of these ants has been summarized in previous publications, and the following information has been taken from Bernstein 1974 and 1975, Brown et al. 1975, Carroll and Janzen 1973, Pulliam and Brand 1975, Whitford and Ettershank 1975, Whitford et al. 1975 and Wilson 1975.

Harvester ants are heavily involved in seed consumption in deserts, and studies have demonstrated that the day-foraging ants may remove up to 20% of the total available seeds. The seeds are collected by the ants because of the high nutrient value, water content and availability. It is thought that only a small percentage of total seed production is removed by the foraging ants, and the percentage of seeds harvested by plant species can be a function of availibility and preferred species.

Harvester ants forage under plants and in the open. They usually follow relatively permanent foraging trails. Nests are built in sandy soil and seeds are stored in underground nest chambers. Foraging ants collect seeds with rough coats, often with bracts or awns still attached. The ants will also forage on both live and dead insects as they are available.

Communication in harvester ants is based on chemoreception. Nest odor, alarm pheromones and "smelling" with the antennae are all indicative of chemoreception. These ants can recognize soil from their oun nests and the guard ants check returning foragers with their antennae and will release alarm pheromones if they perceive a threat to the colony. Harvester ants defending the nest have both a painful sting and bite.

Under normal conditions, there is a strong separation of foraging grounds and nests. Young queens attempting to found a colony are usually killed or expelled if they attempt to remain near an established colony. Nest site availibility and food resources also help to determine the density of nests in a given area.

Materials and Methods

A record of the density of harvester ant nests/100 square meters was determined for each beach studied by pacing the beach and counting the number of ant nests within the paced area. Information as to the level of usage for each beach was obtained from the National Park Service and river guides.

The frequency with which various food items were taken by foraging ants was determined by direct observation. The observations were taken in three categories as a function of the nest placement. That is, observations were taken on foraging ants which were from nests 1) on or within 10ft. of a heavily used campsite, 2) 10-50ft. from a campsite, and 3) more than 50ft. from a campsite. In each nest group, as many nests as possible were studied. At each nest a count was made of 25 foragers returning with collected food items. The items were counted and assigned to 1 of 5 categories: 1)human food scraps, 2)see 3)plant items, 4)insect items and 5)sand or grease balls.

Results and Discussion

The results of this study are presented in Tables 8-1, 8-2 and Figures 8-1 and 8-2. The data indicate that there was no increase in density of harvester ants with medium and high human usage of the beaches (Figure 8-1 and Table 8-1). There was an average of about 2.4 nests/100 square meters of habitat on most beacher regardless of the level of human usage. The scouring action of the 1983 Colorado River floods and the subsequent disturbance to the ants was probably disturbed the previously observed pattern of higher ant densities in areas of frequent human usage.

The data on foraging particle type indicates that the closer the ants were to the portion of the beaches occupied by human recreationists, the greater the frequence of human related debris in the ant diet. Table 8-2 and Figure 8-2 demonstrate this relationship. When the food scraps and sand/grease ball data are combined (the grease comes from various forms of human waste water being dumped on the beach), it can be eaisly seen that the ants are greatly influenced by the recreationists. For example, the foragers closest to the human use area brought in 53% human related material, the ants intermediate in distance to human use areas had 23% human related material and the ants farthest away only brought in 2% human related material.

Table 8-1. Harvester ant densities (nests/100 square meters) and patterns of human use on select colorado River beaches in Grand Canyo

BEACH NAME	NESTS	HUMAN USE	NEST SIZE
Badger	3	high	small
Mile 34.7	3	high	small
Anasazi Bridge	3	high	medium
Nankoweap	3	high	medium
Awatubi	2	high	small
Little Colorado (R)	4	Continuous	small
Lava Canyon	3	medium	small
Unkar	3	high	medium
Nevill's	2	high	medium
Grapevine	2	high	small
Bass	3	high	large
Blacktail	2	medium	large
Forrester	3	low	medium
Mile 125	5	low	large
Mile 131	1	low	medium
Lava Rapid Beach	1	medium	medium
Mile 180.5	2	medium	large
Mile 209	2	high	large

Table 8-1 (Continued)

Mile 220	4	high	large

Nest disk size: small, less than 6 inches in diameter; medium, 6-12 inches; large, greater than 12 inches.

Table 8-2. The relative frequency of food items collected by foraging harvester ants in relation to distance from heavily used human campsites on Colorado River beaches in Grand Canyon.

FOOD ITEMS	AREA 1*(n=7)	2(n=15)	3(n=5)
Seeds	58 (33%)	203 (54%)	82 (66%)
Plant Parts	14 (8%)	88 (24%)	34 (27%)
Insect Parts	10 (6%)	60 (16%)	7 (6%)
Food Scraps	32 (18%)	6 (2%)	0 (0%)
Sand/Grease	62 (35%)	17 (5%)	2 (2%)
Total	176	374	125
Total % Food+sand/grease	(53%)	(23%)	(2%)

1*= on or within 10 ft. of a heavily used campsite
2 = 10-50ft. from a heavily used beach
3 = more than 50 ft. from a heavily used beach

Conclusions

Harvester ant density was not greater in 1983 on beaches which h human recreational use. This lack of correlation between ant density and human recreational use is probably due to the disturbance of the ants by the 1983 Colorado River floods.

Ants foraging close to human use areas have a greater percentage of human related food items in their foraging product than ants foraging in non human use areas.

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Betty Byars

Figure 8-1 Nest Density + Beach Usage Graph

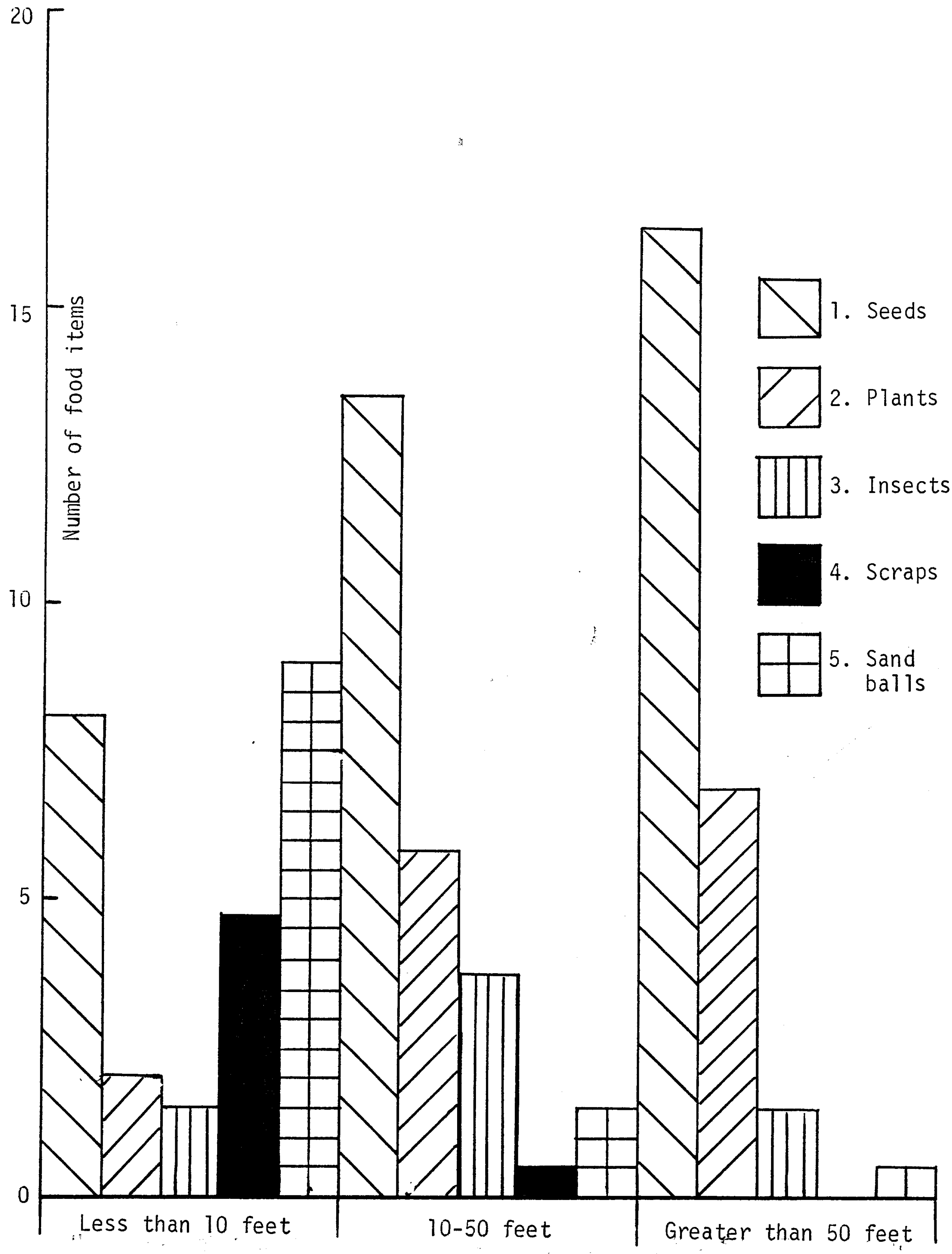

Figure 8-2. Average numbers of food items in given categories at given distances.

SMALL MAMMAL POPULATIONS WITHIN THE COLORADO RIVER CORRIDOR

Fern Spears and George Spears

INTRODUCTION

The purpose of this study was to determine the distribution of small mammals in four specific habitats along the Colorado River Corridor. The zones from which samples were taken were: (1) the desert grass/cactus talus zone, which is not influenced by the river environment; (2) the mesquite/acacia zone, which represents the pre-dam high water mark; (3) the grassy cobble/boulder zone, which on some beaches extends into the tamarisk/willow zone; and (4) the tamarisk/willow habitat along the river. References made to specific zone numbers in this report relate to these habitats.

METHODS

During the 10-day river trip, mammals inhabiting six beaches were sampled using Sherman live traps baited with oatmeal. The traps were set in the evening and divided evenly among the zones which occured. Captured mammals were identified by sex and species in the early morning of the following day. The mammals were then released.

RESULTS

The following tables present the results of the trapping. Table 9-1 is a gazeteer of the sites from which samples were taken and indicates sex and the number of each species caught per zone at each site, as well as the total caught across zones. Mammals at the first site were not identified as to sex.

Table 9-1. Distribution of small mammals in four habitats between miles 19 and 166 along the Colorado River Corridor, Grand Canyon National Park, Arizona, from July 19 to August 5, 1983. M = Male; F = Female; L = Left side of river; R = Right side of river.

DATE LOCATION NUMBER OF TRAPS SET	SPECIES	NUMBER OF SMALL MAMMALS FOUND								
		Zone 1 Desert Grass/ Cactus Talus		Zone 2 Mesquite/ Acacia		Zone 3 Grassy Cobblebar/ Boulder		Zone 4 Tamarisk/ Willow		TOTAL
		M	F	M	F	M	F	M	F	
July 19 19½ Mile Camp (L) 54 traps	*Peromyscus eremicus*	1 (not sexed)								1
	Peromyscus maniculatus							1 (not sexed)		1
	Peromyscus crinitus	1 (not sexed)								1
July 30 Nankoweap (R) 54 traps	*Peromyscus eremicus*	3	1	3		1				8
	Peromyscus maniculatus	1				6				7
	Perognathus formosus	1								1
August 1 Unkar (R) 49 traps	*Peromyscus eremicus*	2		2	4			1	2	11
	Peromyscus crinitus		1							1
	Perognathus formosus		2							2
	Neotoma lepida							1		1
August 2 Granite (L) 20 traps	*Peromyscus eremicus*	1						3		4
August 3 Forster Canyon (L) 40 traps	*Peromyscus eremicus*	2						1		3
	Perognathus intermedius	1	1							2
August 5 National Canyon (L) 38 traps	*Peromyscus eremicus*	3	3			2				8

Figure 9-1 shows a diagrammatic cross-section of the vegetation zones in the Inner Gorge and indicates in which areas each species was found. Table 9-2 combines data from all sites to indicate the total number of each species found in each zone and, within each species, shows the percentage found in each habitat.

Fifty-one individual small mammals were trapped, giving a 20% trap success. This comprises 6 different species.

CONCLUSIONS

The results of this study can be loosely compared to a similar study in 1982 by Trimble and others[1]. For this purpose, it will be assumed that the salt cedar and willow habitats described in that study are equivalent to Zone 4 as described in this report and that the desert scrub of the 1982 study encompasses Zones 1 and 2 of this report (see Table 9-1. The present study also includes a fourth category, grassy cobble/boulder, which has no apparent equivalent in the 1982 study.

With these equivalencies in mind, the following comparisons are interesting. In 1982, 63% of the small mammals captured were trapped in the tamarisk/willow habitat (Zone 4), while only 35% were from this habitat in 1983. In 1982, 37% of the small mammals trapped were found in Zones 1 and 2, while the 1983 count yielded 65% from these non-riparian habitats. So, in 1983 more mammals were trapped in habitats away from the river. At this point, it might also be noted that in the 1983 study, while there were no significant variations in the types of species captured, the trap success in 1983 (20%) was almost 3 times that of 1982 (7%).

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[1]See Appendix A.

Figure 9-1. Diagrammatic cross-section of vegetation zones in the Inner Gorge of the Grand Canyon, Arizona, indicating small mammal species found in each zone.

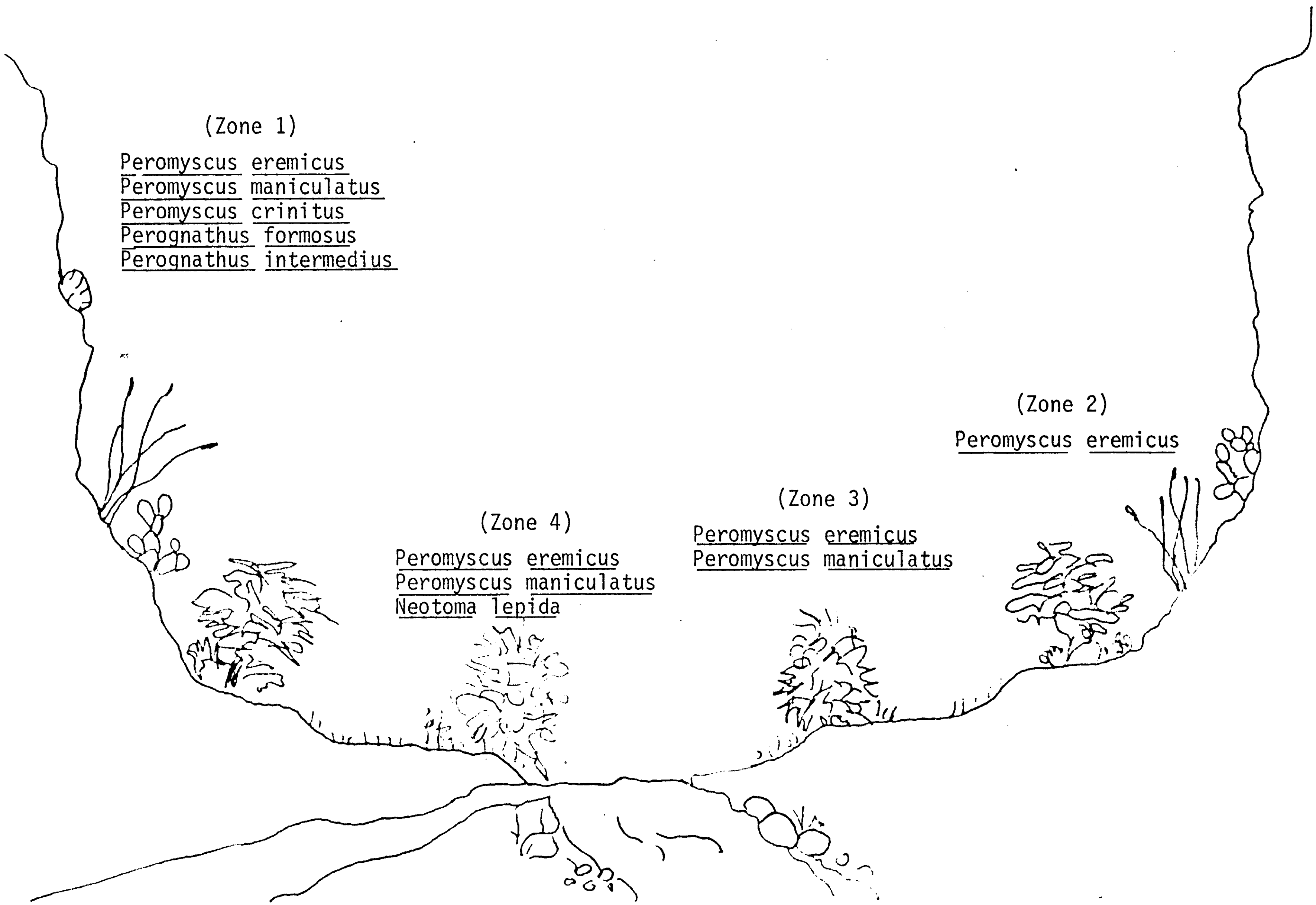

Table 9-2. Distribution over four vegetation zones of six small-mammal species trapped from July 19 to August 5, 1983, in the Inner Gorge along the Colorado River in the Grand Canyon, Arizona. N = number caught; % = percentage of the total number captured for each species.

	ZONES							
	1		2		3		4	
SPECIES	N	%	N	%	N	%	N	%
Peromyscus eremicus	16	46	9	26	3	9	7	20
Peromyscus maniculatus	1	13			6	75	1	13
Perognathus formosus	3	100						
Perognathus crinitus	2	100						
Perognathus intermedius	2	100						
Neotoma lepida							1	100

Total number of small mammals caught = 51

Total traps set = 255

Trap success = 20%

Perhaps both of the above observations can be explained by the high water of June and July in 1983. It might be that the floods during those months drove mammals from Zones 3 and 4 to higher ground, thus increasing the density of the mammals in these zones. It would be expected, then, that the percentage of small mammals trapped in these habitats would be greater, as would trap success. Likewise, the percentage of small mammals trapped in the riparian habitats would decrease in comparison to the 1982 study.

APPENDIX A

Small mammal trap results* by habitat type, Colorado River, August 1982.

Species	Habitat			
	Salt Cedar	Willow	Mesquite/Acacia-Desert Scrub	Total
Peromyscus eremicus	12 (30%)	13 (33%)	15 (37%)	40
Peromyscus maniculatus	5 (100%)	0	0	5
Peromyscus boyleii	3 (100%)	0	0	3
Peromyscus crinitus	1 (25%	0	3 (75%)	4
Peromyscus intermedius	0	0	1 (100%)	1
Neotoma albigula	2 (29%)	2 (29%)	3 (43%)	7
				60

*800 trap nights total, 60 mammals captured = 7% trap success.

Distribution of Beaver in the Grand Canyon: Lee's Ferry to Diamond Creek, Summer 1983

by George Spears

These observations of the distribution of beaver in the Grand Canyon took place from July 29 to August 7. Since the raft the observer was using was not free to search for other tangible evidence of a colony, such as the actual burrow or gnawings on food supplies, the observer depended solely on ground proofing---the drag marks of the tail and accompanying footprints, ending in a slide mark into the water. The raft was usually in mid-stream when sightings were made which led the observer to be conservative in his count; any doubtful markings were not included in the count, and in almost every case he asked another person on the raft to corroborate the sighting.

The observer had read Ruffner's report[1] and had talked to Mr. Ruffner about his findings. Ruffner had found that the Grand Canyon beaver (Castor canadensis) colonies were always found where there was a supply of coyote willow (Salix exigua Nutt.). This observer found coyote willow on or near every beach where he saw markings.

Ruffner made two censuses, one in 1979 and one in Februrary, 1983, before the high water (90,000 cfs) releases from Glen Canyon Dam. The tallies and comparisons of those two surveys can be found in Table 10-2 of his report.[2] The chief purpose of this current report is to suggest the effect of said high water on the distribution of the beavers. The results of the July-August observations are found in Table 10-1. Note that no colonies were sighted between R.M. 69.1 and R.M. 165.6 --- the

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[1]George A. Ruffner, "Abundance and Distribution of Beaver and Coyote Willow in the Grand Canyon," Report submitted to the Resource Management, Grand Canyon National Park, May, 1983.

[2]Ibid., p. 12.

Table 10-1. Distribution of beaver (Castor canadensis) burrow complexes based on ground-proofing observations, Grand Canyon National Park, Arizona. Sightings were between Lee's Ferry and Diamond Creek, July - August, 1983.

AREA	DATE	NO. OF SIGHTINGS
R.M. 1.8 - 10.0	29 July	16
R.M. 23.0 - 51.5	30 July	11
R.M. 52.5 - 69.0	1 August	13
R.M. 165.7 - 172.7	5 August	1
R.M. 172.7 - 212.7	6 August	15
R.M. 212.7 - 214.1	7 August	2
	TOTAL	58

Inner Gorge. In this area there was very little or no evidence of coyote willow or other plants necessary to beaver colonization, and the rock that formed the banks had a high resistivity, supporting Ruffner's observations.[3]

How these sightings compare with Ruffner's are shown in Table 10-2. Note the sightings in the summer of 1983 began at R.M. 1.8 as compared to R.M. 20.0 in Ruffner's report. Perhaps the high water in the spring of '83 forced the animals closer to Lee's Ferry as the beaches further down stream were carried away and the liveable areas were inundated. Whenever the water returns to pre-flood levels (7,000 - 28,000 cfs), perhaps another census should be made to see if the colonies remain or return down river.

Ibid., p. 9.

Table 10-2. Comparison of the number of sightings of beaver (*Castor canadensis*) burrow complexes between the spring, 1983 (before the high water) and summer, 1983 (after high water), Grand Canyon National Park, Arizona. Data were gathered between Lee's Ferry (R.M. 0) and Phantom Ranch (R.M. 87.6).

SPRING SIGHTINGS	AREA	SUMMER SIGHTINGS
0	R.M. 0 - R.M. 19.0	16
3	R.M. 19.0 - R.M. 37.6	1
11	R.M. 37.6 - R.M. 47.3	1
14	R.M. 47.3 - R.M. 58.3	13
9	R.M. 58.3 - R.M. 65.6	9
9	R.M. 71.9 - R.M. 76.5	1
46	TOTAL	41

HUMAN IMPACT ON THE BEACHES OF THE COLORADO RIVER

Steven W. Carothers, Dennis M. Walsh, Marilyn Johansson, Fern T. Spears

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 system 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 1950's. 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 has been 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 Lee's Ferry to Diamond Creek (NPS 1981). The high waters and ensuing floods of 1983 has 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, vegetative and animal community composition and overall ecosystem stability relative to b) determining and evaluating the impacts of river recreationists[1] on the changing aquatic and terrestrial systems and c) mitigating such recreational impacts to the extent that natural park values are not compromised.[2]

As mandated by "The Planning Process of the National Park Service" in 1975, a Colorado River Management Plan (NPS 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 baseline data and to 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, vegetation density and diversity (Burden and Randerson 1972; Whitson 1974; Dolan et al. 1974; Bates 1935; Dotzenko et al. 1967; LaPage 1967; Liddle 1975; Liddle and Greig-Smith 1975; Young and Gilmore 1976). Preliminary data from Grand Canyon (Carothers and Aitchison 1976) indicated

[1]The definition of river recreationists here is expanded to include non-river running back country users who frequently utilize and potentially impact river beach campsites.

[2]On the Colorado River in Grand Canyon, Glen Canyon Dam has so altered the system, that an ecological/aesthetic definition of naturalness is not apparent.

that similar changes or impacts were taking place on the principal campsites (100 + popular campsites; Borden 1976) 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 back country campsites where recreational use is clearly in excess of the natural purging capacity of the system.

The 1983 floods have cleaned the beaches, resorted the sand, and given the system a fresh start. Along with this cleansing, new beaches have formed and others are gone. The 1983 study will establish important baseline data for future investigations.

Early in 1976, approximately 25 Colorado River campsites in Grand Canyon were selected for the purpose of monitoring levels of recreational impact (see Carothers 1977). In 1980-81, 9 additional beaches in the 15 miles of Glen Canyon below Glen Canyon Dam were evaluated for levels of human impact (Carothers et al. 1981). Since 1976 the original Grand Canyon sites have been monitored and re-evaluated several times (Carothers and Johnson 1980). In 1982 human impact data for 35 beach sites in Glen and Grand Canyons was presented and compared with the results of previous sampling efforts.

This report presents human impact data for 22 Grand Canyon beach sites, including 17 of the beaches evaluated in 1982 and 5 new beaches. 11 of the original beaches are no longer campable and were dropped from this study.

OBJECTIVES

The specific objectives of this study in 1983 were to establish new baseline data on the beaches composed of cleansed and resorted sand. The amount of litter and charcoal particles (greater than 1 cm. in size) found along transects of the beach surface was measured and the amount of sand discoloration was determined. Future studies can then be compared with this data to monitor levels of recreationally related debris into major river campsites. The transects were photographed so that the same areas can be sampled in future studies.

MATERIALS AND METHODS

1. A 40 m transect line was established through the principal use area of the beach. The first choice was to use the exact same line as the previous years. If the beach was altered so much by the floodwaters as to change patterns of use, a new transect line was established. At several sites, the transect was taken in two sections. This is documented.

2. Black and white photographs of the transect, including the metric tape and river mile marker, were taken from each direction. It was found that the mile number for the inclusion in the photograph of the transect could be written on the back of the data sheet with a wide-tipped blue or green permanent marker. A fine-tipped black permanent marker worked best for recording data. The sheet with the mile number was clipped to a clipboard and either held by a person or positioned in the sand for the photographs.

3. Along each transect line, 10 - 1 m^2 plots were selected as follows:

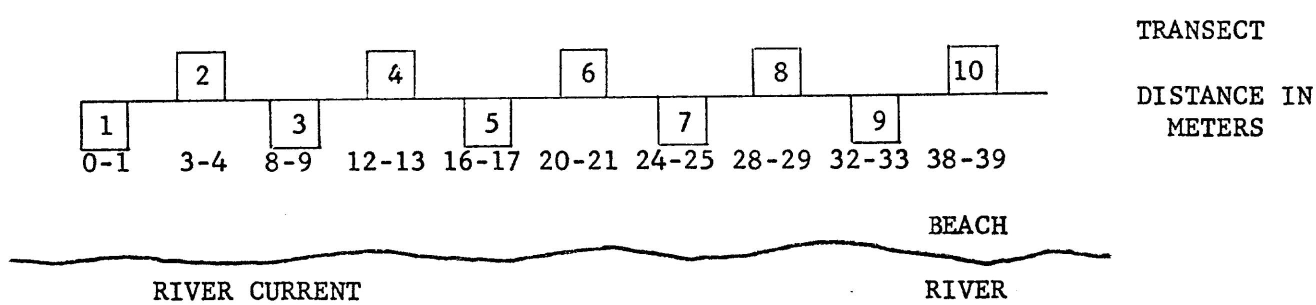


Figure 11-1

Sample 1 always began upstream, on the river side. Samples 1,3,5,7,9 were taken on the river side of the transect. Samples 2,4,6,8,10 on the bank side of the transect. See Figure 11-1.

4. In addition, a sample from the beach at the sand and water interface and a sample from the terrace was taken. In 1983, it was not necessary to include a beach sample as it was clear that all the sand at the site was newly deposited.

5. Each m^2 sample was inspected for human litter and charcoal, and sand samples from the surface were taken.

6. Each sand sample was sifted through a 150 micron stainless steel mesh in the apparatus shown in Figure 2 until the amount of sifted material completely covered the bottom.

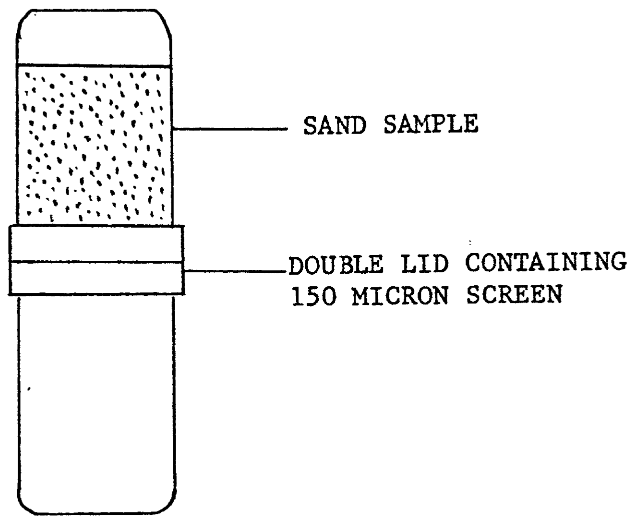


Figure 11-2

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

8. The filter paper was removed and stored in a labelled petri dish.

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 (Figure 11-3).

10. The Colorguard II Reflectometer is an instrument operating with an optical system, photocell amplifier, digital readout and portable power system, and is used to make reflective measurements. Hence, with a digital readout 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 grey standard to calibrate the instrument.

11. Means and standard deviation of the reflectometer readings from the 10 samples along with each transect were calculated. These were statistically analyzed and compared with the 1982 data and subjected to a small sample T test of .05 level of significance to determine if a significant difference in the 1982 and 1983 data existed. A computer program with all this information is available for future studies.

RESULTS

The results of the sand sampling are presented in Table 11-1 where the values recorded for the sand discoloration (reflectometer readings)) charcoal accumulation and human debris are presented for each of 22 campsites, including the common name of the camp and river mile location.

It is apparent from a comparison of 1982 and 1983 data on charcoal, that charcoal is essentially non-existent in the samples. The dramatic decrease in the presence of charcoal must be attributed to the cleansing and resorting of beach sand by the 1983 flood waters. What is impressive about the 1983 results is that there is no evidence of charcoal being carried from one site and re-deposited at another. All the Grand Canyon beaches are essentially free of charcoal (See Table 11-1).

At Shinumo Beach, Mile 29, a band of fine dark sediments was visible in the sand. This was suspected to be a deposit of finely ground charcoal, but upon analysis was found to be magnatite which produced no discoloration of the filter paper.

The presence of human litter was also essentially non-existent at our sample sites. These findings were also attributed to the cleansing and resorting of the sand by the 1983 flood waters (See Table 11-1).

The reflectometer readings were consistently high, indicating clean sand. Significant differences, indicating cleaner sand, were found at 15 of the 17 sites for which 1982 data was available. A look at the means of the two sites which did not show significant differences also indicated cleaner sand. The reflectometer readings at the 5 new sites sampled were comparable to those at the other 17 sites. Again, the observable differences in the 1983 data was attributed to the cleansing and resorting of beach sand by the 1983 flood waters. See Figure 11-4 comparing 1983 sand discoloration values with 1982 values.

Figure 11-5 shows the variation of reflectometer readings at 4 sites. It is hypothesized that low reflectometer readings at sample sites may coincide with kitchen areas on the beaches.

Several sites yielded terrace samples, from areas undisturbed by human activity, but which produced reflectometer readings significantly lower than the readings from the beach sand. These observations were very obvious at Dubendorff and at Poncho's Kitchen. It is interesting to note that those sites were also the only ones that did not yield significant differences in the reflectometer reading between 1982 and 1983. The terrace sample contained fine silt or clay particles and this material was observed to be washing down onto the beach. The samples at Dubenforff (1 and 2) which were in this wash area gave lower reflectometer readings.

The presence of silt, clay, or natural organic materials in beach sand may be a natural source of beach sand discoloration. If so, beaches may show a natural discoloration as this material is incorporated into the sand. Some beaches, for example, Dubendorff, may be more likely to undergo natural beach sand discoloration than others. It is mentioned here because it must be considered as a factor before all sand discoloration is attributed to human use.

The results of the 1983 study of human impact on Grand Canyon beach campsites indicate that new baseline data has been established. The results from the cleansed and resorted sands can be compared in future studies to determine if degradation caused by human use exists. Trends indicating overuse or misuse of the resource can be identified before the changes affect the aesthetic quality of the beaches.

TABLE 11-1. Results of Human Impact Analysis on Beach Campsites in Grand Canyon, August 1983 (means only)

Camp-site No.	Camp-site Name	River Mile	Sand Dis-coloration 1982	Sand Dis-coloration 1983	Std. Dev.	Sig. Diff.	Charcoal ("1 cm)/m^2 1982	Charcoal ("1 cm)/m^2 1983	Human Litter/m^2 1982	Human Litter/m^2 1983
1	Badger	8.0	64.6	71.65	1.65	Yes	10.7	0.8	0.4	0.1
2	Twenty-Mile	20.0	58.8	66.74	3.53	Yes	1.0	0.1	0.5	0.0
3	Shinumo 1	29.0	62.9	70.01	3.00	Yes	1.0	0.0	0.5	0.0
4	Anasazi Bridge 2	43.0	64.8	73.28	1.24	Yes	0.2	0.0	0.1	0.0
5	Nankoweap	52.0	59.5	73.21	2.33	Yes	9.0	0.0	0.0	0.0
6	Awatubi	59.0		72.4	1.34			0.0		0.0
7	Chuar 3	66.0	57.5	70.66	.83	Yes	1.1	0.1	0.4	0.0
8	Unkar	72.0	64.3	68.93	2.67	Yes	1.9	0.0	0.1	0.0
9	Nevills	75.0	66.9	72.0	1.91	Yes	0.7	0.0	0.2	0.0
10	Grapevine	81.0		71.91	1.43			0.0		0.0
11	Granite 4	93.0	58.0	68.2	2.49	Yes	3.0	0.0	0.2	0.1
12	Lower Bass	108.0	59.4	66.53	2.39	Yes	3.6	0.0	1.2	0.1
13	Forster 5,6	123.0		70.04	3.05			0.0		0.0
14	Dubendorff	131.0	64.4	69.12	3.36	No	1.2	0.0	0.3	0.0
15	Deer Creek 7	136.0	62.0	67.82	2.03	Yes	4.7	0.2	2.5	0.1
16	Pancho's Kitchen	137.0	62.3	65.91	3.11	No	1.6	0.0	1.3	0.0

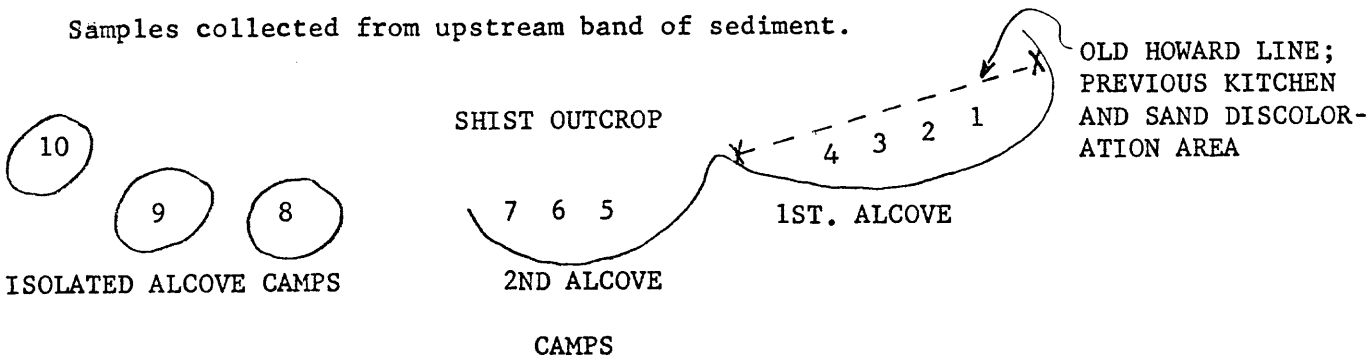
Campsite No.	Campsite Name	River Mile	Sand Discoloration 1982	Sand Discoloration 1983	Std. Dev.	Sig. Diff.	Charcoal ("1 cm)/m^2 1982	Charcoal ("1 cm)/m^2 1983	Human Litter/m^2 1982	Human Litter/m^2 1983
17	Upper National	166.0	59.2	71.22	.96	Yes	0.8	0.0	5.6	0.0
18	Upper National B	166.0		69.39	2.73			0.0		0.0
19	Lava Falls	179.0	60.8	69.39	2.60	Yes	2.6	0.3	0.2	0.0
20	Granite Park 8,9	209.0	60.4	69.7	3.78	Yes	7.7	0.0	0.3	0.0
21	Pumpkin Bowl	212.0		73.66	.94			0.0		0.0
22	220 Mile	220.0	62.3	67.5	2.61	Yes	13.8	0.0	0.4	0.0

1. Samples 6 and 8 contained about 50% rocks.

2. Only 5 samples taken at Anasazi Bridgè, no transect.

3. Charcoal present in a windrow 2-3m from transect.

4. Camp greatly eroded since last sampling; cannot get a 40m straight line.
Samples collected from upstream band of sediment.



5. Sample 10 contained silt and produced a lower reflectometer reading.

6. Transect A (samples 6-10) begins with 0 in upstream, 31.5m from Tamarisk.

/. Sample 6, 0-1m; 7, 4-5m; 8, 8-9m; 9, 12-13m; 10, 18-19m.

7. No transect, charcoal noted about site.

8. Transect line 34m to willow tree, shot off boll.

9. Small pieces of charcoal evident in windrow on beach.

Figure 11-3.

SAND DISCOLORATION DATA SHEET

DATE________________

TIME________________

RIVER MILE__________

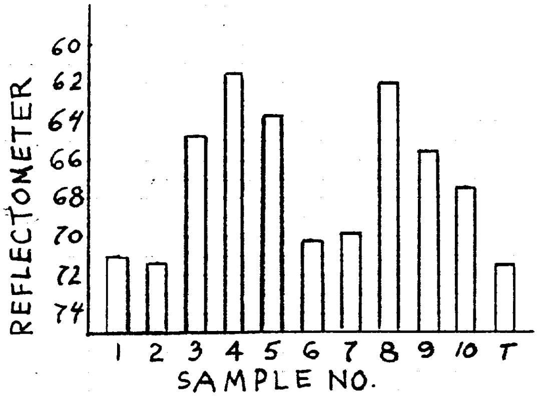
NAME________________

DISTANCE	SAMPLE	SAND DISC.	CHARCOAL 1cm/m^2	HUMAN LITTER/m^2
	Calibration			
	Filter Paper			
	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	Beach			
	Terrace			
	Other			
	Mean			
	Std. Dev.			

NOTES:

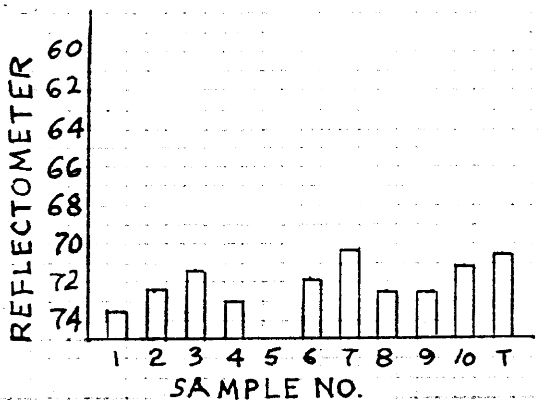
Figure 11-5: VARIATION IN REFLECTOMETER VALUES AT FOUR SITES

20 MILE BEACH

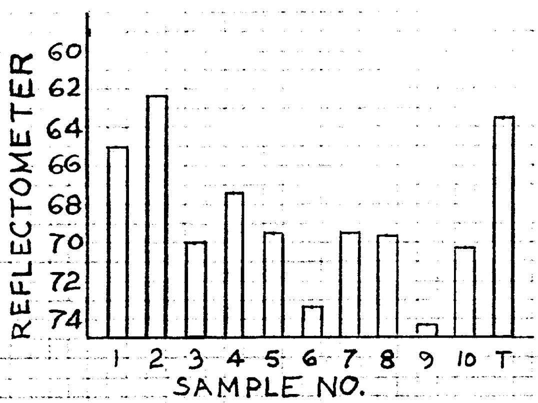


NOTE: SAMPLE NO. 8 LOCATED UNDER TAMARISK

AWATUBI BEACH

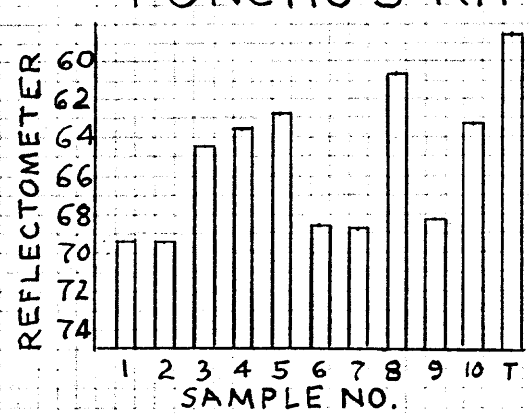


DUBENDORFF



NOTE: SAMPLES 1 AND 2 CONTAINED CLAY AND/OR SILT FROM TERRACE

PONCHO'S KITCHEN



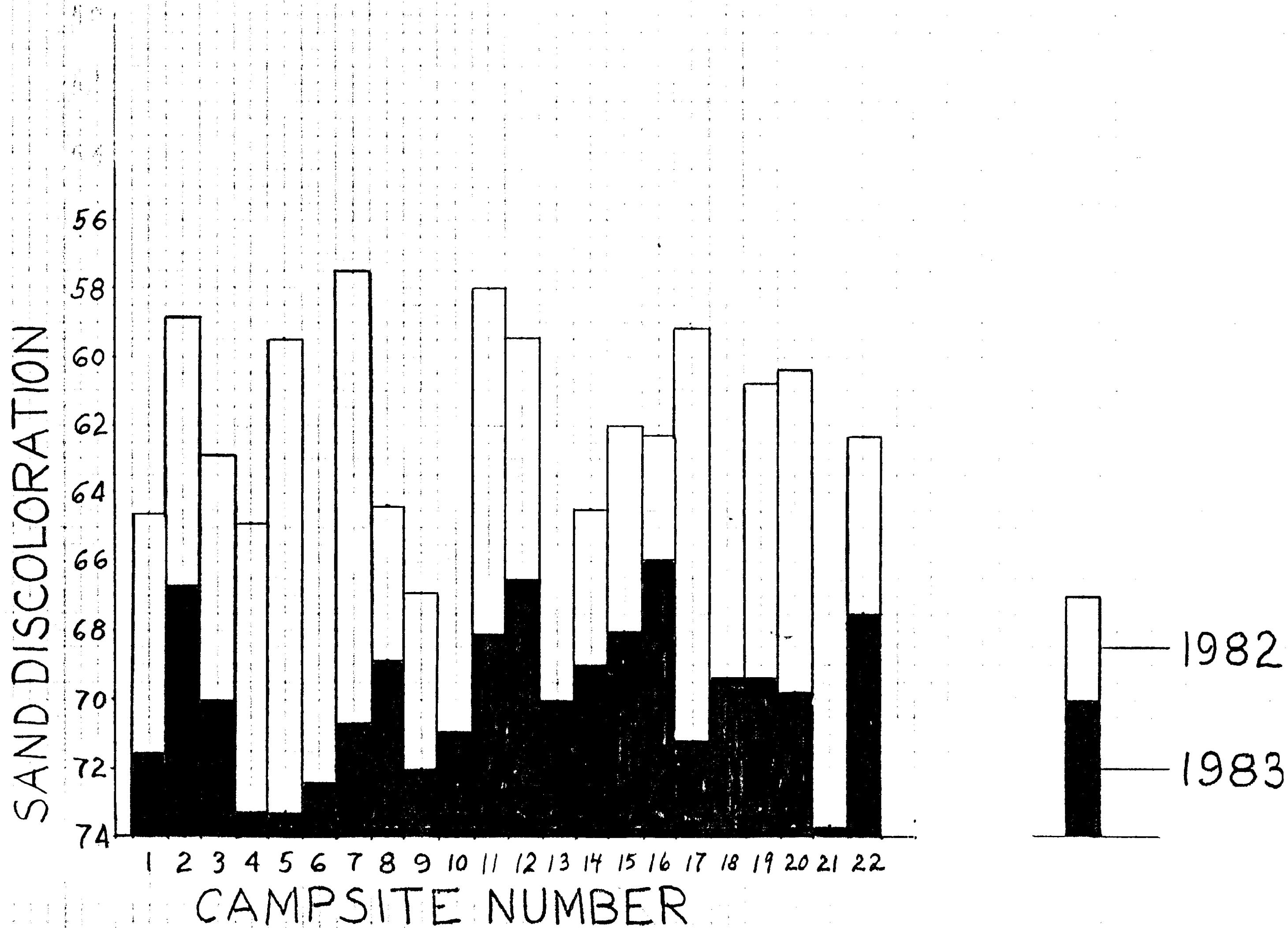

SAND DISCOLORATION
56
58
60
62
64
66
68
70
72
74
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
CAMPSITE NUMBER
1982
1983

Figure 11-4

CHAPTER 12. RIVER EXPEDITION REPORT: SOCIOLOGICAL DATA, SUMMER, 1983

by M.R. Johansson

INTRODUCTION

This report summarizes field notes compiled during a Grand Canyon River expedition. This notes were compiled according to instructions for National Park Service (NPS) Patrol trips. The instructions, taken from the NPS Sociological Data Collection Handbook are available from the Division of Resources Management. Data gathered include details on daily river contacts (river-river, river-shore, and shore-river) plus camp contacts (shore-shore) and aircraft encounters. In addition, the trip schedule including locations of all camps and research site locations is also presented herein.

SCHEDULE

Since this was a research project involving students and faculty from Northern Arizona University, a large number of stops (26) were made compared to normal river trips, solely for the purpose of conducting necessary tests and research activity. These stops are identified in the Trip Schedule at Table 12-1 as Beach Research (BR). Seven more of these research stops were made coincident with camping for a total of 33. Five stops also occurred to survey rapids, two stops specifically for lunch and one for phone calls (Phantom Ranch). A total of 42 stops, including Diamond Creek (exit) were recorded. All camp stops were for a single night except at Nankoweap and Forster Canyon were a two night stop occurred to accomodate a full day of geological research in those areas.

Table 12-1. Trip Schedule 29 July - 8 August 1983

Stop No.	Location	River Mile	Arrive Time	Arrive Day	Depart Time	Depart Day	Reason for stop
0	Lees Ferry	0			1255	1	Start
1	Badger Creek	8	1355	1	1608	1	BR, L
2	Beach	18.2	1720	1	1730	1	BR
3	20 Mile Beach	20	1745	1	0920	2	BR, C
4	Shinumo Wash	29	1015	2	1108	2	BR
5	Nautaloid Canyon	34.8	1155	2	1440	2	BR, L
6	Anasazi Bridge	44.5	1600	2	1625	2	BR
7	Nankoweap	52.2	1730	2	0800	4	BR, C
8	Awatubi	59.8	0850	4	0920	4	BR
9	Above Little Colorado	61.5	0940	4	0955	4	BR
10	Below Little Colorado	61.8	1010	4	1138	4	BR
11	Lava Canyon (Chuar)	65.5	1210	4	1410	4	BR, L
12	Unkar Creek	72	1450	4	0900	5	BR, C
13	Neville's (75 Mi. Cr.)	75	0930	5	0958	5	BR
14	Hance	76	1020	5	1035	5	Rapids
15	Grapevine	81.5	1109	5	1345	5	BR, L
16	Phantom Ranch	87.5	1425	5	1633	5	Phone
17	Granite Rapids	93.4	1740	5	0835	6	BR, C
18	Crystal Rapids	98.2	0940	6	1000	6	Rapids
19	Crystal Rapids	98.6	1010	6	1048	6	Rapids
20	Lower Bass	108.	1158	6	1221	6	BR
21	Hakatai Camp	109.4	1230	6	1336	6	BR, L
22	Beach	113	1355	6	1421	6	BR
23	Blacktail Canyon	120	1510	6	1734	6	BR
24	Forster Canyon	122.8	1756	6	0710	8	BR, C
25	Fossil Rapid	124.3	0723	8	0815	8	BR
26	Beach	131	0858	8	0950	8	BR
27	Dubendorff Rapid	132	0956	8	1020	8	BR
28	Deer Creek	136	1048	8	1104	8	BR
29	Poncho's Kitchen	137	1115	8	1128	8	BR
30	Matkatamiba Canyon	147.6	1229	8	1336	8	L
31	Ledges Camp	151.5	1400	8	1445	8	BR
32	National Canyon	166	1615	8	0845	9	BR, C
33	Above Lava Falls	179.7	1015	9	1020	9	Rapids
34	Below Lava Falls	179.9	1025	9	1033	9	Rapids
35	Lava Falls Beach	180	1038	9	1116	9	BR
36	Beach	181	1123	9	1226	9	BR
37	Beach	188	1342	9	1414	9	L
38	Whitmore Wash	190	1423	9	1505	9	BR
39	Granite Park	208.9	1630	9	0907	10	BR, C
40	Pumpkin Bowl	212	0933	10	1005	10	BR
41	Beach	220	1050	10	1116	10	BR
42	Diamond Creek	225	1210	10			

BR - Beach Research
C - Camp
L - Lunch
Rapids - to survey rapids and/or take pictures

CONTACTS

Contacts with groups totaled 38. The majority of the contacts were made with commercial motor-powered craft. Enroute many of the contacts were shore to river because of the stops for beach research. Repeated contacts were made with three motor and one oar group. The largest number of contacts on any one day was on day 8 in the vicinity of Deer Creek. A summary of group contacts by day is presented in Table 12-2. Grand totals for the trip are (P-private, C-commercial, T-total) as follows:

River-river			River-shore			Shore-river			Totals		
P	C	T	P	C	T	P	C	T	P	C	T
1	4	5	2	13	15	1	17	18	4	34	38

There were contacts with 26 motor-powered craft and 12 oar-powered craft.

Table 12-2. Group Contacts

Day	Distance Covered	River Mile		River-River			River-Shore			Shore-River			Total		
				P	C	T	P	C	T	P	C	T	P	C	T
1	20	0 to	20	0	1	1	1	1	2	0	1	1	1	3	4
2	32.2	20	52.2	0	0	0	0	3	3	0	0	0	0	3	3
3	0	at 52.2		0	0	0	0	0	0	0	0	0	0	0	0
4	19.8	52.2	72	1	0	1	1	0	1	1	0	1	3	0	3
5	21.4	72	93.4	0	2	2	0	1	1	0	3	3	0	6	6
6	29.4	93.4	122.8	0	0	0	0	1	1	0	1	1	0	2	2
7	0	at 122.8		0	0	0	0	0	0	0	3	3	0	3	3
8	43.2	122.8	166	0	1	1	0	6	6	0	7	7	0	14	14
9	42.9	166	208.9	0	0	0	0	1	1	0	1	1	0	2	2
10	16.1	208.9	225	0	0	0	0	0	0	0	1	1	0	1	1
	GRAND TOTALS			1	4	5	2	13	15	1	17	18	4	34	38

Note: P - Private

C - Commercial

T - Total

AIRCRAFT

The rule used for recording the aircraft encounters was that the aircraft could be seen, heard or both. The motor on our pontoon raft made it difficult to hear planes which would probably be quite distinct to someone on an oar-powered craft. The casual high-altitude or military aircraft passage was not recorded (as being a normal phenomenon, on or off river). Aircraft encounters were high on days 6, and 7 Granite Rapids (mi. 93.4) to Forster Canyon (mi. 122.8) especially due to the fact that we camped and spent the day at Forster Canyon (mi. 122.8) in the path of the scenic flights heading for Lava Falls. Encounters were also high on day 9 when we covered mi. 166 to 208 which included Lava Falls. A summary of encounters by day is presented in Table 12-3. Grand totals are as follows:

Single Engine	Multi-engine	Helicopter	Total
51	72	15	138

CAMPSITES

At camp stops we were alone four nights. Four other nights we could see the boats or campfire of another group, and one night we camped right next to a commercial group.

AVERAGES

A series of averages for daily and group contacts and aircraft encounters are presented in Table 12-A. Total average group contacts were 3.8 per day and total average aircraft encounters were 13.8 per day.

Table 12-3. Aircraft Encounters

Day	Distance Covered	River Mile	Single Engine	Multi-Engine	Helicopter	Total
1	20	0 to 20	0	0	0	0
2	32.2	20 52.2	2	1	0	3
3	0	at 52.2	4	4	0	8
4	19.8	52.2 72	2	1	1	4
5	21.4	72 93.4	7	2	8	17
6	29.4	93.4 122.8	15	12	4	31
7	0	at 122.8	9	29	0	38
8	43.2	122.8 166	4	1	2	7
9	42.9	166 208.9	8	20	0	28
10	16.1	208.9 225	0	2	0	2
GRAND TOTALS			51	72	15	138

Table 12-4. Averages of Group and Aircraft Encounters

1. Group Contacts Per day - total trip

River-River			River-Shore			Shore-River			Total		
P	C	T	P	C	T	P	C	T	P	C	T
.1	.4	.5	.2	1.3	1.5	1.	1.7	1.8	.4	3.4	3.8

2. Aircraft Encounters Per day - total trip

Single Engine	Multi-Engine	Helicopter	Total
5.1	7.2	1.5	13.8

Poem

by

Betty Byars

Time flows through rock
    (sediments deposited in ancient oceans and
    along river deltas; outpourings of magma)
like water flows in a river
    (a river that cuts a canyon revealing
    the ancient rock layers)
both flow in the Grand Canyon.
Life begins, adapts, evolves...
I guess that I love this place as much as the
trilobites did when they lived here.
Right here where I'm standing in Bright Angel Shale,
watching a whiptail lizard hunt harvester ants.

City Vagabond

by

Dale Dancis

City lights, busy streets, cars honking
sirens screaming
Hot crowded subways, traffic jams
People bustling going someplace
from somewhere.

I love the fast pace of New York City,
And spend a lot of time walking through
Central Park, Greenwich Village, the West Side
The neon lights of Broadway
Its exciting, envigorating and comfortable
Its home.

But come summertime I flee to the Canyon
Relax on the river and float like Huckleberry Finn -
Kick off my shoes, let my hair down and feel the
refreshingly cool waters of the Colorado River
I love the tranquility of the Canyon
And spend time walking through
the side canyons of National and Forester Canyon
The luminous stars and meteor showers
The musical canyon wrens
With each canyon experience
I become confident
and serene
This time I leave knowing I will
one day return.

The Desert

by

Patrick Hasenbuhler

The Desert

My home is the desert
so misunderstood.
Most consider it harsh
and grossly absurd.
The desert is living,
teaming with life,
from the thorns on the cactus
to the cactus mice.
This hot arid region
is truly my home.
I cherish the time
I spend in it, Alone.

And What of the River

The Canyon is truly
a remarkable place.
Here lives the tadpole
and the speckled Dace.
Yet feet, maybe inches
grow plants that are scorned,
waiting for water
that seldom ever falls.
Yet feet, maybe inches,
is the death of them all.

What have we to learn

Within the great abyss lies tales untold
of mountain of schist and oceans so old.
We study the fossils and traces of Life
that left long before the Great human race.
I wonder, will our effort to keep it in place
last as long as the Lava Dam Earth Mother Spate
The river cut through it in such a short time
and left the Havasupai good Gardens behind.

and What of Lake Powell, Mead and the others,
Will some unknown species yet underdeveloped
look at our traces and pick through our Bones
and call us all monsters or mysterious unknowns?
Our time here is limited and hers is so great,
The Grand Canyon is a most humbling place.

Rivers Revenge

Look down into the bowls of the Earth! There flows the Colorado, Looking so peaceful, serene, a ribbon of red in a chasm so Grand. They call it The Grand Canyon, and most seldom see the powerful force which caused it to be.

The Earth tried to trap her and for hundreds of miles, shows the scars of that effort, still cutting in deep. The next time you go to see that colorful ribbon, the Colorado, try rafting far down below. You will come to respect her and then you will know. There ain't No stopping the Colorado.

Thoughts upon Observing a Milennia of Time

by

Frank B. Lojko

Time ticks,
While the river carves its way.
Once brown, now blue--the river changes color.
Dark clouds burst above causing sediments and
Rocks to move as muddy water
Heads for the channel of flowing blue.

High, soaring in the blue sky, birds and insects fly
As animals search for a food supply and
Plants reach for the sun.

Time ticks,
While friends and foes come and go.
The Canyonland changes with each revolution of time:
Creatures know no time.
Pristine canyonland changes with time.
Only man can alter the events of time.

CANYON EMOTIONS

by

Wayde Nelson

Living, dreaming, and breathing the Grand Canyon
And its mighty river,
Deeper we drifted, aweing at the large walls of stone
Which stood before us,
Only the cliffs could reveal the true beauty of
Their Creator.

Moving quietly through this tremendous Canyon
We came upon a deathly quiet.
Looking ahead we were able to see the lips of a dragon
Spitting water high into the sky
And drooling over our raft.

As he did this he shot us several feet
Over massive cavities.
We could only plead with this dragon
We all call the Colorado.

Gripping violently to the raft
Many of us felt the real terror of life
For the first time,
Only to find peace at the end of the dragon's throat
With a hot meal along with a warm campsite.

THE RIVER TRIP

by

Dennis M. Walsh

The River carried me backwards into time.
I climbed the frozen sand dunes,
saw fossils from an ancient sea,
their mud bed cemented into layers of shale.
I gazed at limestone
hundreds of feet thick
laid upon the sea floor like so much dust
for millions of years.
And I drifted down to rock
that predates life itself.
I saw asbestos baked from limestone;
great flows of lava and cones of cinder
and was brought back to the present
by the rage of her rapids
and the timeless beauty of her splendid rocks.
My emotions
chilled to embers by demands of modern life
were stoked and fanned by this long drink
   of primeval spirits.
I was re-created.