REDFISH PASS INLET MANAGEMENT PLAN

Submitted To:

Captiva Erosion Prevention District

Submitted By:

Coastal Planning & Engineering, Inc.
2481 NW Boca Raton Boulevard
Boca Raton, FL 33431

August 1995

REDFISH PASS INLET MANAGEMENT PLAN

TABLE OF CONTENTS

REDFISH PASS INLET MANAGEMENT PLAN

TABLE OF CONTENTS
(cont.)

List of Figures

Figure No.

REDFISH PASS INLET MANAGEMENT PLAN

TABLE OF CONTENTS

List of Figures
(cont.)

Figure No.

List of Tables

Table No.

REDFISH PASS INLET MANAGEMENT PLAN

TABLE OF CONTENTS

List of Tables
(cont.)

List of Photographs

REDFISH PASS INLET MANAGEMENT PLAN

TABLE OF CONTENTS

List of Photographs
(cont.)

List of Appendices

REDFISH PASS INLET MANAGEMENT PLAN

I. INTRODUCTION

A. Authorization

At their May 1, 1991 public meeting, the Captiva Erosion Prevention District (CEPD) authorized Coastal Planning & Engineering, Inc. of Boca Raton, Florida to prepare an inlet management plan for Redfish Pass. This plan was prepared according to the guidelines established by the State of Florida Department of Natural Resources Inlet Management Program.

B. Purpose

The inlet management plan analyzes Redfish Pass to determine if the inlet is a significant cause of beach erosion. The plan addresses the extent to which the inlet causes beach erosion and provides recommendations to mitigate its erosive impacts. A number of mitigative actions were considered including inlet sediment bypassing, channel dredging, jetty design, disposal of spoil material, establishment of feeder beaches, beach restoration and beach nourishment, and innovative techniques which are capable of mitigating erosive impacts. Cost estimates necessary to implement corrective measures were developed along with recommendations regarding cost sharing among the beneficiaries.

Additionally, the legislature (S. 161.142, Florida Statutes) recognized the need for maintaining navigation inlets to promote commercial and recreational uses of coastal waters and their resources. The legislation also recognized that inlets alter the natural sediment transport and required that all maintenance dredged sand, or an equivalent quality and quantity of sand from an alternate location, be placed on downdrift beaches. The quantity of sand placed on the downdrift beaches should be equal to the net annual longshore sediment quantity transported.

C. General Description

Lee County is located on the Gulf of Mexico in Southwest Florida, approximately 90 miles south of the entrance to Tampa Bay. The 44-mile county coastline consists of a series of barrier islands separated from each other by passes (tidal inlet connections) and from the mainland by shallow bays and tidal lagoons.

The Gulf shoreline of North Captiva Island is approximately 4 miles long and varies in width from about 200 feet near the lower middle portion of the island to about 2500 to 3000 feet throughout the northern half. Captiva Island is approximately 5 miles long and varies in width from about 200 feet near the south end to about 2000 feet between the center and north end. Natural ground elevations are generally under 10 feet NGVD.

Redfish Pass is bordered on the north by North Captiva Island and on the south by Captiva Island. The pass serves as a physical link from Pine Island Sound to the Gulf of Mexico.

Access to Captiva Island is primarily by car via toll bridge from the mainland. Captiva Island can be reached by travelling north along State Road 867 or by boat. North Captiva Island can only be reached by boat or small plane, as there is no vehicular access (Figure 1).

Redfish Pass is not maintained by either the Federal government or other local interests, though it has continued to remain open since 1921 or 1926 (depending on the reference source used). Local residents recall 1921 as the date of Redfish Pass opening; that date will be used in this report. The inlet maintains a width of approximately 600 feet (Walton, 1974) and swift tidal currents effect the local sediment transport along the adjacent beaches.

D. Scope

This report contains a discussion of the physical processes and natural resources of Redfish Pass and the surrounding area of influence. The extent to which the inlet causes beach erosion is analyzed in detail. The study includes a historical review of inlet changes and beach erosion and accretion patterns adjacent to the inlet.

The initial phase of the study involved the research and collection of available historical photographs, survey information and existing reports. Organizations contacted for information included the Captiva Erosion Prevention District; Florida Department of Natural Resources, Division of Beaches and Shores; Jacksonville District, U.S. Army Corps of Engineers; the University of Florida Coastal Engineering Archives; and the University of South Florida, Geology Department. Reference materials reviewed for this report and a list of aerial photographs, their dates, types and source are listed at the end of this report.

The collected information was analyzed and physical inlet characteristics are summarized in Section II of the report. Shoreline data were digitized and volumetric comparisons are included. The shoreline change rates as well as the volumetric change rates of both North Captiva Island and Captiva Island are used to develop a sediment budget.

E. Public Interest and Use

Redfish Pass is primarily used by recreational boaters. It is also utilized by commercial fishermen who depend on this open channel for their livelihood. Because Blind Pass (5 miles to the south) is much shallower and partially obstructed by a bridge, it is more

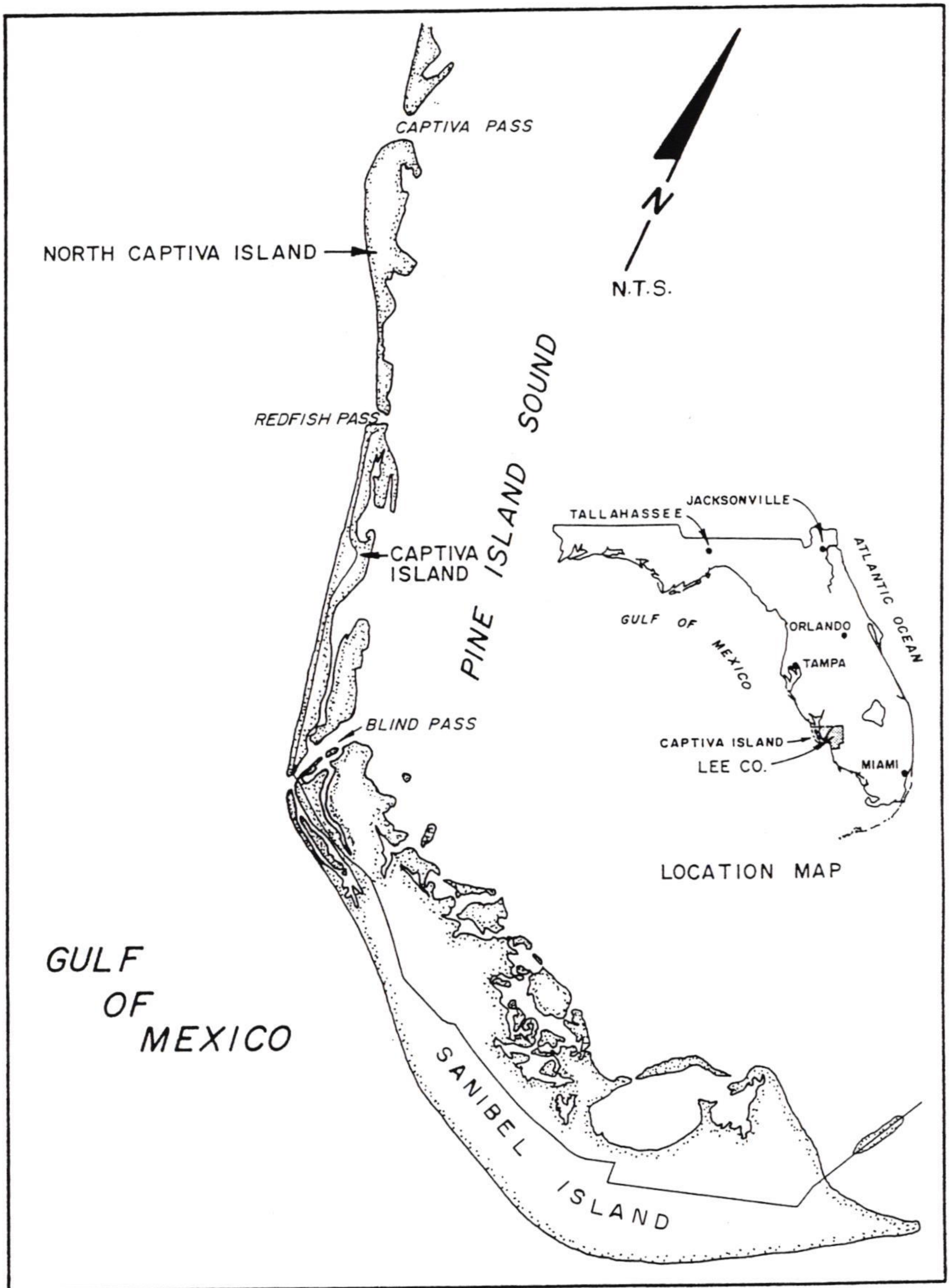


FIGURE I

REDFISH PASS LOCATION MAP

convenient and often safer for local fishermen to navigate through Redfish Pass out to the deeper Gulf waters.

Redfish Pass provides tidal flushing for Pine Island Sound, naturally exchanging estuarine water with the waters of the Gulf. The water quality of the inland basins is dependent on this daily tidal exchange with the Gulf of Mexico. This water circulation promotes the growth of a host of marine organisms that depend on the estuarine waters of the sound for protection, spawning grounds and other critical physiological factors. These organisms, in turn, help support the abundant fisheries resources of the Gulf of Mexico.

F. History of Redfish Pass

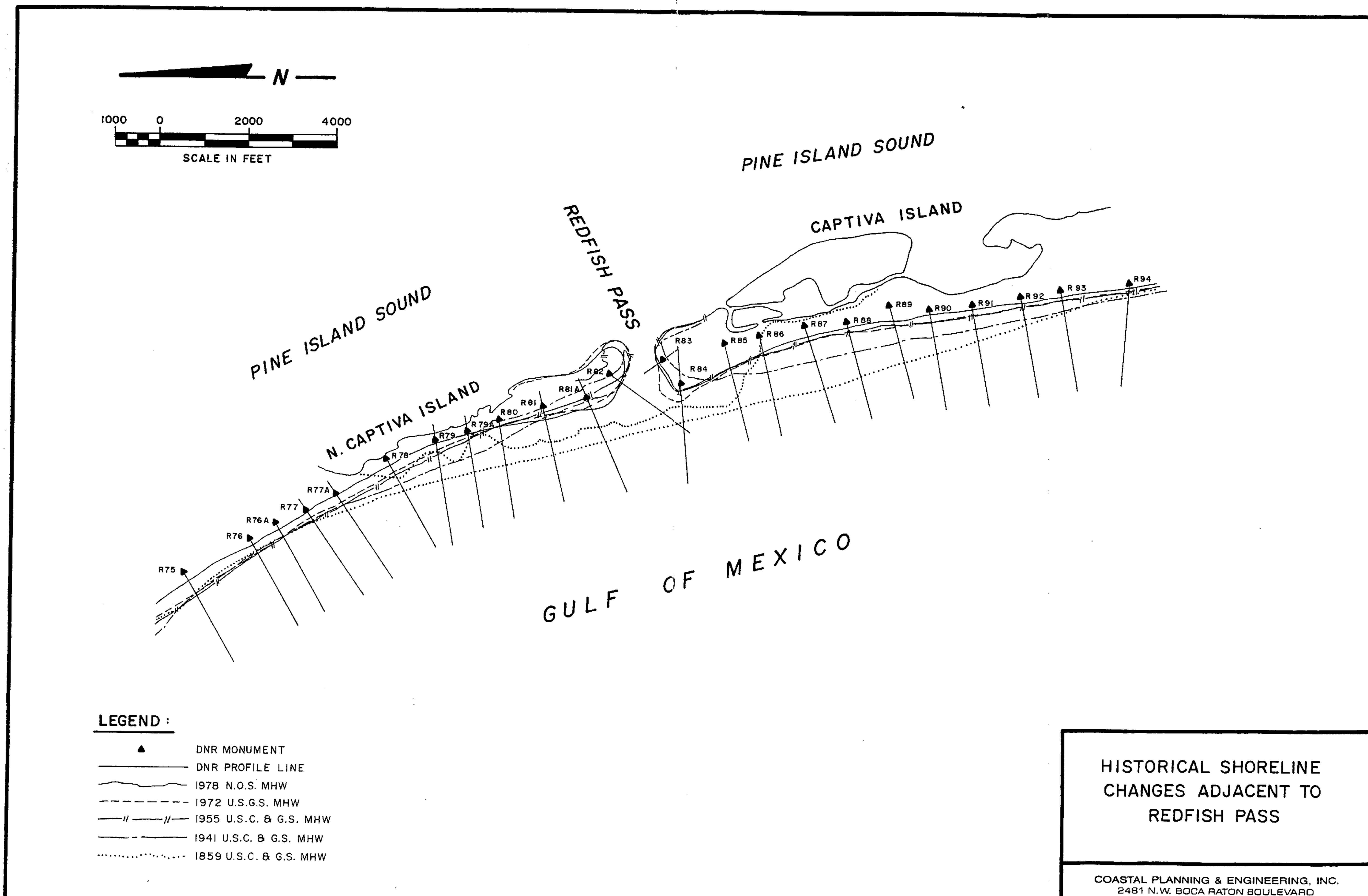
The earliest known history of an inlet in the vicinity of Redfish Pass was reported by Dormer (1979); on the John Lee Williams map of 1837, there is a "Bocca Secca" [Dry Mouth] between Captiva Island and Upper Captiva. This inlet was very narrow and did not appear on earlier maps. Apparently, this has filled in and washed out many times. It is possible that this was the "entrance" by which the Ponce de Leon expedition entered the environs of San Carlos Bay in 1513. Before 1921, there was a neck of land called The Narrows on Captiva.

The exact date Redfish Pass was opened is uncertain. In 1921, the area was hit by a major hurricane that tracked across the Florida peninsula and into the Gulf of Mexico. Five years later, in 1926, a second very powerful hurricane made landfall with a reported storm tide of +12 feet.

Previous reports (University of Florida, 1974) suggest that the 1926 hurricane created Redfish Pass. Local residents, however, indicate that the 1921 hurricane is responsible for the opening. For purposes of this report, we will use 1921 as the date in which Old Captiva Island was first breached and Redfish Pass was opened.

Presented in Figure 2 are the historical DNR mean high water (MHW) shoreline changes both north and south of Redfish Pass. This figure shows the morphological changes that took place following the initial opening of Redfish Pass. Most obvious was the resulting setback suffered by both North Captiva and Captiva Islands. During the early stages of Redfish Pass, tidal currents transferred large amounts of sand from the adjacent shorelines to the rapidly developing flood and ebb shoals of the pass offshore.

Since the initial opening in 1921, the beaches adjacent to Redfish Pass have been impacted by a large number of storms. Table 1 documents many of the significant storms. Photo No. 1 was taken in February 1944, prior to a hurricane occurring later that same year.



HISTORICAL SHORELINE CHANGES ADJACENT TO REDFISH PASS

COASTAL PLANNING & ENGINEERING, INC.
2481 N.W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431

FIGURE 2

Table 1

Historical Glossary of Large Storms

Year	Date	Name	Area	Intensity	Notes
1873	Oct. 5-7		Punta Rassa	Major	Punta Rassa destroyed, tide 14 ft.
1878	Oct. 21-22		SE coast	Minimal	
1882	Oct. 9-11		Near Cross City	Minimal	
1891	Aug. 24		SE coast	Minor	
1896	Oct. 8		Ft. Myers	Minimal	
1910	Oct. 17-18		Entire peninsula	Major	30 killed, damage $365,000.
1921	Oct. 25		West-central coast	Major	6 killed, damage $1,000,000.
1926	Sept. 18-20		NW Florida	Extreme	Miami bar. 27.61 in.; wind 138 mph.
1928	Sept. 16-17		Entire peninsula	Extreme	1836 killed, damage $25,000,000.
1935	Sept. 2-4		Keys, Taylor Co.	Extreme	Keys bar. 26.35 in.; wind 200+ mph.
1941	Oct. 20		Cedar Keys	Minor	10-15 in. rain.
1944	Oct. 18-19		Peninsula	Major	18 killed, damage $60,000,000.
1946	Oct. 7-8		West coast	Minimal	Tides high, damage $5,200,000.
1947	Sept. 17-18		South Florida	Extreme	Pompano bar. 27.97 in.; wind 155 mph.
1949	Aug. 26-27		South Florida	Extreme	2 killed, damage $45,000,000.
1950	Sept. 3-5	Easy	SW Florida	Major	Category 4. Winds to 125 mph.
1951	Oct. 2		SW coast	Minor	Damage $2,000,000.
1953	Oct. 9		SW Florida	Minor	Okeechobee City bar. 29.15 in.
1960	Sept. 10-12	Donna	SW Florida	Major	Opened Blind Pass directly to Gulf. Winds to 135 mph. Bar. 28 psi.
1962	Aug. 26	Alma	SE Florida	Minor	Brought higher than normal tides and storm surges to Florida's west coast.
1964	Aug. 27-28	Cleo	SE Florida	Minor	Hurricane lost strength before impact. Winds reported to 65 mph on Gulf coast.

Table 1

Historical Glossary of Large Storms
(cont.)

Year	Date	Name	Area	Intensity	Notes
1965	Sept. 7-9	Betsy	S. Florida	Minor	A category 3 storm. Winds to 130 mph. Passed south of Captiva 27.49°.
1966	Sept. 8-9	Alma	W. Florida from Key West to Panama City		Wind 115; Bar. 28.76
1968	Oct. 18-20	Gladys	S. Florida	Minor	Bar. = 28.52 in., wind = 80 mph.
1972	June 5-22	Agnes			Blind Pass broke through again, just south of Turner Park groin.
1982	Nov. 10-11	No Name Storm	SW Florida	Minor	Strong northeaster caused accelerated beach erosion on Gulf coast.
1985	Sept. 1-2	Elena	SW Florida	Major	Tempa. bar. 28.67 in. Winds to 125 mph.
1985	Oct. 26-Nov. 1	Juan	Gulf	Major	Winds 86 mph when it struck LA coast, travelling north from center of Gulf. Caused road damage in Captiva.
1988	Nov. 21-23	Keith	SW Florida	Minor	Hurricane downgraded to tropical storm before striking Gulf Coast. Central bar. 2- winds to 60 mph.

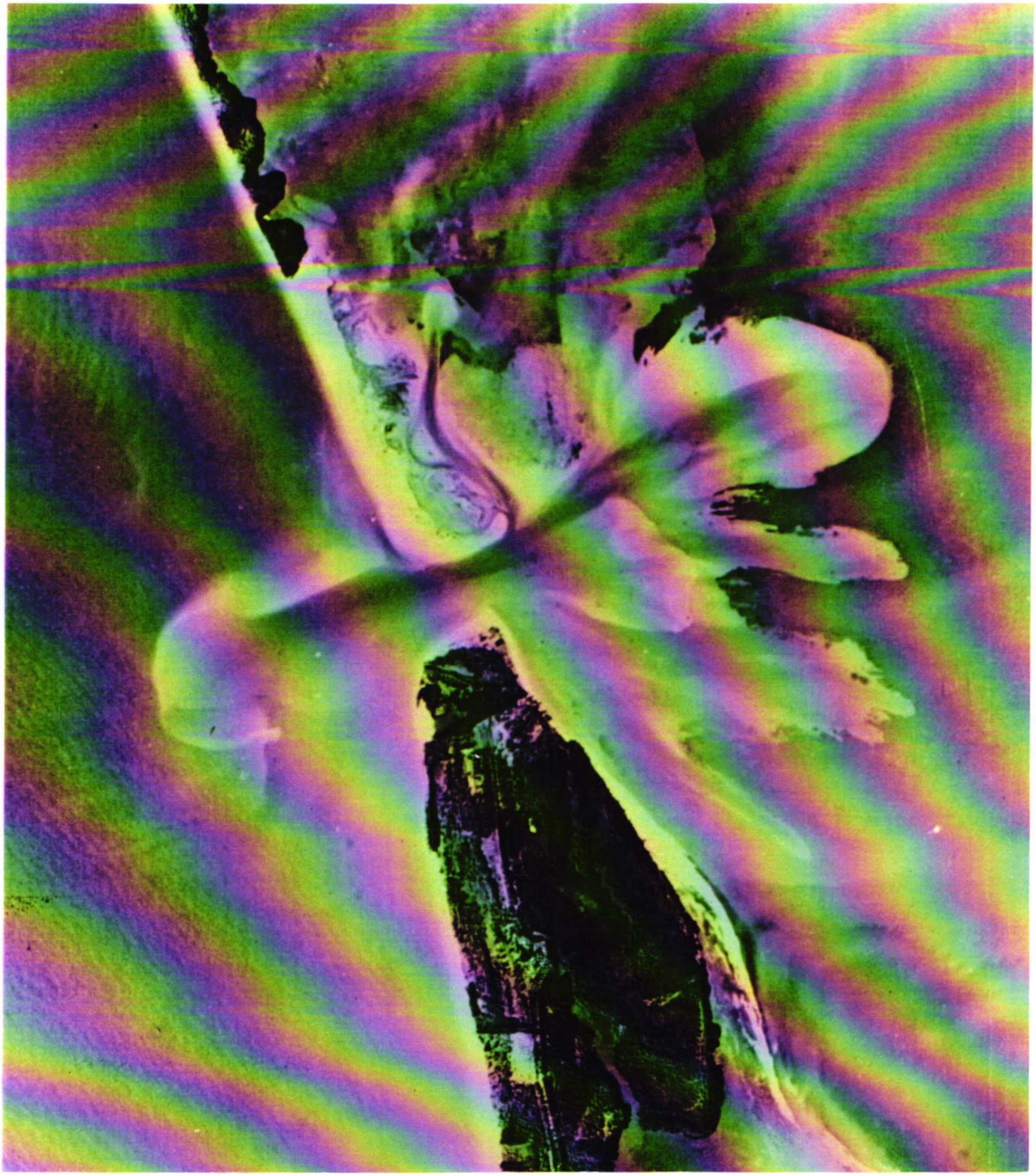


Photo No. 1: Aerial view of Redfish Pass (2/11/44).

Note the visibility of both flood and ebb shoals, and the recurved spit on North Captiva extending inward toward Pine Island Sound.

Photo No. 2, an aerial view of the Redfish Pass area, was taken in May 1952. Note that the inlet channel has become wider and more defined.

Photo No. 3 taken in October 1958, shows the continued development of the Redfish Pass flood shoal within Pine Island Sound. The adjacent beaches have built when compared to the previous photograph (Photo No. 2).

In 1960, Hurricane Donna swept across southwest Florida from September 10-12. Wind gusts recorded as high as 135 mph coupled with storm tides at least 4 to 5 feet above normal, resulted in the overtopping of the southern portion of North Captiva Island and the subsequent opening of five sluiceways 0.5 to 0.7 miles north of Redfish Pass (Photo No. 4). These five openings which closed soon after the storm subsided, resulted in small pockets of sediment accumulation on the backside of the island.

The earliest records of beach nourishment projects on Captiva Island date from the 1960's and are summarized below.

Captiva Island Beach Nourishment Projects

Year	Volume (yd)	Fill Location
1962	7,000	South-central portion Captiva Island
1963	50,000	Central portion Captiva Island
1965	50,000	Central portion Captiva Island
1962-1967	124,000	Central portion Captiva Island
1981	655,500	North end Captiva Island (R-84 to R-93.5)
1988-1989	1,595,000	Captiva Island (R-85 to R-109)

(Balsillie, 1994)

In 1965 and 1968, Captiva Island was impacted by the effects of hurricanes "Betsy" and "Gladys," respectively. Hurricane "Betsy" caused severe damage to a 1300 foot section of roadway along the southern portion of Captiva Island. Hurricane "Gladys" again washed out the shorefront highway at the midpoint of the island.

Approximately seven months after Hurricane Gladys Photo No. 5, showing an aerial view of Redfish Pass was taken. Plumes of sediment migrating from both North Captiva and Captiva shorelines seaward onto the ebb shoal can be seen. It also appears that both shorelines adjacent to Redfish Pass have built up. Accretion along both the southern tip of North Captiva Island as well as the northern tip of Captiva Island is shown in the 1970 Photo No. 6. Approximately ½ mile north of the pass was a narrow strip of land where overwash was prevalent.

In recent years the Redfish Pass area has experienced two major storms. Hurricane Elena (1985) which reported wind speeds as high as 125 mph was followed three years later by Tropical Storm Keith (1988) which caused coastal damage and overwash of portions of Captiva and Sanibel Islands.

Photo No. 7 is an infrared aerial photo of Redfish Pass in August 1988. The inlet channel is oriented to the northwest. The northern beaches of Captiva Island appear to be protected by the ebb shoal in 1988.

Historically, Captiva Island has experienced chronic and significant beach erosion. Two major beach renourishment projects have been constructed to restore and nourish the depleting beach. For both projects sand was dredged from a borrow site located in the Redfish Pass ebb shoal.

In 1981, 655,500 cubic yards of sand were placed along a 10,000 foot length of beach on Captiva Island, known as South Seas Plantation, extending south from Redfish Pass. In conjunction with this beach restoration project, a short terminal structure was constructed on the northwest tip of Captiva Island to stabilize the location of the channel.

In 1988-89, a beach renourishment project was constructed on Captiva Island in which 1,595,000 cubic yards of fill was placed along the entire 4.7 miles of shoreline.

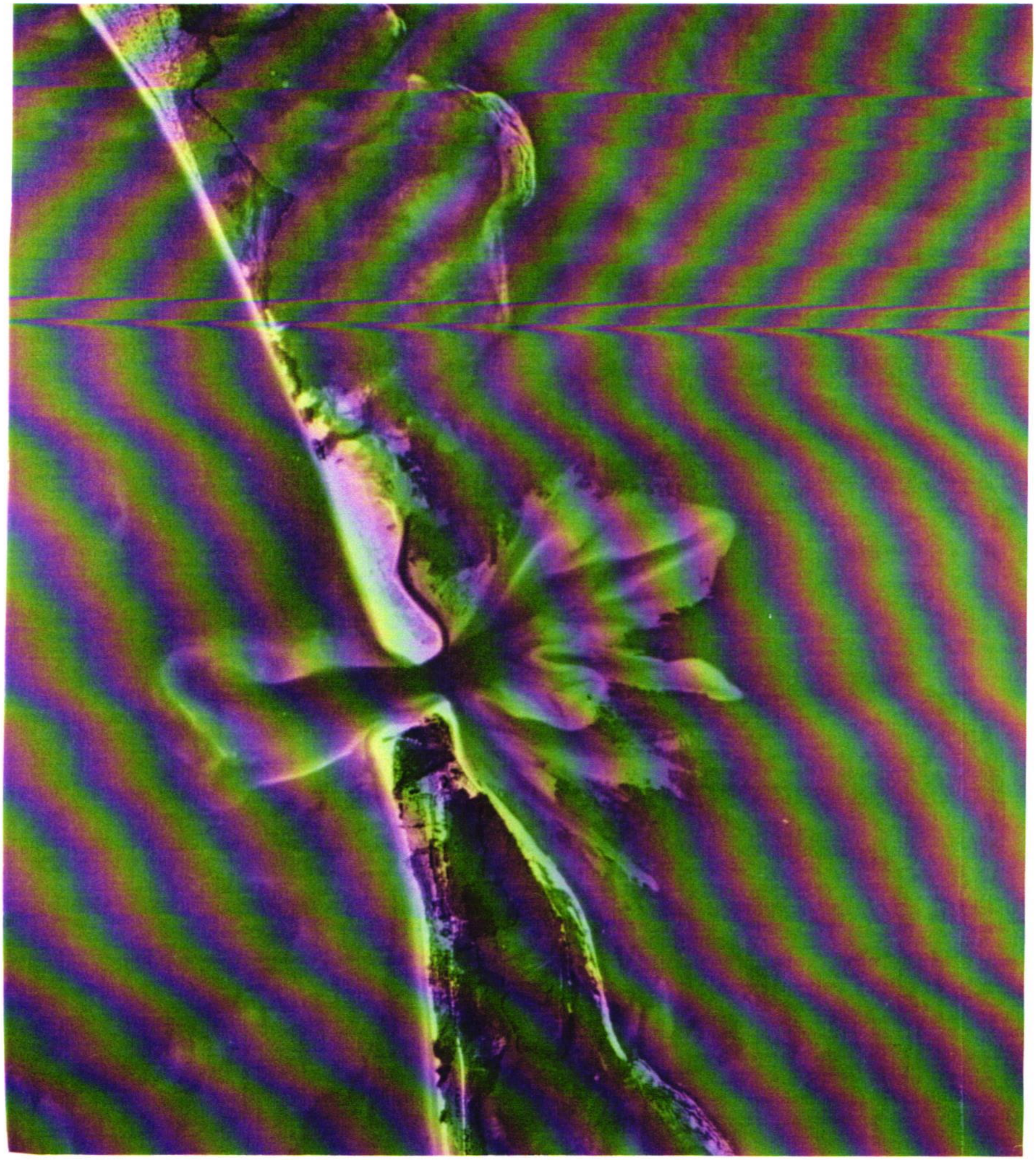


Photo No. 2: Aerial view of Redfish Pass (5/5/52).

Note the erosion of the southern tip of North Captiva Island
and the northern section of Captiva Island.

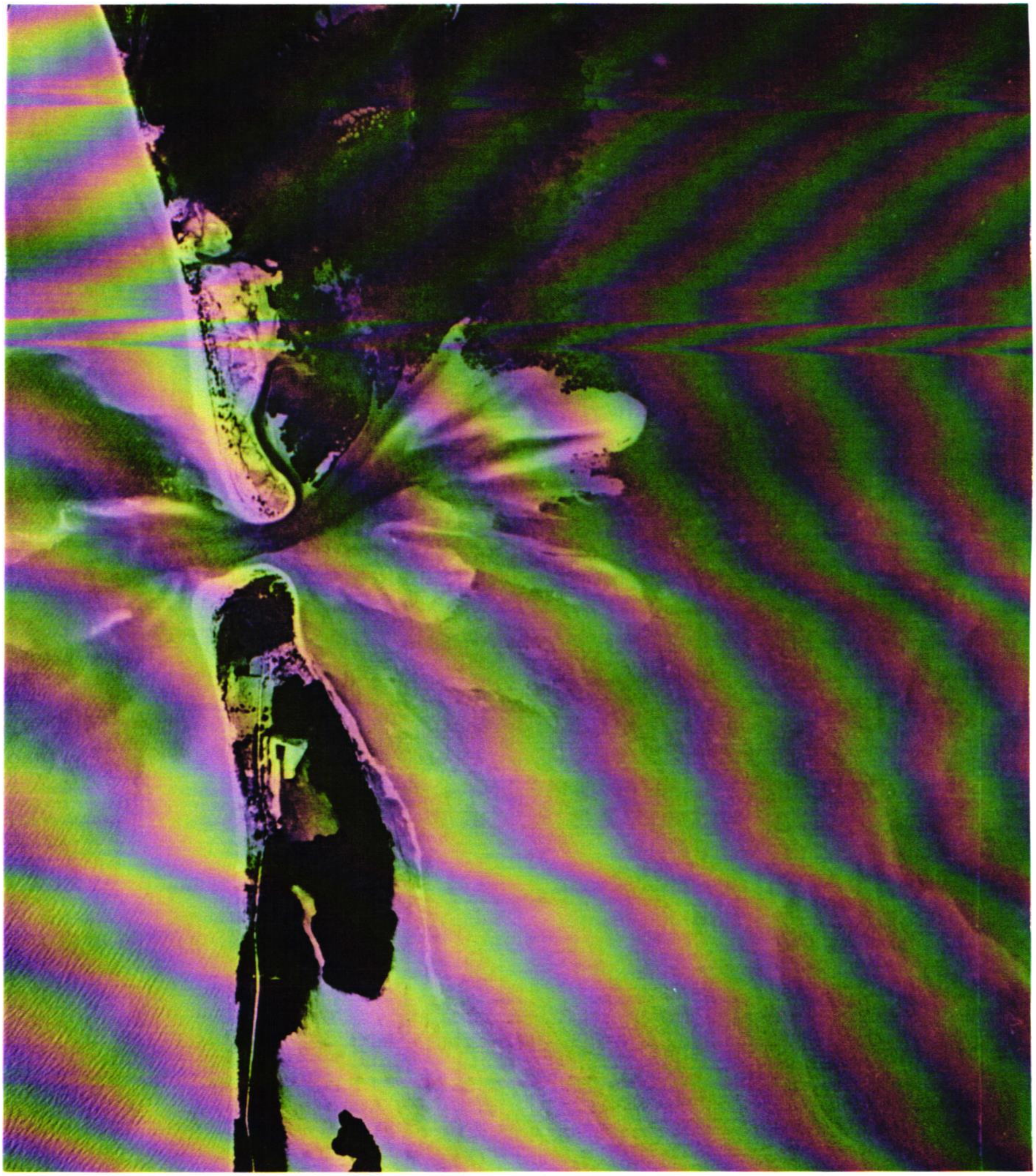


Photo No. 3: Aerial view of Redfish Pass (10/21/58).

Extensive flood shoal is clearly visible. Note increased vegetation on southern portion of North Captiva Island. Adjacent beaches appear to be building since previous photograph.

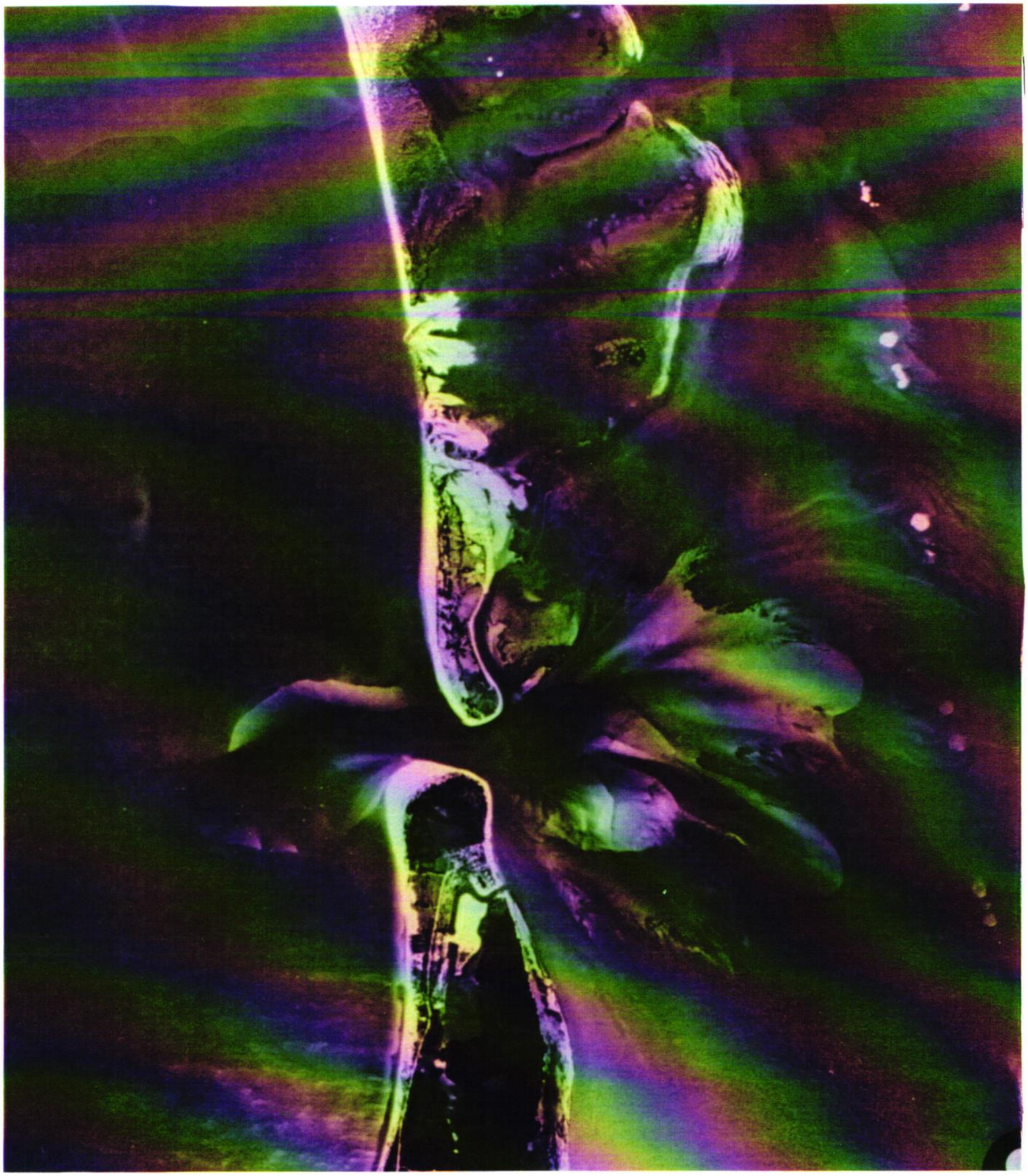


Photo No. 4: Aerial view of Redfish Pass (11/22/60).

Note overtopping and sluiceways on North Captiva Island.

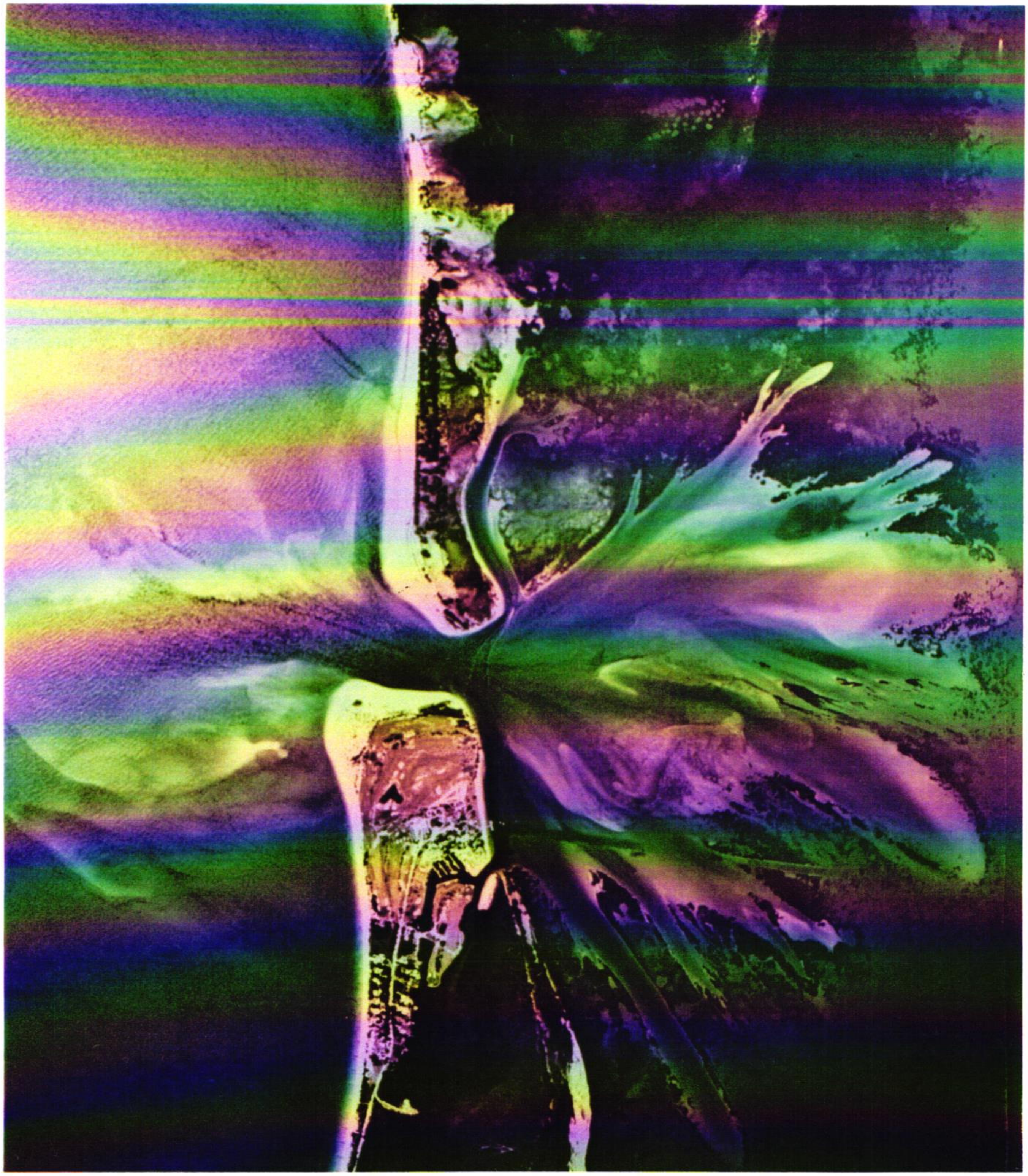


Photo No. 5: Aerial view of Redfish Pass (5/31/69).

Adjacent beaches appear to be in an accretional state. Note that ebb tide is developing sand plumes seaward from both beaches.

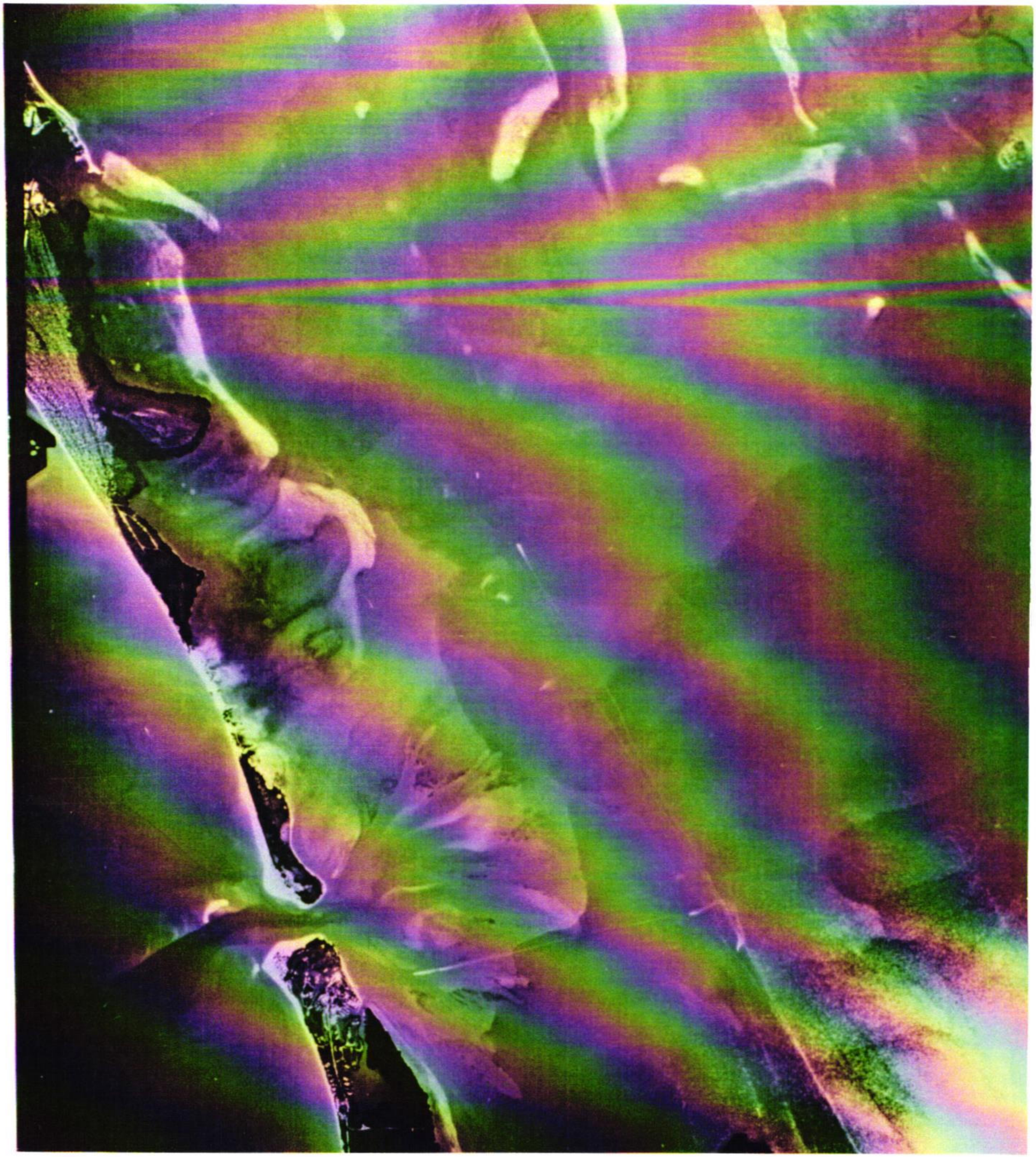


Photo No. 6: Aerial view of Redfish Pass (2/14/70).

Accretion of beaches of Redfish Pass can be observed. Note areas of overwash on North Captiva Island, resulting shoaling of sand within Pine Island Sound.

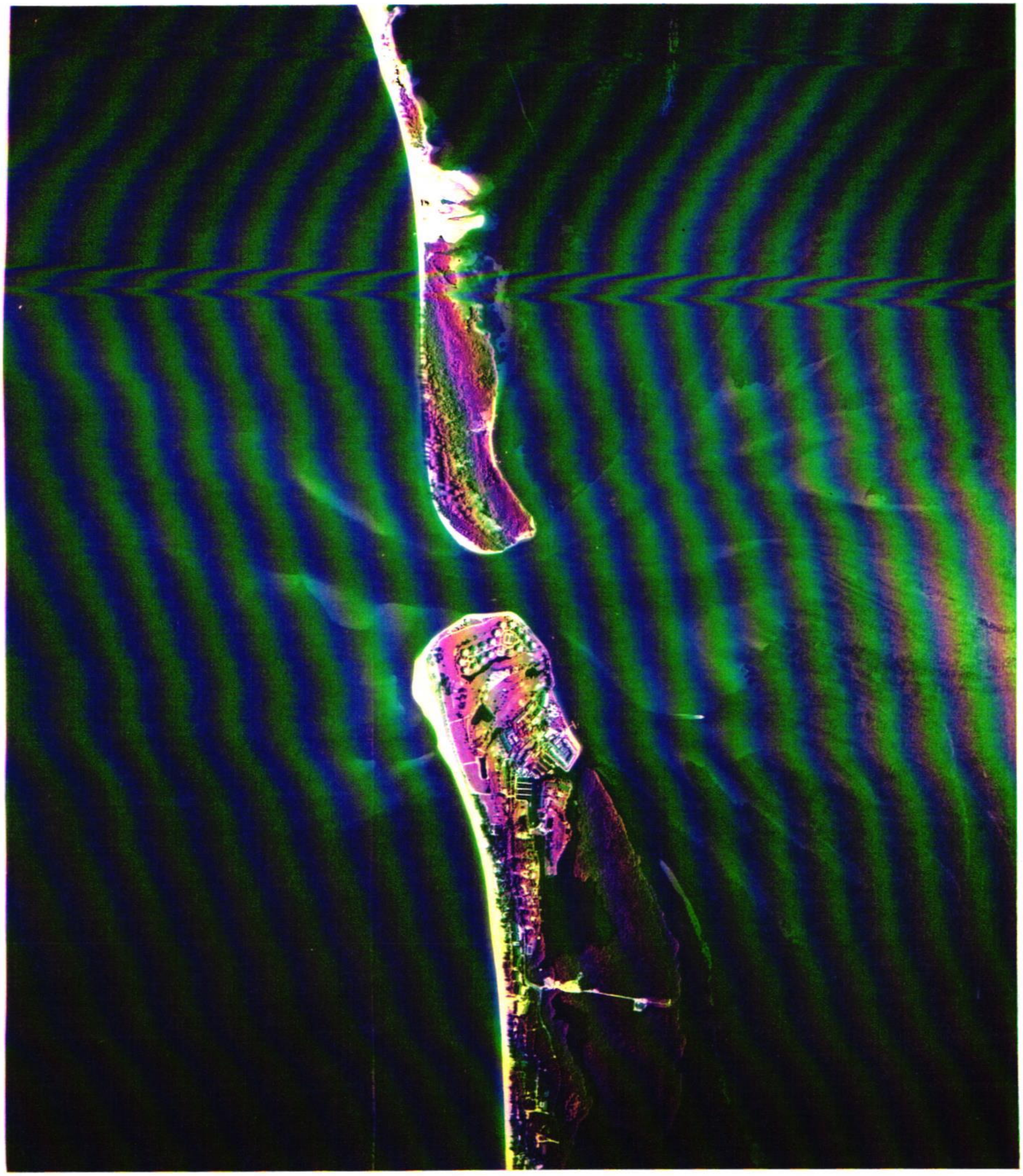


Photo No. 7: Aerial view of Redfish Pass (8/4/88).

Amount of sand on beaches north of Redfish Pass appears to be minimal.

II. PHYSICAL INLET CHARACTERISTICS

A. General

Redfish Pass is influenced by many natural processes. The presence of structures also contributed to the present condition of the inlet. This section will outline and discuss the factors influencing the inlet.

Sand moving along the coast by wave action is captured by Redfish Pass. Longshore sediment transport (littoral drift) occurs within the surf zone and is defined as the movement of sand in a direction parallel to the beach. The longshore transport depends primarily on the incident wave height and wave angle. In the vicinity of tidal inlets, longshore sediment transport is combined with the transport of sediment due to tidal currents. Sand which makes up the longshore transport may move into the inlet or deposit on the ebb and flood shoal.

Like many Florida west coast inlets, Redfish Pass contains both an ebb and flood shoal. The flood shoal is located within Pine Island Sound, and covers an area of about 800 acres. This shoal is created by the deposition of sand as a result of flood currents.

Prior to the 1988/89 Captiva beach nourishment project, the ebb shoal located offshore of Redfish Pass stored approximately 2.8 million cubic yards of sand and was approximately 300 acres in size (Davis & Gibeaut, 1990). Large ebb shoals are common to the west coast of Florida. Captiva Island has been renourished twice through the use of an ebb shoal borrow site.

B. Inlet Influence

When Redfish Pass opened in 1921, the beaches north and south of the inlet quickly retreated. The effects of the inlet on North Captiva Island extended approximately 8,000 feet north of the inlet (see Figure 2). The beaches retreated a maximum of 1,500 feet at the inlet. South of the inlet the beach responded to the inlet opening by retreating for a distance of 12,000 feet south of the inlet.

The inlet captured sand from the beach system in its ebb and flood shoals. The building of the ebb shoal system provided protection for the shore within 2,000 feet south of the inlet where beaches have rebuilt about half of their losses. North of the inlet some recovery is evident after 1972 in the first 3,000 feet north of the inlet.

Today, the inlet is a near total barrier to longshore transport, creating a sediment deficiency and erosion of Captiva Island. The erosion is worst near R-87 and R-88 (3,000-4,000 feet south of the inlet) where a nodal point has been created by the refractive influence of the ebb shoal on the wave climate.

The erosion effect of the inlet has progressively moved south of the inlet over time and now encompasses approximately 6 miles of coast.

When Redfish Pass opened in 1921 it captured most of the tidal prism of Blind Pass. Blind Pass is located 5 miles to the south. This led to the shoreward migration of the ebb shoal of Blind Pass. The disintegration of the shoals of Blind Pass have had an effect on the adjacent shores and overlap the direct effects of Redfish Pass (University of Florida, 1958). The central 2 miles of Captiva Island built up over 200 feet (R94-R104) between 1921 and 1951 while the southern mile lost an average of 500 feet during the same time period. These are indirect effects of Redfish Pass.

C. Shorelines

1. Shoreline Data

The mean high water (MHW) elevation measured at each Florida Department of Natural Resources (DNR) beach profile line was used in this report to represent the typical shoreline location. The MHW elevation at the beaches adjacent to Redfish Pass is approximately +1.25 feet above the National Geodetic Vertical Datum (NGVD) of 1929.

Shoreline locations used in this report were established from historical shoreline maps prepared by the Florida Department of Natural Resources and were supplemented by surveys performed by Coastal Planning & Engineering, Inc. and George F. Young & Associates. The period analyzed for shoreline changes was from 1859 to April, 1991. Shoreline locations relative to DNR reference monuments for selected years are presented in Tables 2 and 3. Shoreline positions on Captiva and North Captiva Island averaged over approximately one-mile intervals are shown in Figures 3 and 4.

A study by Foster and Savage (1989) indicated that the combined map and digitizing error is estimated to be on the order of ±40 to 50 feet for shorelines measured from historical survey maps. Shorelines based on profile surveys have an estimated error on the order or ±10 feet. Due to this mapping error, long-term shoreline comparisons should be considered to yield reliable results. Data based on profile surveys is used when available.

2. Shoreline Changes South of Redfish Pass

The Captiva shoreline between DNR monument R84 at Redfish Pass and R109 at Blind Pass was evaluated to determine shoreline changes south of Redfish Pass. Table 4 presents sequential shoreline changes from 1859 through 1991 as well as during selected periods which coincide with the construction of structures and beach restoration projects.

TABLE 2
MHW STATIONS SOUTH OF REDFISH PASS (CAPTIVA ISLAND)

DNR PROFILE NUMBER	SURVEY STATION FOR THE YEAR OF: 1859	1941	1951	1955	1961	1972	1974	1979	1985	1988	1989	1990	1991
R-84	885.3	-253.0	133.0	181.6	182.6	477.5	178.3	156.6	386.0	348.4	339.5	352.0	348.9
R-85	1503.7	743.7	834.7	603.0	588.5	638.4	526.5	552.2	734.0	749.4	824.2	908.7	883.0
R-86	1447.7	850.0	705.8	425.4	415.4	472.6	390.2	347.3	488.0	455.7	534.7	532.3	545.6
R-87	1489.3	823.5	687.4	348.8	347.8	370.0	284.2	259.7	396.5	362.9	418.4	390.6	370.0
R-88	1283.4	695.4	614.1	264.3	247.4	258.4	155.1	146.1	248.8	218.5	271.4	265.0	254.7
R-89	1355.9	864.1	803.2	484.8	491.5	526.7	374.0	358.2	446.9	408.7	466.7	451.3	458.0
R-90	1026.2	619.7	558.9	322.9	311.7	270.5	147.4	122.5	212.1	164.6	227.3	212.1	220.7
R-91	825.6	559.6	472.8	256.6	259.1	283.7	114.2	110.0	164.1	114.3	194.2	181.0	164.1
R-92	658.5	549.3	447.8	266.5	277.0	229.2	157.7	127.8	197.9	154.9	249.2	231.1	213.6
R-93	527.7	495.6	474.5	276.4	277.1	266.7	186.6	178.3	210.1	179.6	266.1	255.0	246.4
R-94	226.5	324.8	343.4	219.9	206.1	166.4	94.1	94.9	109.7	92.8	219.5	177.8	168.0
R-95	98.3	232.8	252.4	136.6	126.2	183.3	62.8	46.3	51.0	44.8	128.1	122.4	118.2
R-96	55.5	208.3	247.7	116.3	95.6	146.6	79.3	88.6	48.5	70.5	158.9	135.8	133.1
R-97	15.6	190.8	247.1	110.7	94.2	142.7	71.3	37.1	74.0	69.2	201.3	163.9	152.5
R-98	-7.4	174.2	217.6	108.4	97.0	193.5	72.8	49.4	61.1	58.5	208.3	188.9	181.7
R-99	23.0	181.4	254.4	154.1	124.2	207.4	122.9	98.6	94.9	85.0	259.9	250.2	247.1
R-100	-10.1	134.3	232.2	136.2	118.6	135.2	114.3	66.6	88.9	39.7	230.9	232.6	231.3
R-101	-27.2	163.1	238.5	186.4	143.3	176.3	153.1	115.5	129.9	117.0	277.8	286.1	277.8
R-102	1.4	138.2	239.4	129.5	123.8	195.2	111.6	81.7	90.9	96.8	205.8	219.8	227.6
R-103	121.9	224.6	287.1	194.8	182.9	263.1	164.1	135.0	134.8	135.4	237.3	241.7	270.9
R-104	240.3	288.8	294.6	195.4	181.5	175.6	169.7	132.2	122.6	125.8	228.9	211.6	233.6
R-105	256.8	222.1	192.1	128.8	104.6	95.8	87.0	50.4	43.9	52.3	190.2	152.0	145.1
R-106	673.8	494.7	503.2	438.9	422.2	411.5	400.8	380.8	378.0	371.4	460.9	488.5	447.0
R-107	915.4	536.6	564.2	491.7	475.5	534.0	447.4	409.2	407.0	397.7	468.1	497.1	465.7
R-108	898.3	224.8	321.3	259.9	220.6	193.1	102.0	120.7	86.0	117.5	193.8	213.8	157.7
R-109	1701.5	559.3	770.2	537.6	436.2	441.7	118.6	247.0	234.3	241.4	421.5	427.2	428.7

SURVEY DATA SOURCES:		
	1859, 1939-43, 1953-58, 1961	U.S.C.& G.S. (AERIALS)
	1951, 1972	U.S.G.S. (AERIALS)
	1974, 1982	D.N.R.,B.& S. (EL 1.3)
	1978-79	N.O.S. (AERIALS)
	1985, 1988, 1989, 1990, 1991	C.P.E. (EL 1.1)

TABLE 3
MHW STATIONS: NORTH OF REDFISH PASS (NORTH CAPTIVA)

DNR PROFILE NUMBER	SURVEY STATION FOR THE YEAR OF:										
	1859	1941	1951	1955	1961	1972	1974	1978	1982	1989	1991
R-70	452.7	220.1	450.1	264.3		346.2	167.4	164.6	87.5	122.1	
R-71	456.6	82.3	284.8	82.1		362.8	282.5	277.7	402.6	270.7	
R-72	122.2	105.9	234.6	21.9		218.7	201.3	342.4	304.8	507.1	
R-73	206.7	419.0	453.7	299.3		224.0	187.2	226.5	361.1	456.0	
R-74	349.3	645.5	600.5	425.7		308.5	202.8	139.6	214.3	377.3	
R-74A	531.7	583.0	723.4	558.5		471.5	284.5	169.5	119.5	180.0	
R-75	522.5	594.5	792.7	622.1		542.2	390.1	214.7	160.5	155.2	137.5
R-76	323.0	409.3	579.5	398.9		378.0	245.5	196.8	123.2	53.5	54.0
R-76A	404.5	396.6	585.7	388.7		367.4	252.3	-192.4	143.2	76.9	45.5
R-77	349.1	273.2	504.2	305.2		205.1	77.3	40.2		95.7	74.6
R-77A	475.4	328.8	508.4	299.1		222.4	79.9	54.2		73.0	38.0
R-78	840.2	667.8	678.1	462.9		405.6	213.8	152.1	84.4	85.1	57.3
R-79	920.8	631.4	593.9	348.9		309.4	95.5	95.6		113.3	112.2
R-79A	956.6	579.0	437.2	210.5		193.0	82.4	78.7	32.3	88.7	79.9
R-80	975.3	433.1	296.8	115.1	96.0	148.8	85.4	121.3	69.0	-75.6	102.7
R-81	1126.0	287.6	297.7	167.8	119.2	216.4	309.2	306.5	318.9	152.0	174.6
R-81A	1046.3	90.6	67.3	-53.6	-120.7	166.2	180.6	252.7	373.6	143.8	79.0
R-82	1940.4	406.0	280.8	227.9	157.8	306.9	185.1	348.1	396.2	311.5	223.2

SURVEY DATA SOURCES:		
	1859, 1939-43, 1953-58, 1960	U.S.C.& G.S.
	1951, 1972	U.S.G.S.
	1974, 1982, 1989	D.N.R.,B.& S.
	1978-79	N.O.S.
	1991	C.P. & E.

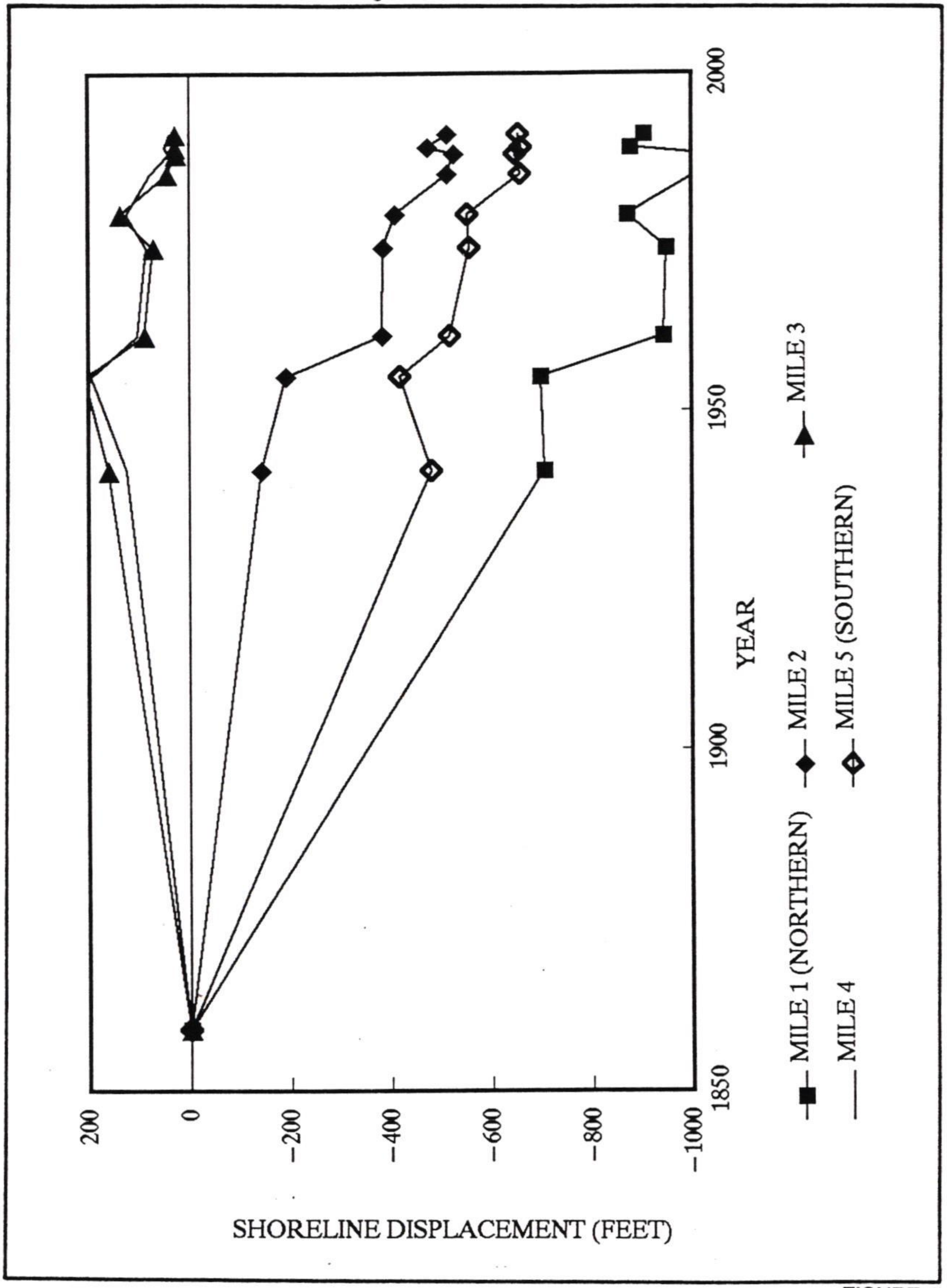


FIGURE 3

SHORELINE POSITION ON CAPTIVA ISLAND AVERAGED OVER ONE-MILE INTERVALS

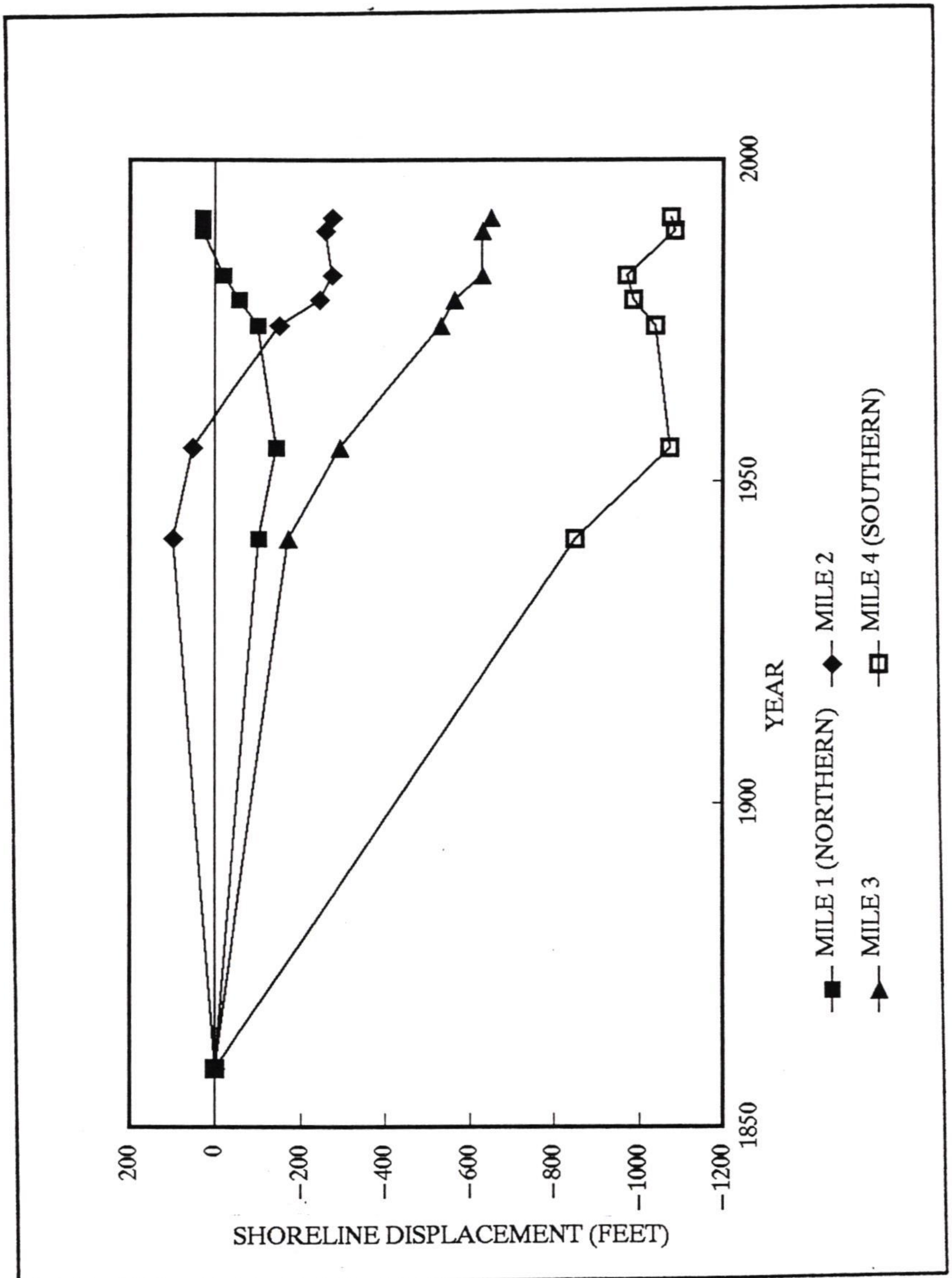


FIGURE 4

SHORELINE POSITION ON NORTH CAPTIVA ISLAND AVERAGED OVER ONE-MILE INTERVALS

TABLE 4
SHORELINE CHANGES SOUTH OF REDFISH PASS (CAPTIVA ISLAND)

DNR PROFILE NUMBER	BETWEEN SURVEYS OF: 1859 1941	1941 1951	1951 1955	1955 1961	1961 1972	1972 1974	1974 1978	1978 1985	1985 1988	1988 1989	1989 1990	1990 1991	1941 1955	1955 1974	1974 1989	1989 1991	1941 1991
R- 84	-1138.2	385.9	48.7	1.0	294.9	-299.2	-21.7	229.4	-37.6	-8.9	12.5	-3.1	434.6	-3.3	161.2	9.4	601.9
R- 85	-759.9	90.9	-231.6	-14.5	49.9	-111.9	25.7	181.8	15.4	74.8	84.5	-25.7	-140.7	-76.5	297.7	58.8	139.3
R- 86	-597.7	-144.2	-280.4	-10.0	57.2	-82.4	-42.9	140.7	-32.3	79.0	-2.4	13.3	-424.6	-35.2	144.5	10.9	-304.4
R- 87	-665.7	-136.2	-338.5	-1.1	22.2	-85.8	-24.5	136.8	-33.6	55.5	-27.8	-20.6	-474.7	-64.6	134.2	-48.4	-453.5
R- 88	-588.0	-81.3	-349.8	-16.9	10.9	-103.3	-8.9	102.7	-30.3	52.9	-6.4	-10.3	-431.0	-109.3	116.3	-16.7	-440.7
R- 89	-491.8	-60.9	-318.4	6.7	35.2	-152.8	-15.8	88.8	-38.2	58.0	-15.4	6.7	-379.3	-110.9	92.7	-8.7	-406.1
R- 90	-406.5	-60.8	-236.0	-11.2	-41.3	-123.1	-24.9	89.6	-47.5	62.7	-15.2	8.6	-296.8	-175.5	79.9	-6.6	-399.0
R- 91	-266.0	-86.8	-216.2	2.5	24.5	-169.4	-4.2	54.1	-49.8	79.9	-13.2	-16.9	-303.0	-142.4	80.0	-30.1	-395.5
R- 92	-109.2	-101.5	-181.3	10.5	-47.8	-71.5	-29.9	70.1	-43.0	94.3	-18.1	-17.5	-282.8	-108.8	91.5	-35.6	-335.7
R- 93	-32.2	-21.0	-198.1	0.7	-10.4	-80.1	-8.3	31.8	-30.5	86.5	-11.1	-8.6	-219.2	-89.8	79.5	-19.7	-249.2
R- 94	98.3	18.6	-123.4	-13.8	-39.7	-72.3	0.8	14.8	-16.9	126.7	-41.7	-9.8	-104.8	-125.8	125.4	-51.5	-156.8
R- 95	134.5	19.6	-115.8	-10.4	57.1	-120.5	-16.6	4.7	-6.2	83.3	-5.7	-4.2	-96.2	-73.8	65.3	-9.9	-114.6
R- 96	152.8	39.4	-131.4	-20.6	51.0	-67.3	9.3	-40.1	22.0	88.4	-23.1	-2.7	-92.0	-36.9	79.6	-25.8	-75.2
R- 97	175.3	56.3	-136.4	-16.5	48.5	-71.4	-34.3	36.9	-4.8	132.1	-37.4	-11.4	-80.2	-39.3	130.0	-48.8	-38.3
R- 98	181.5	43.4	-109.2	-11.4	96.5	-120.7	-23.4	11.7	-2.6	149.8	-19.4	-7.2	-65.8	-35.6	135.5	-26.6	7.6
R- 99	158.4	73.0	-100.3	-29.9	83.2	-84.6	-24.2	-3.7	-9.9	174.9	-9.7	-3.1	-27.3	-31.2	137.0	-12.8	65.7
R-100	144.4	97.9	-96.0	-17.6	16.7	-20.9	-47.7	22.3	-49.2	191.2	1.7	-1.3	1.9	-21.9	116.6	0.4	97.0
R-101	190.3	75.4	-52.1	-43.2	33.0	-23.1	-37.7	14.4	-12.9	160.8	8.3	-8.3	23.3	-33.3	124.7	0.0	114.7
R-102	136.8	101.3	-110.0	-5.7	71.4	-83.6	-29.8	9.2	5.9	109.0	14.0	7.8	-8.7	-17.9	94.2	21.8	89.5
R-103	102.7	62.5	-92.3	-11.9	80.2	-99.0	-29.1	-0.2	0.6	101.9	4.4	29.2	-29.8	-30.7	73.2	33.6	46.3
R-104	48.5	5.8	-99.2	-13.9	-5.9	-5.9	-37.5	-9.6	3.2	103.1	-17.3	22.0	-93.4	-25.7	59.2	4.7	-55.2
R-105	-34.7	-30.1	-63.3	-24.2	-8.8	-8.8	-36.6	-6.5	8.4	137.9	-38.2	-6.9	-93.3	-41.8	103.2	-45.1	-77.0
R-106	-179.0	8.4	-64.3	-16.7	-10.7	-10.7	-20.1	-2.8	-6.6	89.5	27.6	-41.5	-55.9	-38.0	60.1	-13.9	-47.7
R-107	-378.8	27.7	-72.5	-16.3	58.6	-86.7	-38.1	-2.2	-9.3	70.4	29.0	-31.4	-44.8	-44.4	20.7	-2.4	-70.9
R-108	-673.5	96.5	-61.4	-39.3	-27.5	-91.1	18.8	-34.7	31.5	76.3	20.0	-56.1	35.0	-157.9	91.9	-36.1	-67.1
R-109	-1142.2	210.9	-232.6	-101.5	5.5	-323.1	128.4	-12.7	7.1	180.1	5.7	1.5	-21.6	-419.1	302.9	7.2	-130.6
R-84 TO R-109																	
AVG.CHG.:	-228.5	26.6	-152.4	-16.4	34.8	-98.8	-14.4	43.4	-14.1	100.4	-3.6	-7.6	-125.8	-80.4	115.3	-11.2	-102.1
AVG./YR.:	-2.8	2.7	-38.1	-2.7	3.2	-49.4	-3.6	6.2	-4.7	100.4	-3.6	-7.6	-9.0	-4.2	7.7	-5.6	-2.0
R-100 TO R-109																	
AVG.CHG.:	-178.6	65.6	-94.4	-29.0	21.2	-75.3	-12.9	-2.3	-2.1	122.0	5.5	-8.5	-28.7	-83.1	104.7	-3.0	-10.1
AVG./YR.:	-2.2	6.6	-23.6	-4.8	1.9	-37.6	-3.2	-0.3	-0.7	122.0	5.5	-8.5	-2.1	-4.4	7.0	-1.5	-0.2

(1) 1941 TO 1955: PRE-STRUCTURES (NO ROAD REVETMENT)
(2) 1955 TO 1961: POST-ROAD REVETMENT
(3) 1955 TO 1978: POST-REVETMENT & INITIAL GROIN
(4) 1961 TO 1978: LATE PERIOD, POST REVETMENT & INITIAL GROIN
(5) 1955 TO 1974: POST-REVETMENT & PRE-GROIN
(6) 1974 TO 1978: POST-INITIAL GROIN LOSSES
(7) 1974 TO 1988: POST-INITIAL GROIN & POST-SOUTH SEAS PROJECT
(8) 1961 TO 1988: LONG TERM LOSSES WITH AFFECT OF REVETMENTS
(9) 1941 TO 1978: PRE-BEACH FILL PERIOD
(10) 1978 TO 1991: POST-BEACH FILL PERIOD

1859 - 1941

The first available shoreline information following the opening of Redfish Pass is contained in a 1941 USC&GS survey. Between 1859 and 1941 the Captiva shoreline (between R84 and R109) receded an average of 228 feet (-2.8 feet per year).

The opening of Redfish Pass created a total littoral barrier to sediment transport and the beach along what is now South Seas Plantation (R84 to R93) receded 506 feet (-6.2 feet per year). During the same time period, the southernmost beaches located within a mile north of Blind Pass (between R105 and R109) averaged a shoreline loss of 479 feet (-5.9 feet per year). The shoreline in the center of Captiva (between R94 and R104) gained an average of 138 feet (+1.7 feet per year) during this same period.

1941 - 1955

During this period, most of the shoreline south of Redfish Pass eroded. This period most strongly reflects the influence of the sand trapping abilities of Redfish Pass on the Captiva shoreline. During this period the shoreline lost an average of 126 feet (-9 feet per year). Although the shoreline immediately south of the pass (R84) gained 434 feet (+31 feet per year), the shoreline extending south of Redfish Pass to the end of South Seas Plantation (R85 to R93) lost an average of 435 feet (-31 feet per year). The shoreline along the central portion of the island (between R94 and R104) lost an average of 52 feet (-3.7 feet per year) and the southern shoreline (between R104 and R109) also suffered losses averaging 36 feet (-2.6 feet per year).

1955 - 1974

The entire shoreline of Captiva receded an average of 80 feet (-4.3 feet per year) between 1955 and 1974. It was during this period that the road revetment and the revetment further south were constructed. Erosion along the South Seas beach (between R84 and R93) moderated to an average loss of 101 feet (-7.2 feet per year). Likewise, shoreline losses along the center of Captiva (between R94 and R104) moderated to an average of 43 feet (-3.1 feet per year). Losses at the south end of Captiva Island (between R105 and R109) increased to an average of 140 feet (-10 feet per year).

1974-1989

Between 1974 and 1989, the Captiva Island shoreline gained an average of 115 feet or +7.7 feet per year. This time period includes shoreline advancement due to the 1981 South Seas Plantation and 1988 Captiva beach restoration projects. The shoreline immediately south of Redfish Pass between R84 and R93 gained an average 128 feet (+8.5 feet per year). The center of Captiva between R94 and R104 accreted an average of 104 feet (+6.9 feet per year). The southern part of Captiva Island between R105 and R109 gained an average of 115.7 feet during this time period (+7.7 feet per year).

1989-1991

This period includes the first two years after the beach nourishment project completed in 1989. The Captiva shoreline lost an average of -11.2 feet. Both the north (R-84 to R-90) and south (R-100 to R-109) section of the shoreline retreated a moderate -1.3 and -3.0 feet, respectively. The center of Captiva Island (R-91 to R-99) lost an average of -29 feet (-14.5 ft./yr.).

3. Shoreline Changes North of Redfish Pass

Approximately 17,800 feet of shoreline on North Captiva Island between R70 and R82 was analyzed. The period of analysis ranged from 1859 through April 1991. The shoreline changes are compiled in Table 5.

1859-1941

During the 80-year period between 1859 and 1941 the shoreline north of Redfish Pass between R70 and R82 lost an average of 269 feet (-3.3 feet per year). The shoreline immediately north of Redfish Pass between R80 and R82 lost an average of 968 feet during this time period (-12.1 feet per year). Further north, the shoreline between R74A and R79A lost an average of 96 feet (-1.2 feet per year). At the north end of the study area between R70 and R74, the shoreline lost an average of 23 feet (-0.3 feet per year). Although the entire island was in an erosional state during this 80-year period, erosion of the island increased in a southward direction.

1941-1955

Between 1941 and 1955 the shoreline north of Redfish Pass continued to recede an average of 112 feet (-8.0 feet per year). The shoreline immediately north of Redfish Pass between R80 and R82 lost an average of 190 feet (-13.6 feet per year). The shoreline between R74A and R79A lost an average of 97 feet (-6.9 feet per year). Further north, the shoreline between R71 and R74 lost an average of 106 feet (-7.1 feet per year). However, the north end of North Captiva Island (R70) was an exception. This section of beach advanced 44.2 feet over the same 15-year period (+2.9 feet per year).

TABLE 5
SHORELINE CHANGES: NORTH OF REDFISH PASS (NORTH CAPTIVA ISLAND)

DNR PROFILE NUMBER	BETWEEN SURVEYS OF: 1859 TO 1941	1941 TO 1951	1951 TO 1955	1955 TO 1961	1961 TO 1972	1972 TO 1974	1974 TO 1978	1978 TO 1982	1982 TO 1989	1989 TO 1991	1941 TO 1955	1955 TO 1974	1974 TO 1989	1978 TO 1991	1941 TO 1989
R-70	-232.6	230.0	-185.8			-178.8	-2.8	-77.1	34.6		44.2	-96.9	-45.3		-98.0
R-71	-374.2	202.5	-202.8			-80.2	-4.8	124.9	-131.9		-0.3	200.5	-11.8		188.4
R-72	-16.4	128.7	-212.7			-17.5	141.1	-37.6	202.3		-84.0	179.4	305.9		401.2
R-73	212.4	34.6	-154.4			-36.8	39.3	134.7	94.9		-119.8	-112.1	268.8		37.0
R-74	296.2	-45.0	-174.8			-105.7	-63.3	74.7	163.1		-219.8	-222.9	174.5		-268.2
R-74A	51.3	140.4	-164.9			-187.0	-115.0	-50.0	60.5		-24.5	-274.0	-104.5		-403.0
R-75	72.0	198.2	-170.7			-152.1	-175.4	-54.3	-5.3	-17.7	27.5	-232.0	-234.9	-77.2	-439.3
R-76	86.3	170.1	-180.5			-132.5	-48.7	-73.7	-69.7	0.5	-10.4	-153.4	-192.0	-142.8	-355.8
R-76A	-7.9	189.2	-197.0			-115.1	-59.9	-49.2	-66.3	-31.4	-7.8	-136.4	-175.4	-146.9	-319.7
R-77	-76.0	231.0	-199.0			-127.7	-37.1			-21.1	32.0	-227.9	18.4	34.4	-177.5
R-77A	-146.7	179.7	-209.3			-142.5	-25.8			-35.0	-29.6	-219.2	-6.9	-16.2	-255.8
R-78	-172.4	10.3	-215.2			-191.7	-61.7	-67.8	0.7	-27.9	-204.9	-249.1	-128.7	-94.9	-582.7
R-79	-289.4	-37.5	-244.9			-213.9	0.1			-1.1	-282.4	-253.4	17.8	16.6	-518.1
R-79A	-377.6	-141.8	-226.7			-110.6	-3.7	-46.5	56.4	-8.8	-368.5	-128.1	6.3	1.2	-490.3
R-80	-542.2	-136.3	-181.7	-19.1	52.8	-63.5	36.0	-52.3	-144.6	178.3	-318.0	-29.8	-161.0	-18.7	-508.7
R-81	-838.4	10.2	-130.0	-48.6	97.2	92.8	-2.7	12.4	-166.9	22.6	-119.8	141.4	-157.2	-131.9	-135.6
R-81A	-955.7	-23.3	-120.9	-67.1	286.9	14.4	72.1	120.9	-229.8	-64.8	-144.1	234.2	-36.8	-173.7	53.2
R-82	-1534.4	-125.2	-52.9	-70.1	149.1	-121.8	163.0	48.2	-84.7	-88.3	-178.1	-42.8	126.4	-124.9	-94.5
AVG.CHG.:	-269.2	67.5	-179.1	-51.2	146.5	-103.9	-8.3	0.5	-19.1	-7.9	-111.6	-90.1	-18.7	-72.9	-220.4
AVG./YR.:	-3.3	6.8	-39.8	-9.3	13.3	-52.0	-1.8	0.1	-2.7	-3.9	-8.0	-4.7	-1.2	-5.6	-4.6

1955-1974

Between 1955 and 1974 North Captiva Island lost an average of 90 feet (-4.7 feet per year) between R70 and R82. The shoreline immediately north of Redfish Pass between R80 and R82 gained an average of 76 feet (+4.0 feet per year). Between profiles R74A and R79A, the shoreline eroded an average of 208 feet (-11.0 feet per year). At the north end of the study area, the shorelines between R70 and R74 lost an average of 10 feet (-0.5 feet per year).

1974-1989

Between 1974 and 1989, the shoreline of North Captiva Island lost an average of 19 feet (-1.2 feet per year). Between profiles R74A and R79A, the shoreline has eroded an average of 89 feet (-5.9 feet per year). However, the north end of North Captiva Island has appeared to advance approximately 138 feet (+9.2 feet per year). The southern segment (R80 to R82) lost an average of -57 feet (-3.8 ft./yr.).

1989-1991

Between 1989 and 1991, the middle section of shoreline (R75 to R79A) lost an average of 18 feet, retreating at a rate of 9 feet per year. The southern segment (R80 to R82) advanced an average of 12 feet (6 ft./yr.). The profiles closest to the inlet (R81A and R82) both were erosional.

4. Shoreline Change Analysis

Initially, between 1859 and 1941 both the northern and southern tips of Captiva Island were suffering extreme erosion while the middle section was gaining sand. However, since 1941, the extreme north end of the island has been accreting (with the exception of 1955-1974).

The opening of Redfish Pass in 1921 lead to a large retreat of the south end of North Captiva Island. Since 1955, North Captiva Island has demonstrated the characteristics of a classic drumstick barrier island. The north (updrift) end of the island is wide and prograding. The prograding north end of the island starves the downdrift beaches of littoral sand. The dearth of littoral sand narrows the southern beaches, making washovers common. The southern (downdrift) end of North Captiva Island migrates landward. North Captiva Island, like most drumstick islands, appears to be rotating. The rotation consists of the seaward advance of the north end and the landward retreat of the south end. This process is expected to continue.

D. Volumetric Changes

Except where otherwise noted, volumetric changes in the following analysis were estimated by measuring shoreline changes and using a conversion factor of 0.67 cubic yards per foot of shoreline change. These volumes were based on typical berm heights of 6 feet NGVD and a depth of closure of -12 feet NGVD. Using this approximation of shoreline changes, selected time periods were multiplied by the effective distance associated with each DNR beach profile. Effective distance is half the distance between the DNR monuments on either side of the given DNR monument. This procedure is taken from page 4-117 and 4-118 in the *Shore Protection Manual* (1984). The volumetric estimates were then further adjusted to account for beach fill mechanically placed on beaches. A conversion factor of .33 cubic yards per linear foot was used for volume estimates prior to 1941, to compensate for sand lost to overwash near Redfish Pass.

1. South of Redfish Pass

Between 1859 and 1941 the beaches between R84 and R109 lost approximately 1.8 million cubic yards of sand. If we assume that those losses started in 1921, then the annual erosion rate of the island was 90,000 c.y./yr. Losses were concentrated near the northern end of Captiva between R84 and R93 as a result of the opening of Redfish Pass in 1921. The profiles between R105 and R109 also eroded at a higher rate during this period.

Erosion accelerated between 1941 and 1955 when 165,000 cubic yards per year eroded from Captiva. Again, most of the significant losses were experienced between profiles R84 and R93, immediately south of Redfish Pass.

Between 1955 and 1974, the area from profile R84 to R109 lost approximately 1.3 million cubic yards (68,000 cubic yards per year). The greatest losses measured during that time occurred immediately north of Blind Pass at profiles R108 and R109.

During the period from 1974 through 1978, which represents the period after the initial Blind Pass groin construction but prior to the South Seas Plantation fill project, Captiva lost approximately 298,000 cubic yards (-75,000 cubic yards per year). This represents a continuation of the trend from the previous 19 years. During the 1974 through 1978 time period, erosion along the Captiva beaches was relatively uniform except immediately north of Blind Pass, where there was an average gain of approximately 13,000 cubic yards per year.

In 1981 the South Seas Plantation restoration project added 655,000 cubic yards of fill to northern Captiva. Between 1978 and 1988 the beaches between R84 and R109 lost an estimated 160,000 cubic yards of sand (-16,000 cubic yards per year). This erosion rate has been adjusted for the fill placed in 1981. During this time period, the northern profiles between R84 and R93 experienced a gain of sand resulting from the fill project, while the remainder of the island experienced low erosion losses.

The 1988/89 Captiva beach restoration project added approximately 1,595,000 cubic yards of sand to Captiva. Between 1988 and December 1991, the beaches between R84 and R109 lost an estimated 170,000 cubic yards (51,000 cubic yards per year) based on profile analysis. Most of these losses occurred along the northern half of Captiva between R84 and R97.

2. North of Redfish Pass

Between 1859 and 1941 the 17,800 feet of beach north of Redfish Pass (R70 to R82) lost approximately 1.42 million cubic yards. Most of this sand volume loss occurred on the southern end of North Captiva Island (R74A to R82), probably as a result of the initial breaching of Old Captiva Island in 1921 and the subsequent development of the Redfish Pass shoals. The evidence of overwash along the southern shoreline (R78 to R82) necessitated a change in conversion factors from 0.67 to 0.33 cubic yard per foot.

Between 1941 and 1955, North Captiva lost 1.24 million cubic yards of sand. Profiles R79 through R82 lost approximately 799,100 cubic yards of sand (-57,100 cubic yards per year). The middle sector of the island (R73 - R77A) eroded approximately 220,900 cubic yards of sand (-15,800 cubic yards per year) while the northern sector of North Captiva Island (R70 - R72) lost only 54,400 cubic yards of sand (-3,900 cubic yards per year).

From 1955 to 1974, the beaches between profile R73 and R82 lost 890,000 cubic yards of sand. It appears that a large portion of this erosion occurred within the middle section of North Captiva Island (R73-R80). Washover appears to be a major contributor to the high erosion. Both ends of North Captiva Island were relatively stable, with the exception of profile R70 which is the northernmost point.

Between 1974 and 1989, there was a total loss of 158,000 cubic yards of sand on North Captiva Island. Most of the accretion occurred along the northern beach at profile R72. There was an erosion "hot spot" located south of profile R75 where a total of 460,000 cubic yards of sand was lost.

3. Volumetric Change Analyses

Tables 6, 7 and 8 list the volumetric changes by one mile segments for North Captiva and Captiva Islands. Accompanying these tables are Figures 5 and 6, which illustrate the cumulative volume changes for both islands. Figure 7 combines the previous two figures and charts cumulative volumetric changes as a function of time. Through the use of these volumetric tables and figures, in conjunction with the tables previously presented concerning shoreline positions, the following conclusions are apparent:

Composite Volume Changes:

The 1974 to 1988 volume changes for Captiva Island are based on a composite of shoreline and profile based volume changes. This composite was necessitated because earlier profile data was unreliable when compared to recent profile data. The derivation of the 1974 to 1988 volume figures are shown in Table 6.

Table 6

Composite Annual Volume Change Rate
Captiva Island
(cu. yds. x 1000/yr)

REACH	Shoreline Based 1974-1985	Profile Based 1985-1988	Composite 1974-1988
MILE 1 - R84-R88	+12*	-20	+5
MILE 2 - R89-R94	-13*	-20	-15
MILE 3 - R95-R99	- 5	-15	- 7
MILE 4 - R100-104	- 9	-19	-11
MILE 5 - R105-R109	- 5	- 3	- 5
TOTAL	-20	-83	-33

*Beach nourishment volumes deducted.

$$\text{COMPOSITE RATE} = \frac{\text{'74 -'85 Rate x 11 years + '85 -'88 rate x 3 years}}{\text{14 years}}$$

Captiva Island:

a. The rate of erosion on Captiva Island has decreased over time. The erosion rate since the 1988/89 beach restoration has risen slightly.

b. The northern 1 mile of Captiva Island has changed from high erosion 1941-1955 to accretion 1974-1988. This change represents an approximate 78,000 c.y. reduction of erosion for the island.

c. The erosion rate of Captiva Island (mile 2) currently has the highest erosion rate of the island segments.

d. In mile 3, the moderate erosion suffered by Captiva Island between 1941 and 1955 decreased to slow erosion between 1955 and 1988. In recent years (1988-1991), erosion has again increased.

e. In mile 4, accretion of Captiva Island has increased during the 1988-1991 time period, possibly indicating a transfer of erosion to the south.

f. In mile 5, erosion of Captiva Island decreased between 1974 and 1988; some groin effect is evident during this time period. In the past three years (1988-1991), erosion of the segment of Captiva Island has increased.

<u>North Captiva Island</u>:

a. The northern 1 mile of North Captiva Island was initially losing sand between 1941 and 1955. However, the northern portion of the island appears to have rebounded and has been gaining sand since 1955. The influence of Captiva Pass may be the reason for this accretion trend.

b. The second segment of North Captiva Island (mile 2) has been suffering erosion since 1941. However, there are indications that in recent years, erosion of this area is decreasing.

c. Mile 3 of North Captiva Island currently has the highest erosion rate of the island segments.

d. The southernmost segment (mile 4) of North Captiva Island has shown alternate periods of erosion and accretion since 1941, with a moderate erosion trend dominating.

e. Even though Figure 7 indicates that North Captiva Island is losing an increasing amount of sand from its beaches, it should be pointed out that since 1955 this sand is eroding predominantly from the middle portion of the island and that both the northern and southern tips of the island seem more stable.

Table 7

Yearly Volumetric Changes: Captiva Island
(cu. yds. x 1000/yr)

REACH	1941 TO 1955	1955 TO 1974	1974* TO 1988	1988** TO 1991
MILE 1 - R84-R88	-73	-14	+5	-8
MILE 2 - R89-R94	-61	-24	-15	-12
MILE 3 - R95-R99	-17	- 7	-7	-26
MILE 4 - R100-R104	- 5	- 5	-11	+10
MILE 5 - R105-R109	- 9	-17	-5	-15
TOTAL	-165	-67	-33	-51

**Based on beach profile comparisons.
* Composite based on 1974-1985 shoreline and 1985-1988 profile data.

Table 8

Yearly Volumetric Changes: North Captiva Island
(cu. yds. per year x 1000)

REACH	1941 To 1955	1955 TO 1974	1974 TO 1989	1989 TO 1991	1941 TO 1989
MILE 1 - R70-R73	-10	+11	+31		+11
MILE 2 - R74-R76A	- 9	-32	-24	-14	-23
MILE 3 - R77-R79	-24	-34	-6	-30	-23
MILE 4 - R79A-R82	-45	+8	-12	+21	-14
TOTAL:	-88	-47	-11	-23	-48

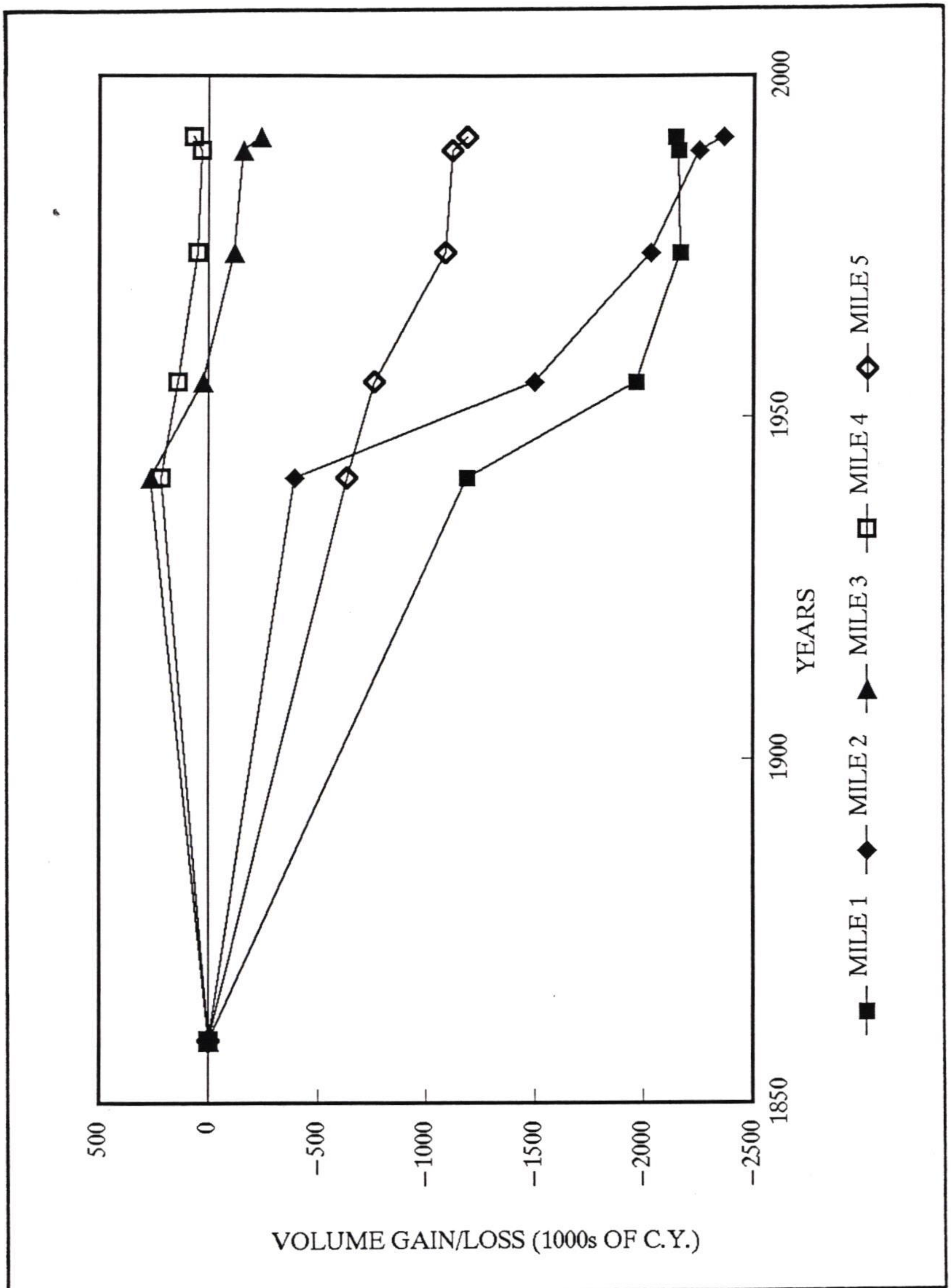


FIGURE 5

CUMULATIVE VOLUMETRIC CHANGE
CAPTIVA ISLAND

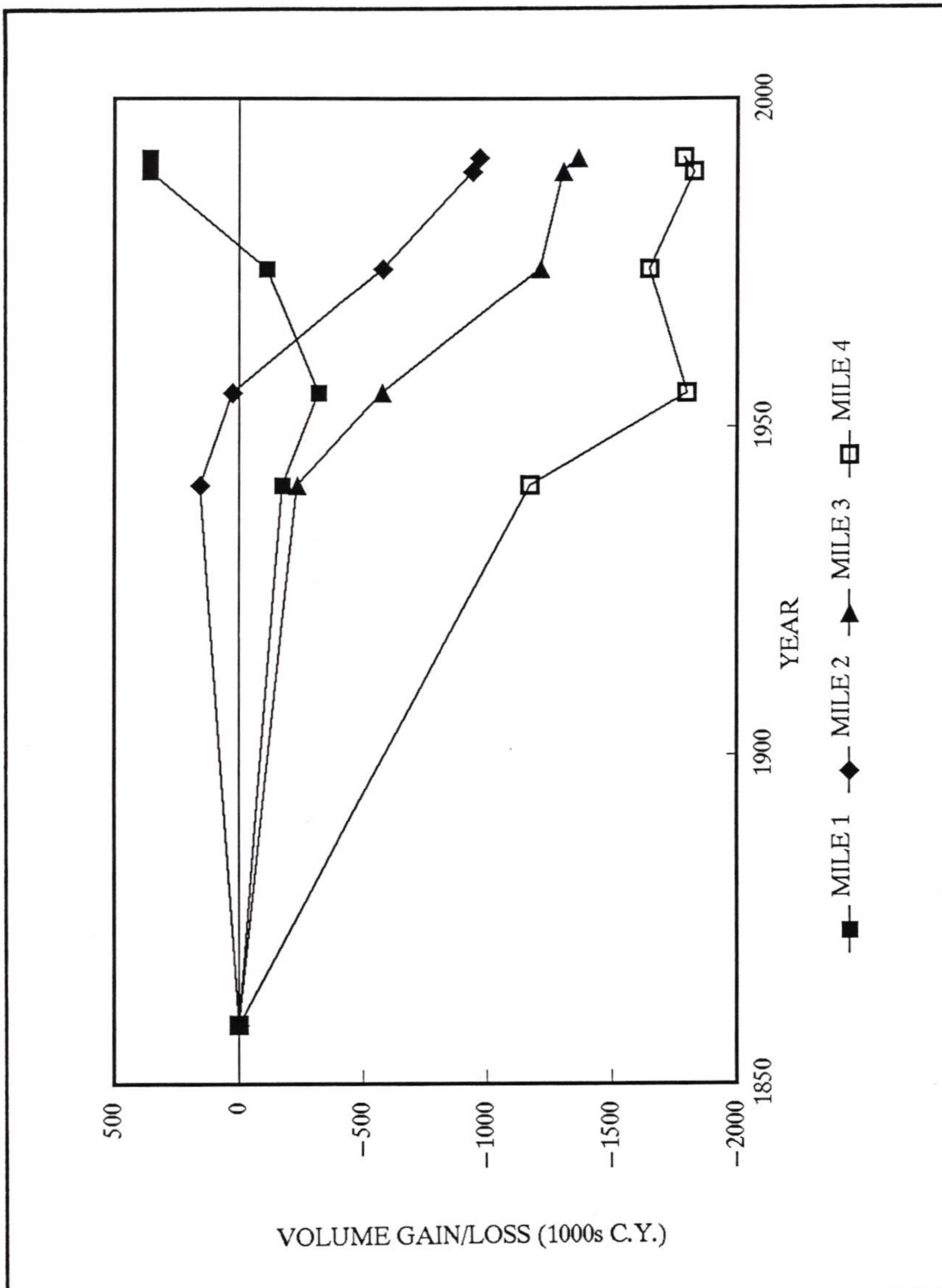


FIGURE 6

CUMULATIVE VOLUMETRIC CHANGE
NORTH CAPTIVA ISLAND

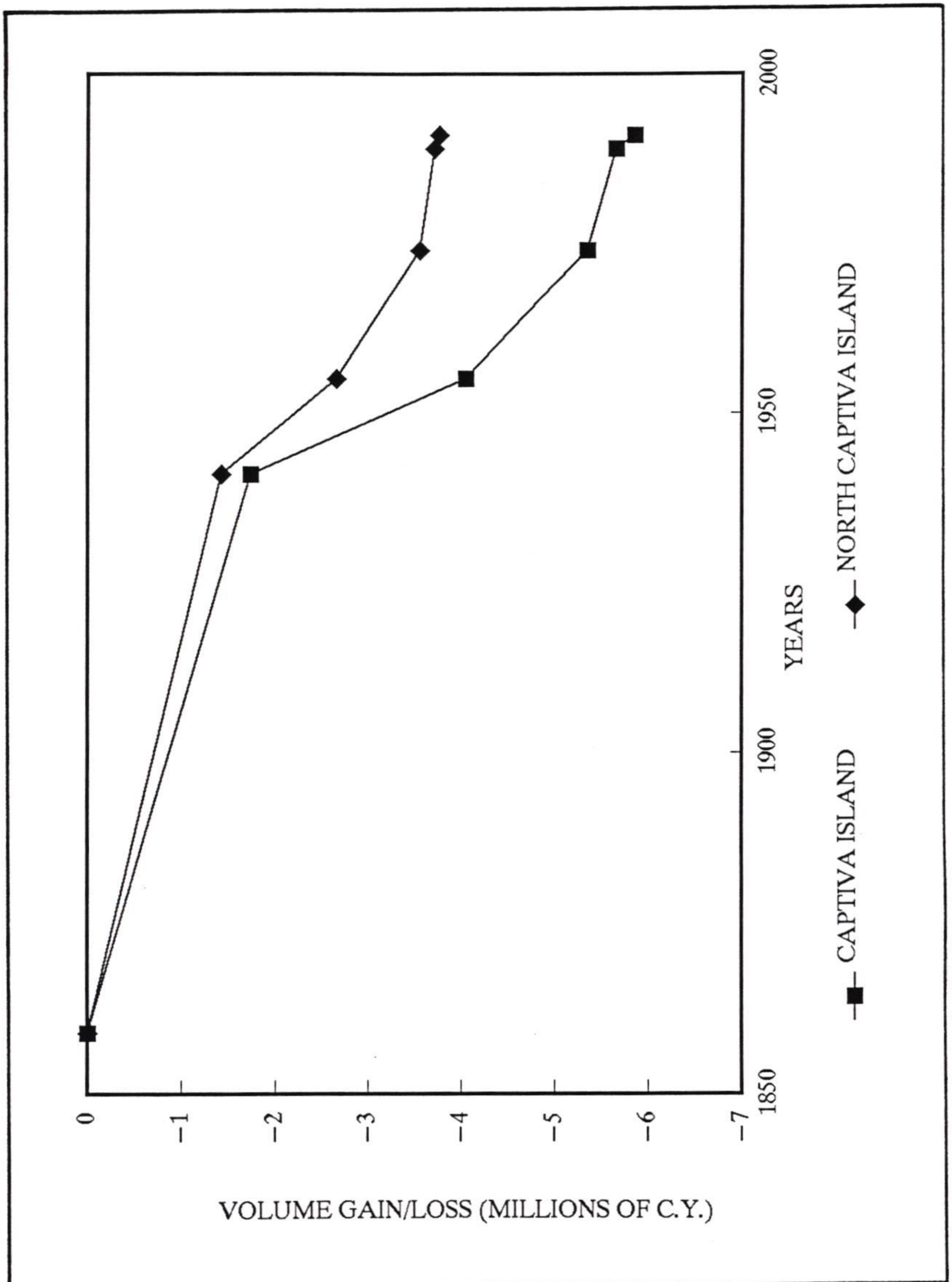


FIGURE 7

CUMULATIVE VOLUMETRIC CHANGES CAPTIVA AND NORTH CAPTIVA ISLAND

E. Inlet Bathymetry, Ebb and Flood Shoals

Redfish Pass has a classic tide-dominated morphology. The pass has a well defined main ebb channel with associated sand bodies (shoals) that are oriented perpendicular to the shore. Marginal flood channels which carry sediment to the throat and to the ends of the barrier island are often present.

The main channel of Redfish Pass has been stable since its development by the 1921 hurricane (Davis and Gibeaut, 1990). The channel has maintained a minimum width of 200-300 meters (650-980 feet) and it achieved a maximum depth of 12 meters (39 feet) in 1955 (Vincent & Corson, 1980). The gorge creation contributed between 250,000 c.y. to 500,000 c.y. to the shoals when it was first cut through the barrier island.

The flood shoal was formed quickly after the formation of the inlet, probably within the first 20 to 30 years. It is a very distinct, multilobate shoal containing about 3.7 million cubic yards of material (Figure 8).

There is good evidence that the flood shoal is moderately stable. Comparison of a USGS 1961 survey and 1989 bathymetric survey shows a loss of approximately 300,000 cubic yards. A close examination of 1961-1989 surveys show erosion in the flood channels and building of the north and south lobes of the shoal; the buildup has been on the order of 200,000 cubic yards from 1961-1989. Seagrass has generally populated those areas where the changes have been small. The apparent erosion may be due to sand redistribution to the shoal's extremities.

Based on the above information, we conclude that active building of the flood shoal stopped after the first 20 to 30 years and that flood currents have been redistributing sand in the shoal ever since. The flood shoal was estimated to be 2.6 million cubic yards in 1958 by Davis & Gibeaut (1990) and 3.75 million cubic yards by the University of Florida (1974).

The ebb tidal shoal of the inlet probably formed over a longer period of time after the inlet opened in 1921. Estimates of ebb tidal area have steadily increased from 6.6 million square feet in 1953 to 12.9 million square feet in 1979. The estimated shoal volume in 1960 was 4.25 million cubic yards (University of Florida, 1974), based on comparison of USGS charts 1879 to 1960.

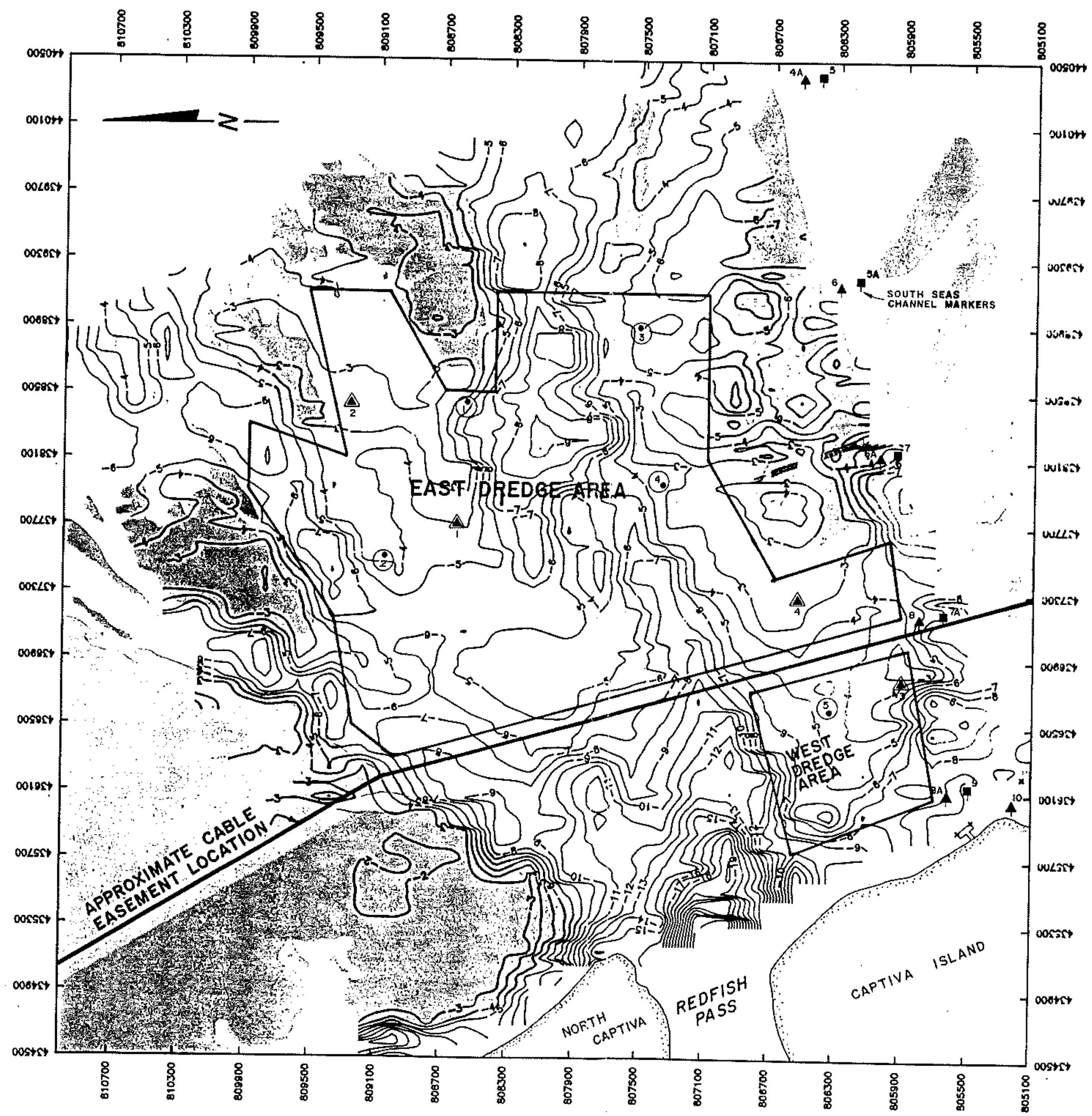
Another estimate of the 1982 ebb shoal size was reported by Hine and Davis (1986) to be 2.8 million cubic yards. This estimate was made after a 1981 nourishment project placed approximately 655,000 cubic yards on South Seas from the ebb shoal. This would suggest a pre-dredge volume of only 3.5 million cubic yards. This is significantly less than previous estimates and might suggest erosion or at least stability of the shoal since about 1960; although it could also represent the difference in methods used to compute volume. An analysis of the theoretical capacity of the ebb shoal suggests that the shoal was not fully mature in 1960 and was still building. Based on the minimum inlet cross-

REDFISH PASS
FLOOD TIDAL SHOAL BATHYMETRIC SURVEY

DECEMBER 5, 1989

LEGEND:

- SAND SAMPLE LOCATION w/ SAMPLE NUMBER
- CABLE CROSSING AREA
- GREEN CHANNEL MARKER
- RED CHANNEL MARKER
- SEAGRASS BEDS
- CPE VIBRACORE, 1990



500 0 250 500

SCALE IN FEET

NOTES:

1. BATHYMETRIC SURVEY CONDUCTED: DEC. 5, 1989.
2. SURVEY TRACKLINES WERE RUN N 65° E AND S 65° W AT 300 FOOT INTERVALS. DEPTHS WERE OBTAINED EVERY 20 FEET ALONG TRACKLINES.
3. CONTOURS AND SOUNDINGS SHOWN WERE INTERPOLATED FROM TRACKLINE DATA BY COMPUTER.
4. POSITIONING ACQUIRED BY A DEL NORTE 540 TRISPONDER SYSTEM. GUIDANCE ALONG TRACKLINE OBTAINED BY USING AN AUTOCARTA II NAVIGATION SYSTEM.
5. DEPTHS OBTAINED BY AN INNERSPACE 448 FATHOMETER WITH BUILT—IN DEPTH DIGITIZER.
6. SOUNDINGS ARE FEET REFERENCED TO NATIONAL GEODETIC VERTICAL DATUM (NGVD), 1929.
7. COORDINATES ARE BASED ON FLORIDA STATE PLANE COORDINATE SYSTEM, WEST ZONE, NORTH AMERICAN DATUM, 1927.
8. DATE OF SAND SAMPLES: DEC. 5, 1989.
9. SEAGRASS BEDS SCALED FROM HIGH ALTITUDE INFRARED AERIAL PHOTOGRAPH TAKEN AUGUST 3rd, 1989 BY KUCERA SOUTH, INC.
10. A LEE COUNTY ELECTRIC COOPERATIVE (LCEC) SUBAQUEOUS CABLE EASEMENT ACROSS REDFISH PASS WAS PLOTTED USING AN EASEMENT DRAWING (#10594) PROVIDED BY LCEC AS SURVEYED BY JOHNSON ENGINEERING, INC.

COASTAL PLANNING & ENGINEERING, INC.
BOCA RATON SARASOTA JACKSONVILLE FLORIDA

PROJECT:
CAPTIVA ISLAND
REDFISH PASS
FLOOD TIDAL SHOAL BATHYMETRIC SURVEY
DECEMBER 5, 1989

DRAWN BY: Computer/ Mr /S.B.

CHECKED BY: J.L.A.

DATE: 1/25/90

COMM. NO.: 8401.54

SCALE: AS SHOWN

SHEET: 1 OF 1

REVISION DATE: 3/27/91

sectional area of 12,200 square feet (1974), the predictive ebb shoal size at equilibrium should be:

$$V = 45.7\ A^{1.28} \qquad \text{(Walton \& Adams, 1976)}$$
$$V = 7.77 \times 10^6 \text{ cubic yards}$$

Using the 1988 minimum cross-section of 10,790 square feet suggests an equilibrium shoal of 6.64×10^6 cubic yards. Therefore, the ebb shoal of the inlet could theoretically build to a volume of between 6-8 million cubic yards.

Our own direct calculation of the change in ebb shoal size using the 1961 and 1991 bathymetries shows an erosion of 1.4 million cubic yards. When this value is corrected for the material removed from the ebb shoal for Captiva Island nourishment projects, the ebb shoal would have accreted by 840,000 cubic yards (28,000 c.y./yr.). An annual growth rate of 28,000 c.y./yr may represent the long term shoaling rate of the ebb shoal.

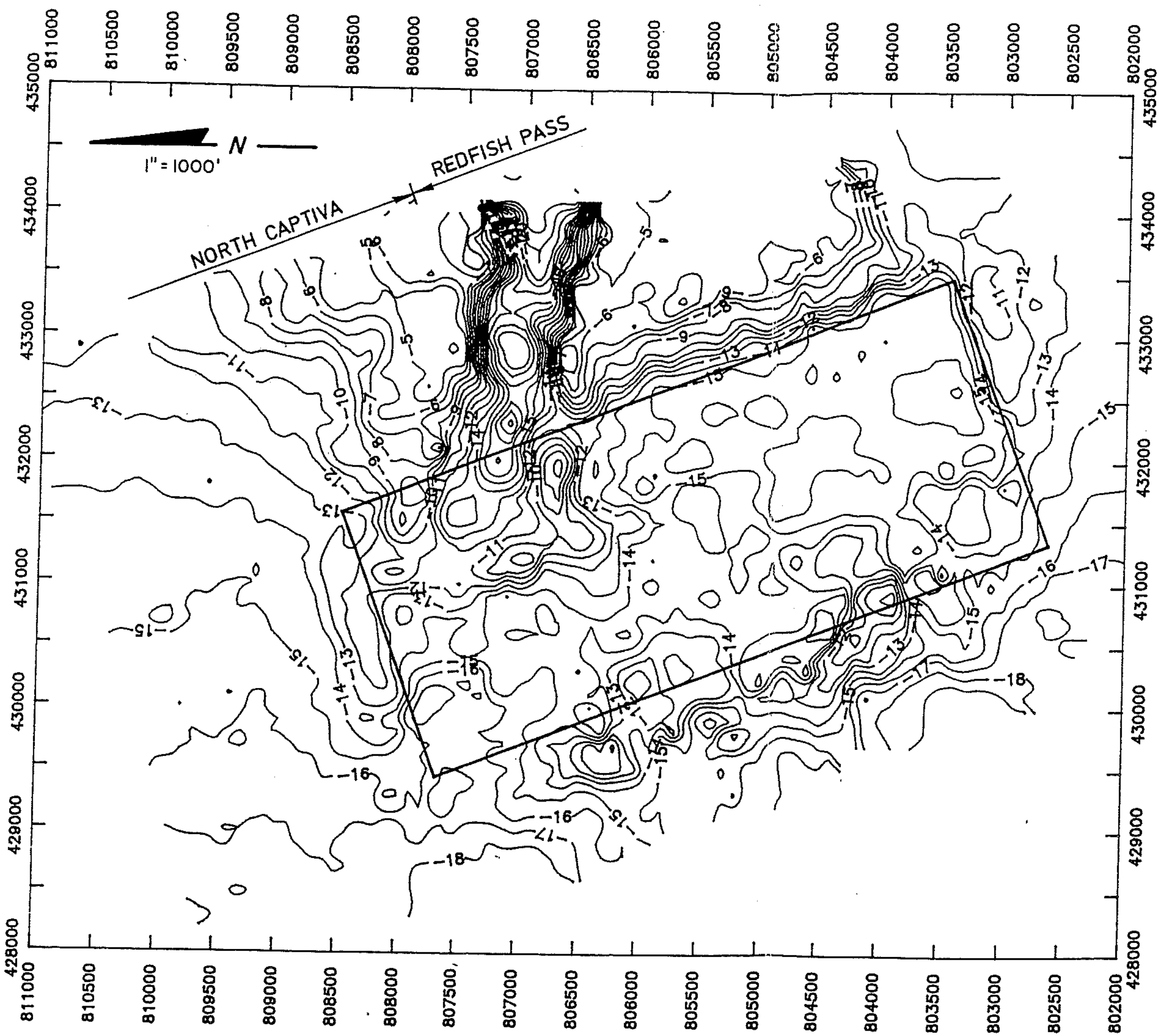
It appears from the above analysis that the ebb tidal shoal built steadily since the inlet opened in 1921. There may have been a slowing of shoaling rates in recent years as evidenced by the lower recent shoal volume estimates. However, the shoal area calculations suggest a steady increase in the area of the shoal over time (See Figure 9).

Direct evidence of shoaling rates in the ebb shoal borrow areas were obtained by post dredge surveys of borrow areas. The surveys showed the following:

Surveyor	Surveys Compared	Volume Measured	Annual Rate
Tackney & Associates (1983)	Feb. '82 - Aug. '83	105,000 c.y.	70,000 c.y.
George F. Young (1988)	Sept. '85 - Oct. '87	146,000 c.y.	71,000 c.y.
CPE	April '89 - April '91	46,000 c.y.	23,000 c.y.

Recent ebb tidal shoal rates are best represented by the CPE comparison because the survey covered a broader area of the shoal. Of the above surveys, only the CPE survey included areas outside the immediate borrow area. The CPE survey showed that gains in the borrow area were partially offset by losses on the perimeter of the borrow area. Therefore, it is concluded that the shoaling rates on the ebb shoal after 1981 were closer to 23,000 c.y./yr. than 70,000 c.y./yr. These rates were calculated over short time frames. Ebb shoal changes between 1989 and 1991 are shown in Figure 10.

A study of west coast inlets (Davis & Gibeaut, 1990) quantified the shoal volumes at Redfish Pass. The ebb shoal in 1982 was estimated to contain approximately 2,800,000 cubic yards of sand, which is significantly less than the 4.25 million cubic yards reported by the University of Florida (1974). CPE analyzed the shoal with 1991 bathymetries, 1880 and 1956/60 charts, and confirmed the higher figure. Since 840,000 cubic yards

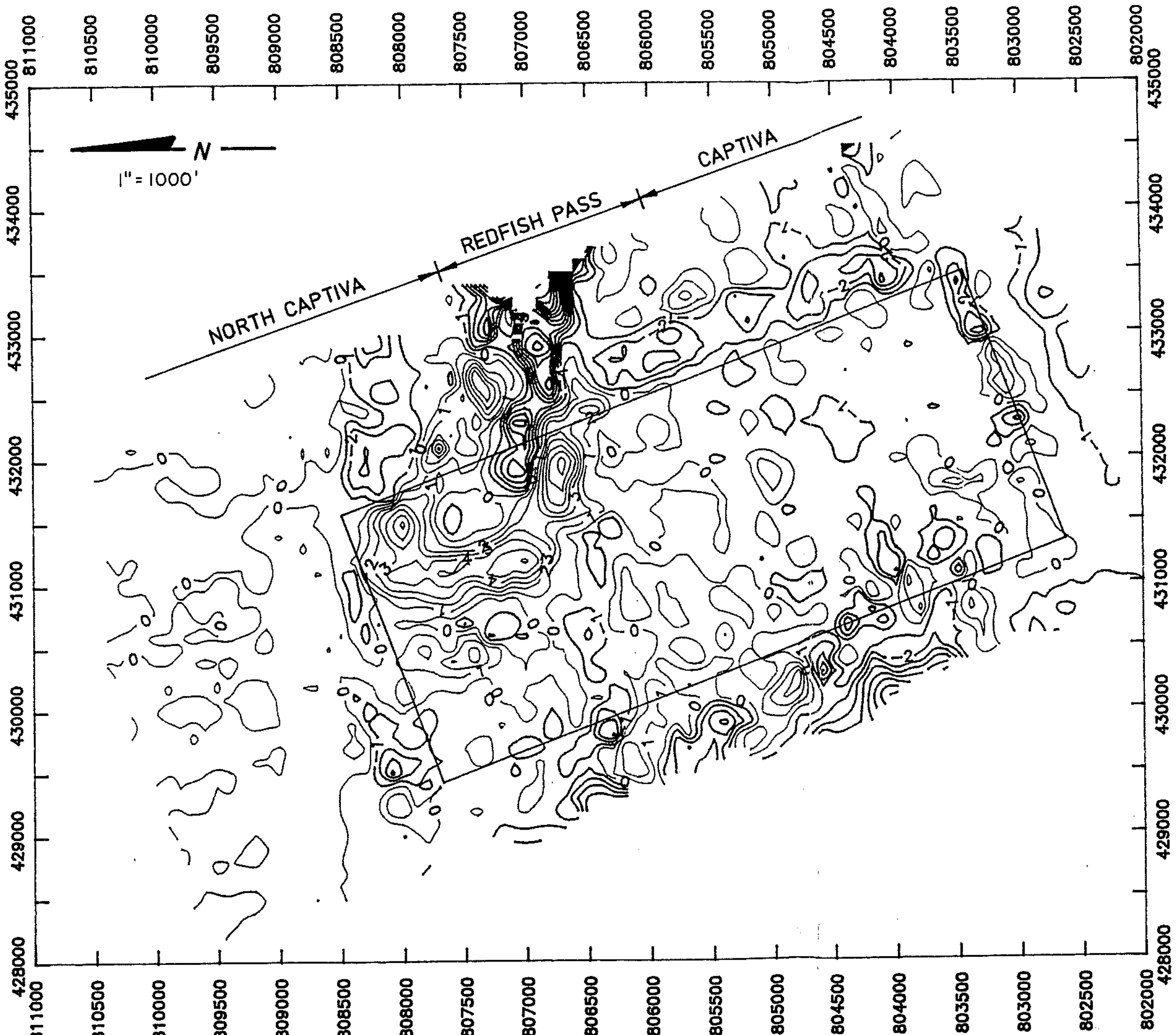


NOTES:

1. SOUNDINGS ARE IN FEET REFERENCED TO NATIONAL GEODETIC VERTICAL DATUM (NGVD) 1929.
2. COORDINATES ARE BASED ON FLORIDA STATE PLANE COORDINATE SYSTEM, WEST ZONE, NORTH AMERICAN DATUM 1927.

REDFISH PASS
"EBB SHOAL"
BATHYMETRIC CHART
APRIL 1991

FIGURE 9



LEGEND:
ACCRETION
EROSION

REDFISH PASS

SHOAL MAP

APRIL 1989 — APRIL 1991

FIGURE 10

are known to have shoaled at the ebb shoal since 1961 and 2.25 million cubic yards were dredged in 1981 and 1988/1989, the present ebb tidal shoal at Redfish Pass is estimated to contain at least 2,840,000 cubic yards of material. At an annual infill rate of 28,000 c.y./yr. it will take the ebb shoal until 2060 to regain all the sand dredged from the inlet in the 1980's.

The accretion and erosion of the ebb and flood shoals are critical to an understanding of the littoral processes on Captiva, North Captiva and Redfish Pass. As a relatively new inlet, Redfish Pass has been a sediment trap for most of its life, with significant effects on the adjacent islands. The data on shoal sizes, accretion and erosion was combined to show the shoaling history (Figure 11). The shoal growth (ebb and flood) is assumed to start at inlet opening in 1921. Island erosion and shoal accretion will be rapid initially. The combined ebb and flood shoals have accreted 9 million cubic yards since 1921, including sediment removed for Captiva Island nourishment.

F. Sediment Budget

This section contains an estimate of longshore transport at Redfish Pass which is responsible for the downdrift transport of sediment, and a discussion of the resulting sediment budget.

1. Longshore Transport

Longshore transport is defined as the movement of sand within the surf zone in a direction parallel to the beach. The longshore transport depends primarily on the incident wave height and wave angle. Two of the most popular methods of evaluating this transport are by either comparing measured beach volumes or by using simple empirical equations that relate the transport to basic wave properties. Because sediment transport is directly dependent on the local wave climate, there tend to be seasonal variations in this transport, whether it be a change in magnitude, a shift in direction or a combination of both. Figure 12 demonstrates the variability of transport at Redfish Pass from 1956 to 1975 based on WIS wave data.

Estimates for the net longshore transport at Redfish Pass vary widely. A University of Florida (1974) report calculated that the net longshore transport was 90,000 cubic yards southward. Applied Technology and Management, Inc. (1987) assumed that the net longshore sediment transport was also in the southward direction with a magnitude of 100,000 cubic yards. Empirical equations summarized in the *Shore Protection Manual* (USACE, 1984) generated net longshore transport values at Redfish Pass ranging from 60,000 to 138,000 cubic yards per year in the southward direction.

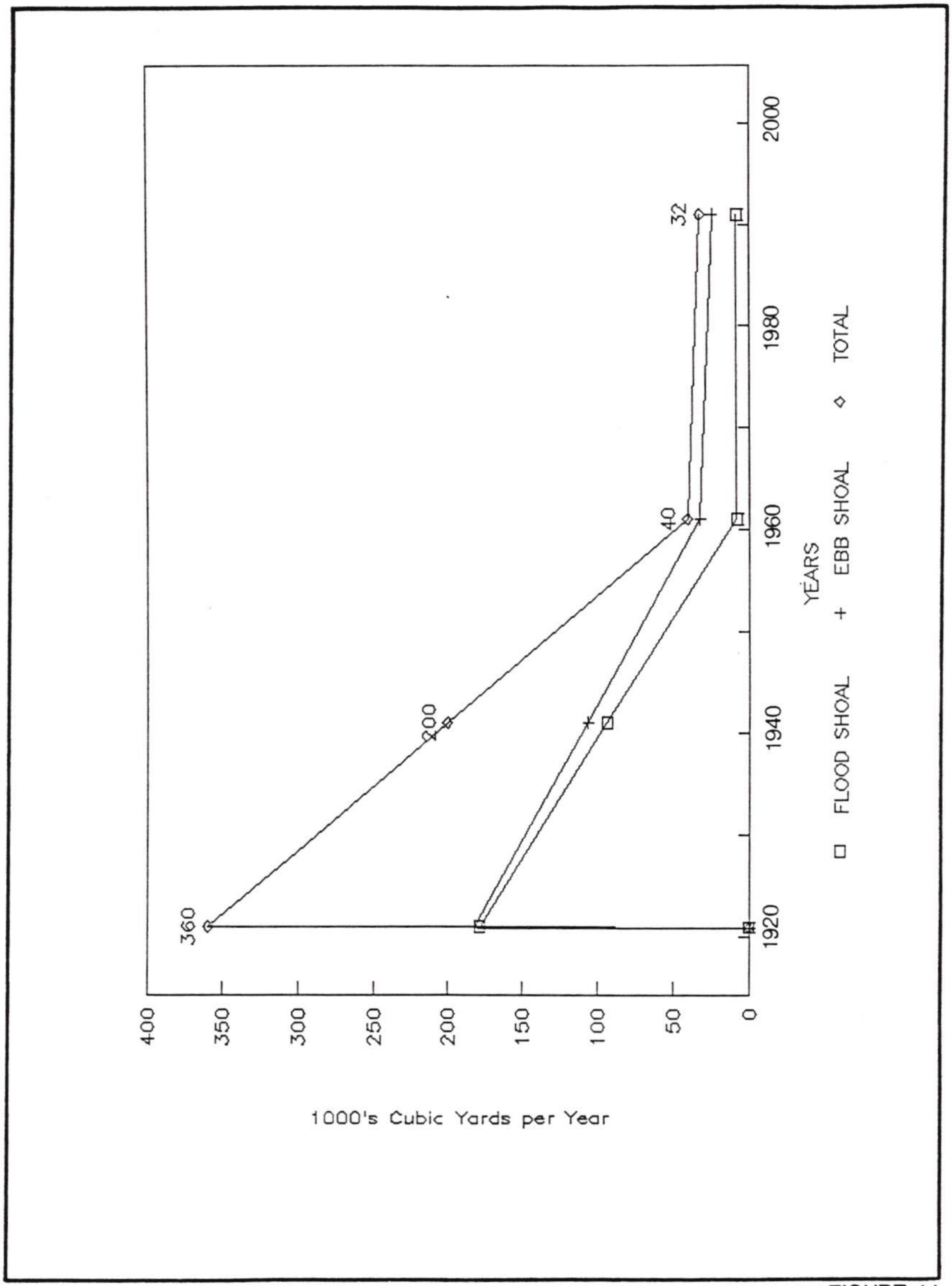


FIGURE 11

REDFISH PASS
SHOAL GROWTH RATE

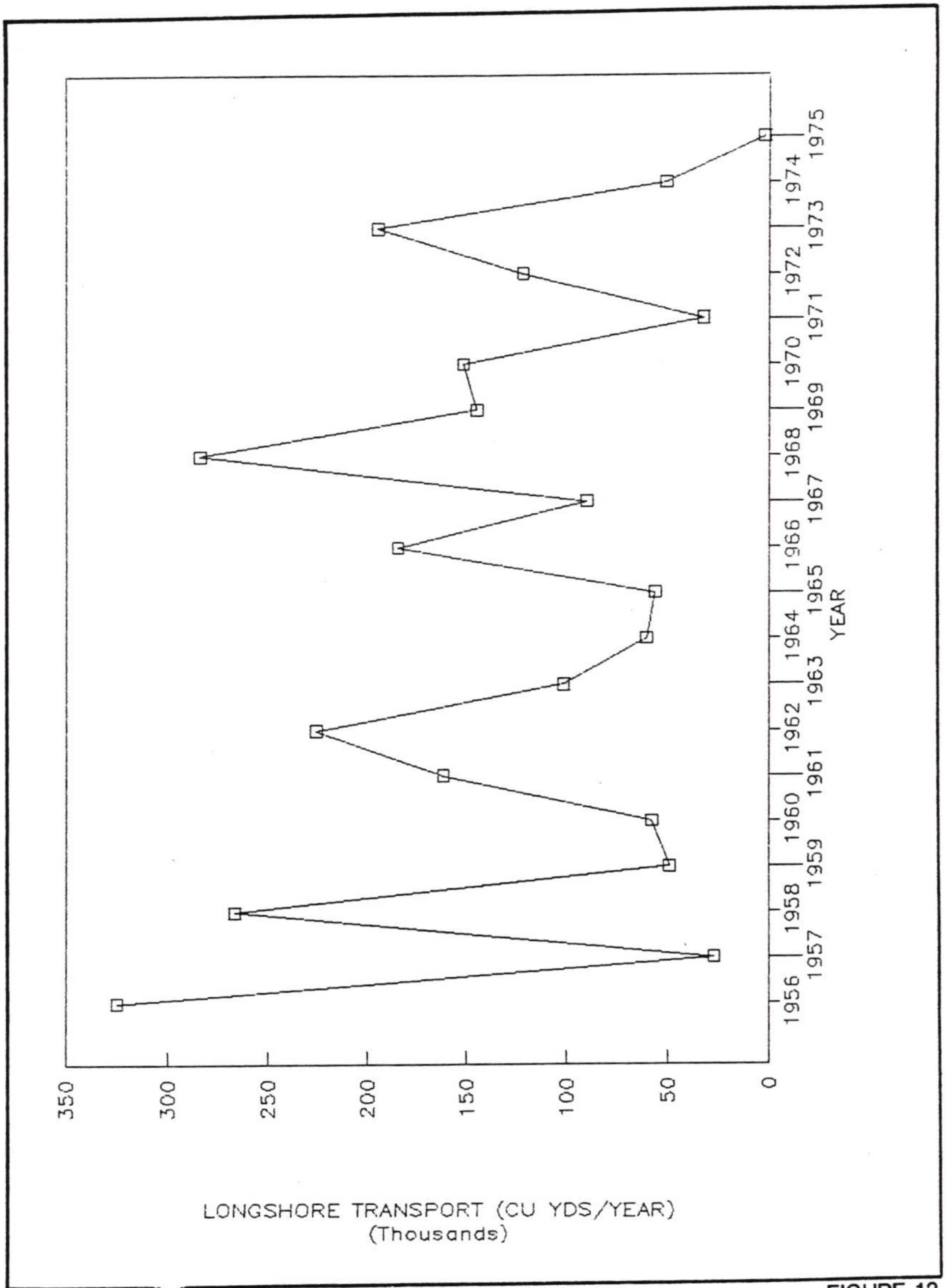


FIGURE 12

ANNUAL NET (SOUTHWARD) TRANSPORT VALUES

TABLE 9
MONTHLY LONGSHORE TRANSPORT RATES

MONTH	NORTH DRIFT (CY/DAY)	SOUTH DRIFT (CY/DAY)	NET DRIFT (CY/DAY)	NORTH DRIFT (CY/MO)	SOUTH DRIFT (CY/MO)	NET VOLUME (CY/MO)	NET DRIFT DIRECTION
JAN	200	1100	-900	6200	34100	-27900	SOUTH
FEB	160	960	-800	4480	26880	-22400	SOUTH
MAR	160	550	-390	4960	17050	-12090	SOUTH
APR	150	100	50	4500	3000	1500	NORTH
MAY	120	100	20	3720	3100	620	NORTH
JUN	130	30	100	3900	900	3000	NORTH
JUL	100	130	-30	3100	4030	-930	SOUTH
AUG	160	80	80	4960	2480	2480	NORTH
SEP	200	110	90	6000	3300	2700	NORTH
OCT	40	280	-240	1240	8680	-7440	SOUTH
NOV	80	420	-340	2400	12600	-10200	SOUTH
DEC	120	300	-180	3720	9300	-5580	SOUTH
TOTAL				49180	125420	**-76240**	SOUTH

NOTES:
DRIFT RATES FROM WALTON (1976) FIGURES A-170 TO A-182
FOR A SHORELINE ORIENTATION OF 255 DEGREES.

In this investigation a net longshore transport rate of approximately 76,000 cubic yards per year was computed, using longshore transport roses specifically calculated for the west coast of Florida (Walton, 1976).

Table 9 lists longshore transport values by month and divides the drift for each month into northward and southward directions. The gross monthly values as well as the net monthly values are presented in Figures 13a and b. Figure 13a demonstrates that there is a significant decrease in southward transport during the summer months (April - September). Although the northward drift appears much smaller in magnitude, the drift in the northward direction tends to be more constant. The southward drift decreases so much during the summer months that the net longshore transport (Figure 13b) shifts to the northward direction. This type of occurrence is common along the west coast, as well as the east coast of Florida.

2. Sediment Budget

The littoral sand budget is a balance of sand movement during specific time periods and over specific segments of coast. The following summarizes the littoral sand budget based on shoreline changes from 1941 through 1991 during four time periods on North Captiva and Captiva Islands. The result of sediment budget analysis is presented in Figures 14a and b. The Redfish Pass sediment budget is based in part upon values determined in the Blind Pass Inlet Management Plan (CPE, 1993). A review of the erosion and accretion rates based on four recent time periods is shown in Tables 6 and 7. On Captiva and North Captiva Islands shoreline changes were converted to volume changes by multiplying by 0.67, except where volumes were measured by profiles. Redfish Pass shoaling rates are based on Figure 11.

North Captiva Island is a typical Florida west coast barrier island in that it has a high degree of curvature. At the center of the curvature is a low and narrow section of the island which is subject to overwash and breaches. This is an area that was breached during Hurricane Donna in 1960 and the "No Name" storm of 1982 and subsequently closed in less than a year.

Between 1941 and 1955, it is probable that the Redfish Pass shoals had not fully developed and therefore were not providing protection for the northern shore of Captiva island or the south shore of North Captiva. This would account for the high total erosion rates of both North Captiva and Captiva Island. During this time period, 26,000 c.y. was lost into the pass annually from Captiva and 118,000 c.y. was being lost to the pass from North Captiva island.

During the next time period, 1955 to 1974, the erosion rate of Captiva Island was reduced by more than half from 165,000 c.y./yr to 67,000 c.y./yr. Losses at North Captiva island were reduced by 47% to 47,000 cubic yards annually. The

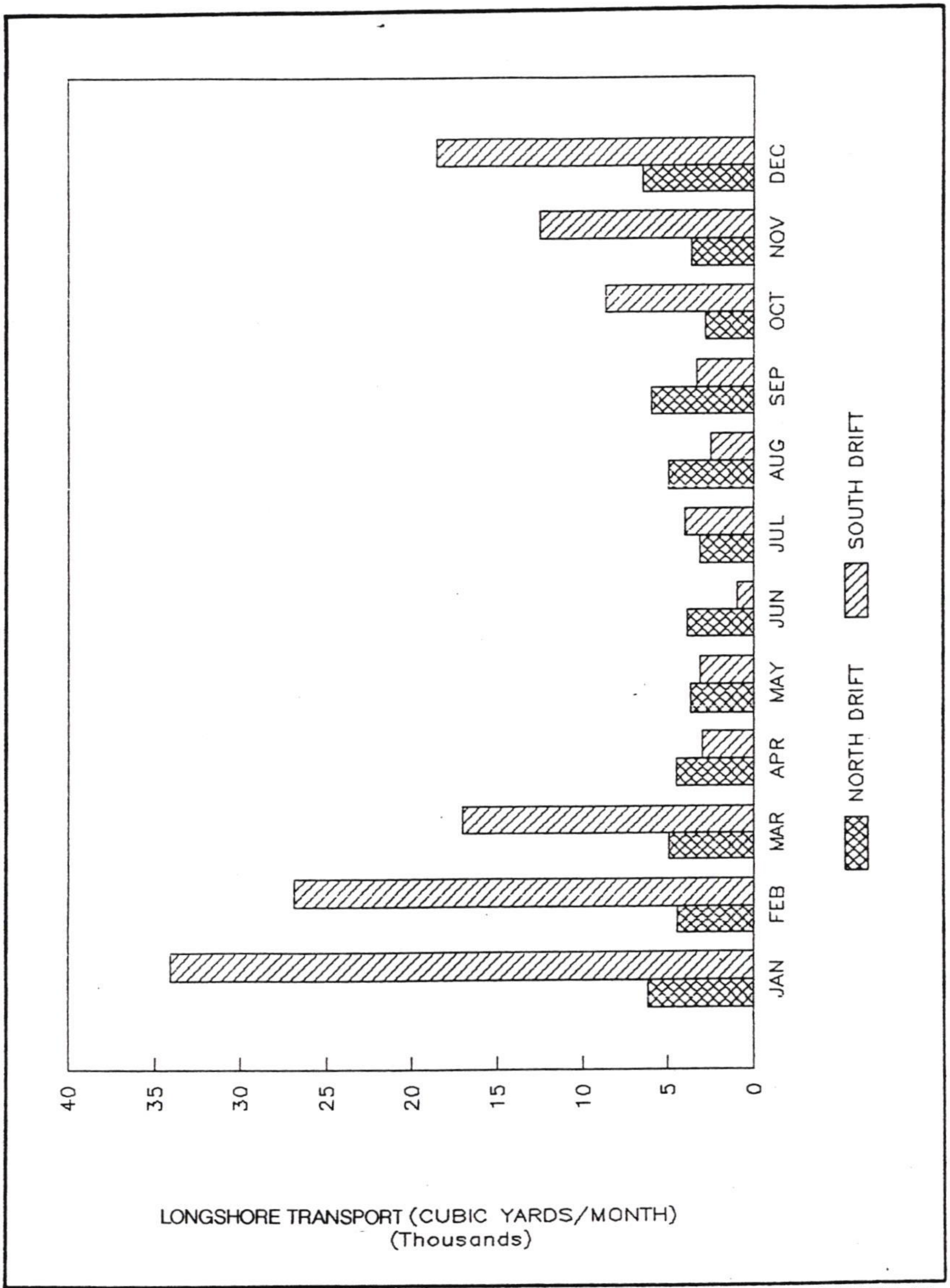


FIGURE 13a

MONTHLY LONGSHORE TRANSPORT

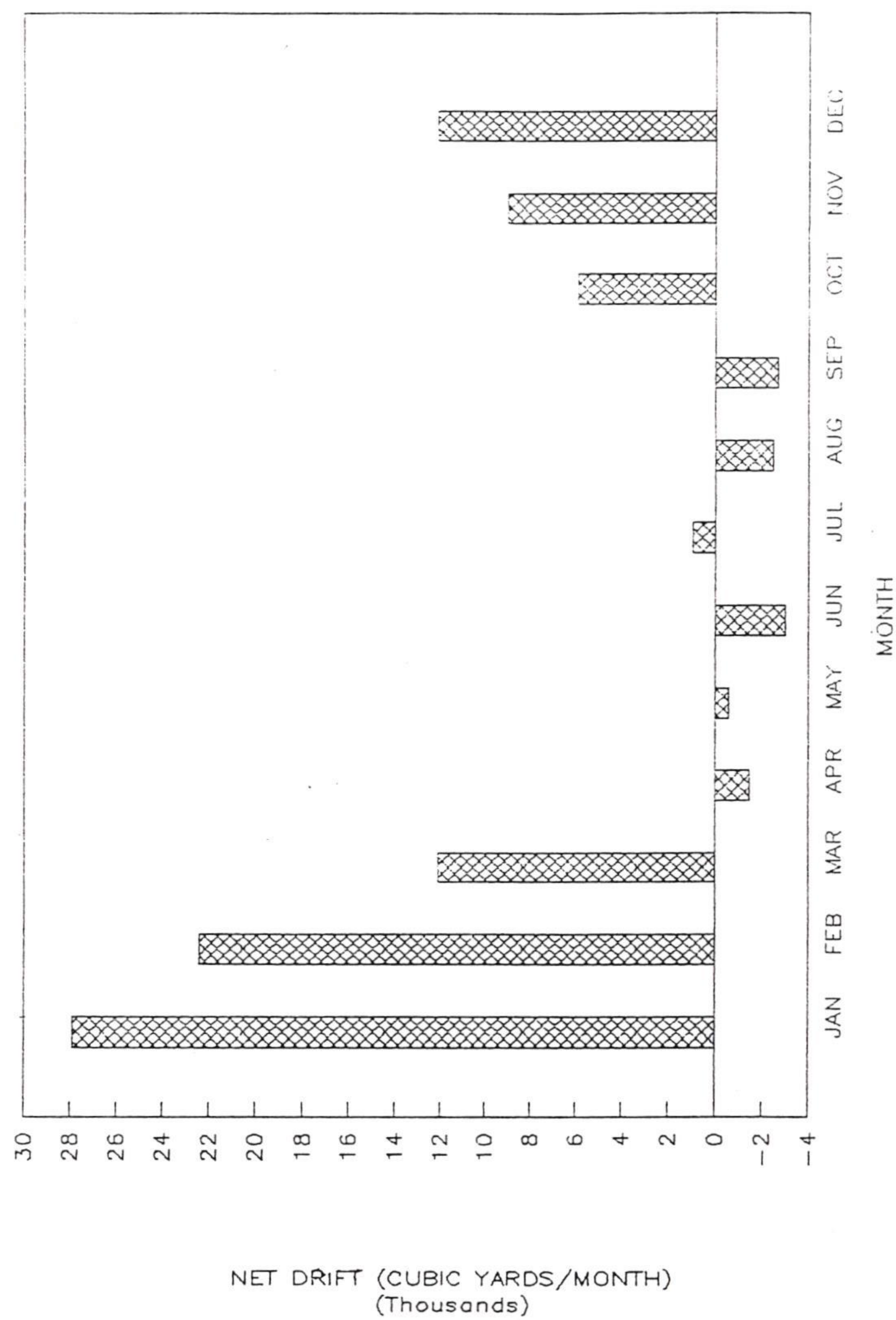
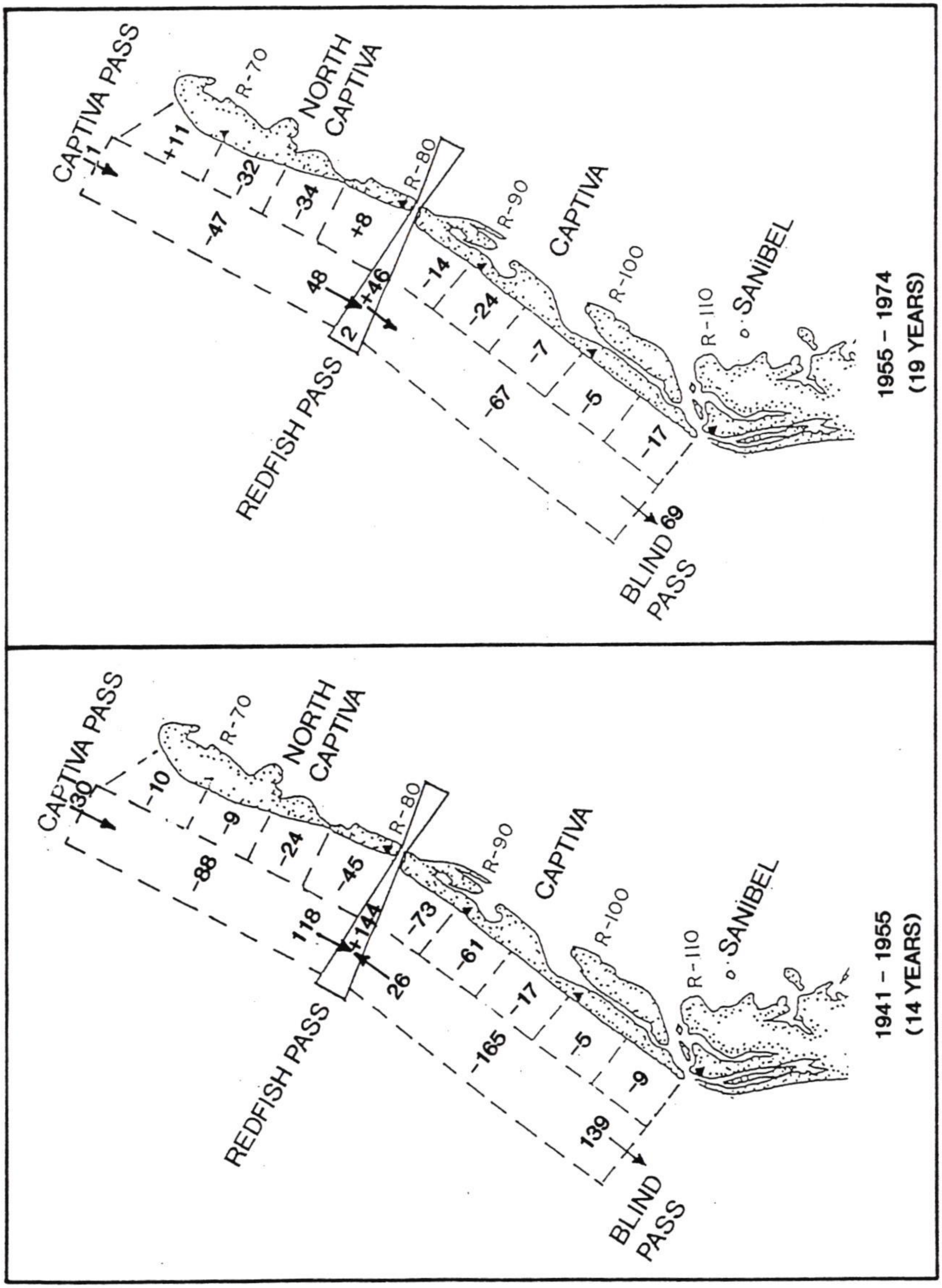


FIGURE 13b

NET MONTHLY LONGSHORE TRANSPORT



VOLUMES ARE 1000s C.Y./YR.

FIGURE 14a

NORTH CAPTIVA-CAPTIVA SEDIMENT BUDGET

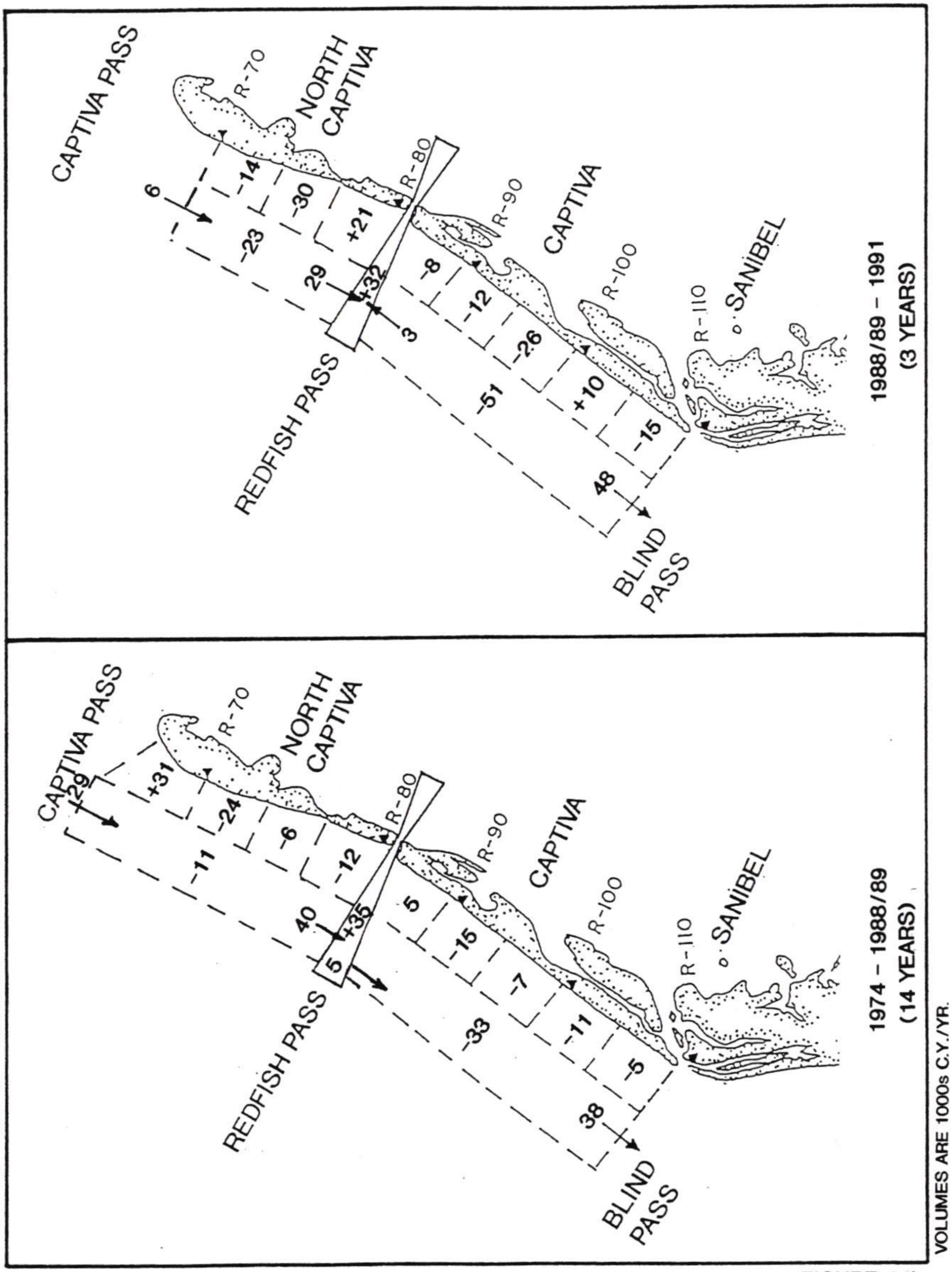


FIGURE 14b

NORTH CAPTIVA–CAPTIVA SEDIMENT BUDGET

reduction in erosion rates can be partially explained by a more developed ebb shoal of Redfish Pass which prevented the losses into Redfish Pass from the severely eroded beach.

The loss of sand to Sanibel Island from Captiva Island was reduced by 45% during this time period (from 139,000 to 69,000 cubic yards/year). During this time period, 134 "dog bone" groins were installed on Captiva Island (including 2 wooden groins) and portions of the road revetment were constructed. It is likely that these structures slowed north and south longshore transport along Captiva Island. The most likely reason for the reduction in south drift was the reorientation of segments of the island as a result of major recession of the northern beaches. The northern segment was pinned by the wooden groins and revetment at the north end of the road. The southern segment was first pinned by the county terminal groin at Blind Pass (1972) then by a revetment located 1200 feet north of the groin during the 80's. The increased size of the Redfish Pass ebb shoal partially protected the island from southwesterly waves.

During the period 1974 through 1988, two beach restorations were constructed at Captiva Island. The terminal structure at Blind Pass and a revetment 1/4 mile north of Blind Pass controlled the movement of sand to Sanibel Island. The losses from Captiva Island to Sanibel Island were further reduced during this time from 69,000 to 38,000 cubic yards/year. This represents a reduction of 31,000 cubic yards/year.

Between 1974 and 1989 the overall shoreline at North Captiva Island was more stable. The north 1-mile segment accreted while the remainder eroded at a lower rate.

During the post-construction time period, 1989 through 1991, the Captiva beaches lost approximately 51,000 cubic yards per year. An estimated 3,000 cubic yards per year moved from Captiva north into Redfish Pass.

The sediment budget shows regional processes, therefore small scale processes are not visible. The most important of these smaller scale processes is the reversal of net longshore drift that occurs south of Redfish Pass. This process occurs in the first mile segment south of Redfish Pass. The nodal point occurs approximately 2,000 to 5,000 feet south of the inlet. The sediment budgets for 1974 to 1988 and 1988 to 1991 show a reversal in the first mile segments.

Between 1989-1991, North Captiva Island lost an estimated 23,000 cubic yards per year. Unfortunately, the data set for 1989 did not extend over the entire island. The 6,000 cubic yards/year transport from Captiva Pass on Figure 14b actually represents transport from the northern 1 mile of North Captiva. The southern 1-mile of North Captiva Island accreted while the center segments of the island continued to erode.

3. Sediment Budget Analysis

The boundaries for the littoral budget analysis extend from Captiva Pass to the north of North Captiva Island to Blind Pass south of Captiva Island (Figure 14). The key to the sediment budget analysis is the relationship of the three inlets to the adjacent islands. Captiva Pass is a long established natural inlet that has been stable for the last 100 years (Davis & Gibeaut, 1990). Redfish Pass, on the other hand, was created in 1921, and has experienced very rapid, natural development through 1941, and continues to mature and grow today. Blind Pass was similar in size as present day Redfish Pass prior to 1921. Since then, Blind Pass has lost tidal prism to Redfish Pass, and has lost much of its ebb shoal to Sanibel Island. The three inlets are from north to south, stable, growing and shrinking.

Redfish Pass had its greatest impact on the adjacent islands from 1921-1941. Redfish Pass also stopped the flow of sand form North Captiva Island to Captiva Island creating an erosion condition on Captiva, especially focused on the northern beaches. The longshore transport deficiency created by Redfish Pass was concentrated primarily on Captiva Island through 1955, as evidenced by the high erosion rate from 1941 through 1955, when the island lost 165,000 cubic yards per year.

The littoral budget suggests that during the period (1941-1955) as much as 118,000 cubic yards of sand were leaving the south end of North Captiva Island, while only 26,000 cubic yards were leaving the north end into Redfish Pass.

North Captiva Island also experienced high erosion during this period, averaging losses of 88,000 cubic yards per year. The sediment budget suggests this occurred in spite of 30,000 cubic yards of material bypassing Captiva Pass to North Captiva Island. The loss of 118,000 cubic yards annually into Redfish Pass was the main contributor.

From 1955 to 1974, the erosion trend decreased throughout the area. This suggests the maturing of Redfish Pass by the building of an ebb shoal, which limited loses on the north end of Captiva Island and south end of North Captiva. North Captiva and Captiva lost respectively, 47,000 and 67,000 cubic yards per year to erosion, while only North Captiva lost a significant amount to Redfish Pass. Total losses to the Redfish Pass shoals in this period decreased 68% to 46,000 cubic yards per year.

The years 1974 to 1988 include the first beach nourishment for Captiva Island. During this period, the erosion on Captiva averaged 33,000 cubic yards/year, while North Captiva Island remained relatively stable. This suggests the first signs of Redfish Pass approaching stability. In addition, the gulf shores for one mile south of Redfish Pass showed no erosion, further suggesting inlet stability.

The second nourishment of Captiva Island took place during 1988-1989, again using the ebb shoal of Redfish Pass as a borrow source. This period included two other significant events: Tropical Storm Keith and an atypical stronger northward sand movement along the Gulf coastlines (CPE, 1992). These events may have affected the rate of erosion that has been measured on both islands. Both islands continued to have moderate erosion trends. The buildup of the Redfish ebb and flood shoals slowed only marginally, in spite of the large quantity of material removed from the ebb shoal. The terminal groin at the north end of Captiva Island may contribute to the slow losses to Redfish Pass.

The 1974-1988 and 1988-1991 sediment budgets were partially confirmed by the results of the Redfish Pass wave refraction analysis. The sediment budget shows transport from Redfish Pass changing from 5,000 c.y./yr. from the pass during the period 1974-1988, to 3,000 c.y./yr. into the pass after 1988 (Figure 13b). Results of the wave refraction analysis (Appendix G) show a reversal and decrease in average longshore transport immediately south of the inlet. The magnitude of the average longshore transport decreased by 40% and reversed direction in the first 4000 feet south of the inlet, which agrees with the sediment budget values.

North Captiva Island's losses to Redfish Pass have decreased with each successive time frame. Losses between 1955 and 1974 averaged 48,000 c.y./yr. These losses decreased to 40,000 c.y./yr. from 1974 to 1989, and further decreased to 29,000 c.y./yr. from 1989 to 1991.

Redfish Pass has developed significantly since its opening in 1921, and demonstrates many attributes of a mature inlet. In spite of these attributes, Redfish Pass shoals have room to grow further, as demonstrated by the minimal inlet bypassing recorded to date and the continued growth of the ebb shoal. The ebb can be expected to grow by at least the quantity of material removed from the shoal by dredging.

4. Inlet's Contribution to Beach Erosion

The inlet's contribution to beach erosion on Captiva Island can be quantified. Without the inlet, Captiva Island would receive all the longshore transport from the North Captiva Island area, with small losses to other sinks. With the inlet, both islands are losing material into the Redfish Pass ebb and flood shoals. Recently, these losses have averaged 32,000 c.y./yr. If not for the inlet's effect, this sand would be available to Captiva Island, and reduce erosion by 32,000 c.y./yr.

G. Stability and Hydraulic Characteristics of the Inlet

Redfish Pass has been subject to few improvements since it opening in the 1920's. The most significant human actions have included the construction of a small groin on Captiva Island adjacent to the inlet and the use of the Redfish Pass ebb shoal as the sand source for two nourishment projects on Captiva Island. Beyond these actions, Redfish Pass has developed naturally since its opening.

Redfish Pass did have initial adverse effects on Blind Pass. When Redfish Pass first opened, the net longshore transport southward was halted, denying sand to the beaches adjacent to Blind Pass. Because a new channel had been cut connecting Pine Island Sound to the Gulf waters, there was a new avenue for the water to escape. As a result, tidal currents at Blind Pass were reduced. These reduced currents lead to a reduced channel at Blind Pass.

A hydraulic stability analysis of Redfish Pass was conducted. The two equilibrium velocity theories used to examine Redfish Pass were developed by Escoffier (1977) and O'Brien (1966). Both theories are based on Keulegan's inlet velocity theory (1967).

The data used in this stability analysis were taken from the 1974 University of Florida "Coastal Engineering Study of Captiva Island." The current in Redfish Pass was measured from March 28 to April 1, 1973. The report estimated that spring tide would produce a measured tidal prism 20% greater than the current measured during the three day field trip. The following data was determined in 1973:

TABLE 10

1973 TIDAL MEASUREMENTS

Mean Range of Tides	1.75 ft
Throat Cross-Sectional Area (Ac)	12,200 sf (MLW)
	12,540 sf (MTL)
Maximum Flood Velocity	2.8 fps
Maximum Ebb Velocity	2.4 fps
Bay to Gulf Tide Ratio	0.85

The results of the Escoffier and O'Brien calculations are shown in Figure 15a. The tidal prism associated with the measured maximum velocity is 6.32×10^8 cubic feet. The spring tidal prism is estimated to be 7.48×10^8 cubic feet. The stability figure (Figure

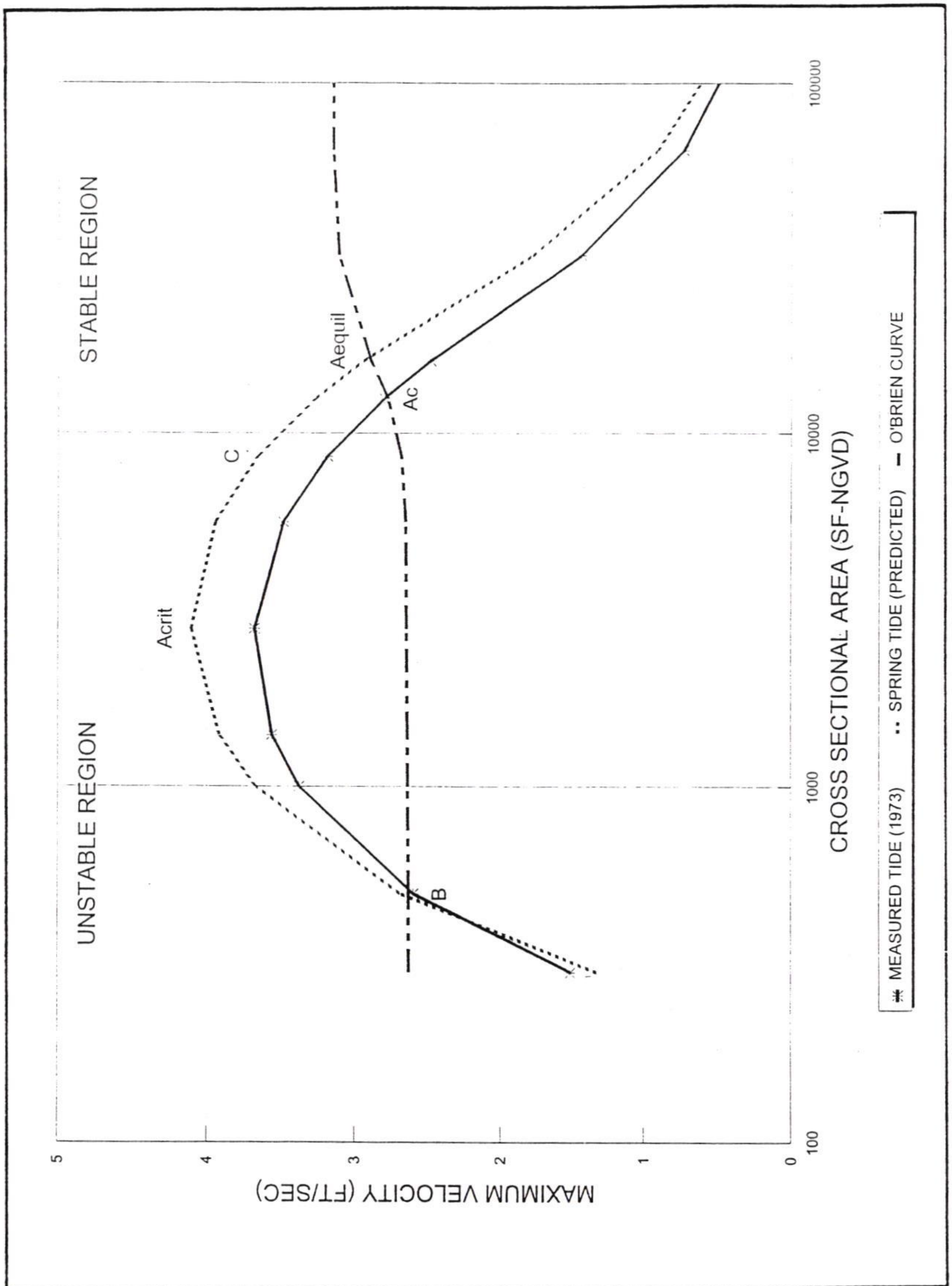


FIGURE 15a

INLET STABILITY CURVE
REDFISH PASS, FLORIDA

15a) shows two Escoffier curves, one based on measured current velocities and one based on a spring tide situation. The following discussion will deal with the spring tide curve.

The analysis of 1973 inlet characteristics is relevant to the existing inlet stability. The cross-sectional area of the inlet throat in 1992 was 12,630 sf MTL, only 1% larger than the 1973 inlet throat (see Table 11 and Figure 15b). Redfish Pass is a relatively short inlet with a large capacity to efficiently exchange bay and Gulf waters. Small changes in throat area will not change its stability characteristics.

TABLE 11

HISTORIC YEAR	INLET WIDTH (FT)	DIMENSIONS THROAT AREA (MTL)
1960 (1)	682	13,400
1973 (2)	625	12,540
1988 (1)	590	10,790
1992 (3)	625	12,630

(1) Davis & Gibeaut, 1990
(2) University of Florida, 1974
(3) CPE, 1992

The Escoffier curve in Figure 15a shows two regions, one of increasing maximum velocity with increasing K (repletion coefficient) and one with decreasing maximum velocity with increasing K. Escoffier (1977) noting that K is a function of the cross-sectional area, indicated that the curve shows the stability of the inlet at different size cross-sections.

When considering inlet stability, it is easier to interpret the Escoffier diagram if the maximum velocity is plotted versus cross-sectional area rather than K. Escoffier indicated that the crest of the curve corresponded to the critical cross-sectional area, A_{crit}. If the actual cross-sectional area is less than A_{crit}, then the inlet is unstable and will close. If the cross-sectional area is larger than A_{crit}, the inlet is stable and will remain open.

To demonstrate this concept, consider two points on the curve (Figure 15a). Point B is located in the unstable region and Point C is located in the stable region. For Point B, a decrease in A_c is accompanied by a <u>decrease</u> in the maximum velocity. This causes the inlet to shoal further and ultimately close. For Point C, a decrease in A_c is accompanied by an <u>increase</u> in the maximum velocity. This causes the inlet to scour and return toward Point C.

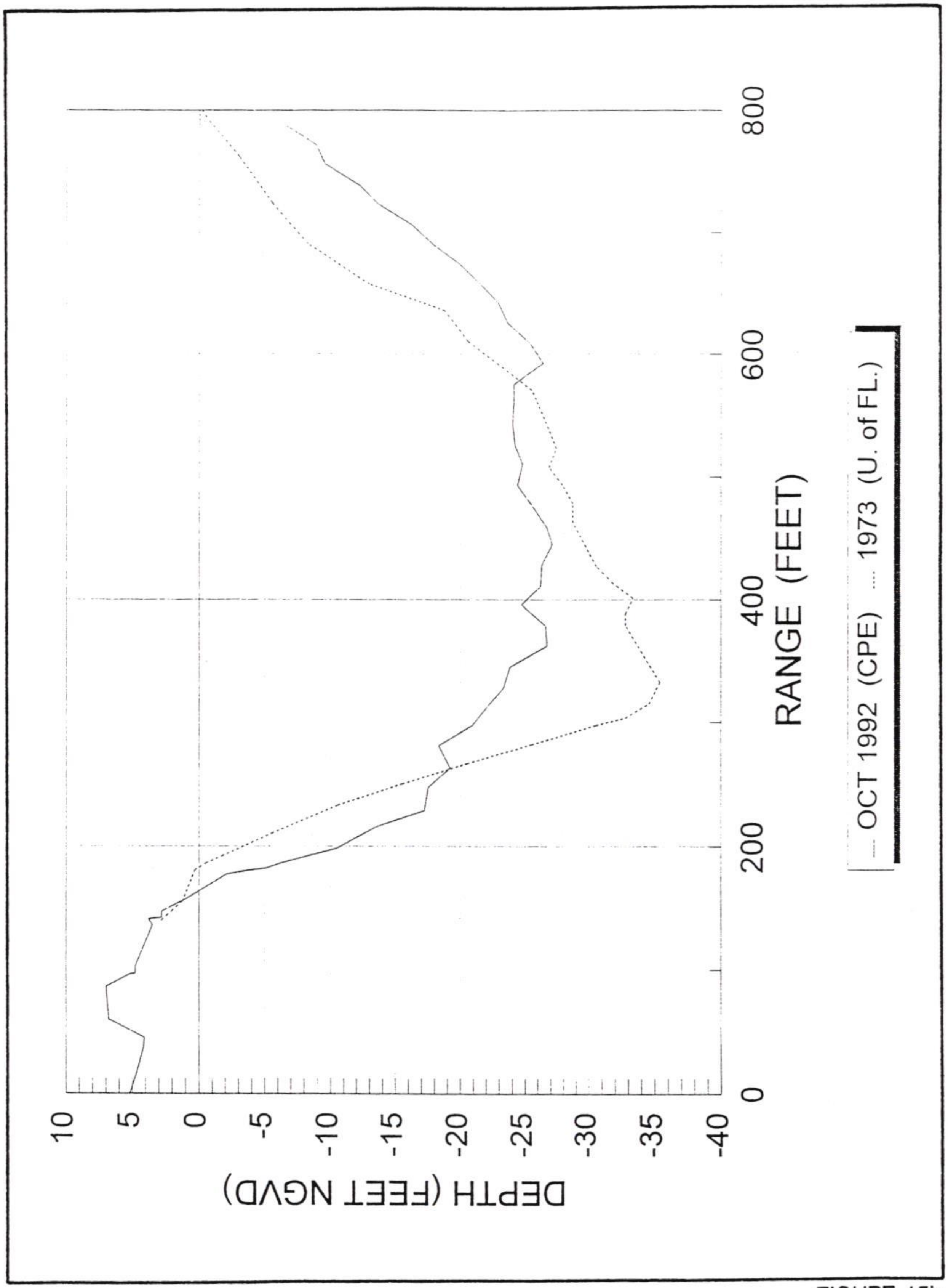


FIGURE 15b

THROAT CROSS-SECTION
REDFISH PASS, FLORIDA

The major limitation to Escoffier's theory is that any cross-sectional area greater than A_{crit} is considered to be stable. However, if an inlet with a cross-sectional area just slightly larger than A_{crit} was impacted by a large storm, then A_c could decrease to a point less than A_{crit} and the inlet would become unstable.

O'Brien (1966) analyzed tidal prisms and cross-sectional areas for stable inlets on sandy coasts. Ultimately, O'Brien found that a relationship existed between the maximum velocity and the repletion coefficient, K. This maximum velocity that must occur for an inlet cross-section to be stable is widely referred to as O'Brien Equilibrium Velocity.

When O'Brien's curve is combined with an Escoffier diagram, the intersection of the two curves indicates two stable cross-sections (Points B and A_{equil} in Figure 15a). Point B on the left side of the curve is stable only if no scouring or deposition occurs. This is an unlikely situation; therefore, this cross-sectional area is not considered stable. The point (A_{equil}) to the right of A_{crit} indicates a point of dynamic stability. If the inlet shoals due to a depositional event, the inlet should then scour back to the intersection point.

Figure 15a demonstrates the Escoffier-O'Brien stability analysis for Redfish Pass. The critical cross-sectional area (A_{crit}) is located at 2800 ft^2. The throat cross-sectional area (A_c) at Redfish Pass was measured to be 12,200 ft^2 MLW (12,540 ft^2 MTL) in 1973. This area is less than the point of dynamic stability (Point A_{equil}, Figure 15a) with a cross-sectional area of 16,000 sf. The cross-sectional area of Redfish Pass was measured by CPE at 12,630 SF in 1992. Considering normal seasonal variations, these cross-sectional areas show excellent agreement and Redfish Pass is dynamically stable.

H. Wind and Wave Climate

To understand the physical processes that affect (drive/control) sediment dynamics in the coastal zone, it is helpful to know the characteristics of the local wave climate. The data source that was used in this investigation was the U.S. Army Corps of Engineers Wave Information Study (WIS), Hubertz & Brooks (1989).

The Wave Information Study (WIS) produced wave climate information for the Atlantic, Pacific, Gulf of Mexico, and the Great Lakes for the years 1956-1975. The wave information was generated by numerical hindcasting models which created wind fields from historical meteorological records (Resio et al., 1982) and calculated wind wave growth and propagation (Corson et al., 1981). The numerical hindcasting programs assume spectral transformation of sea and swell waves, no additional wind effects, and straight, parallel bottom contours. The wave hindcast information is stored at selected points on a numerical grid in the vicinity of the U.S. Coastline (Jensen, 1983).

Since wave information is ordinarily needed for specific application at nearshore points, the WIS wave data is transformed from deep water to shallow water. Station 42 located to the north was used in this study (Figure 16). It should be pointed out that "sea" and "swell" waves are considered separately and are individually transferred from deep water

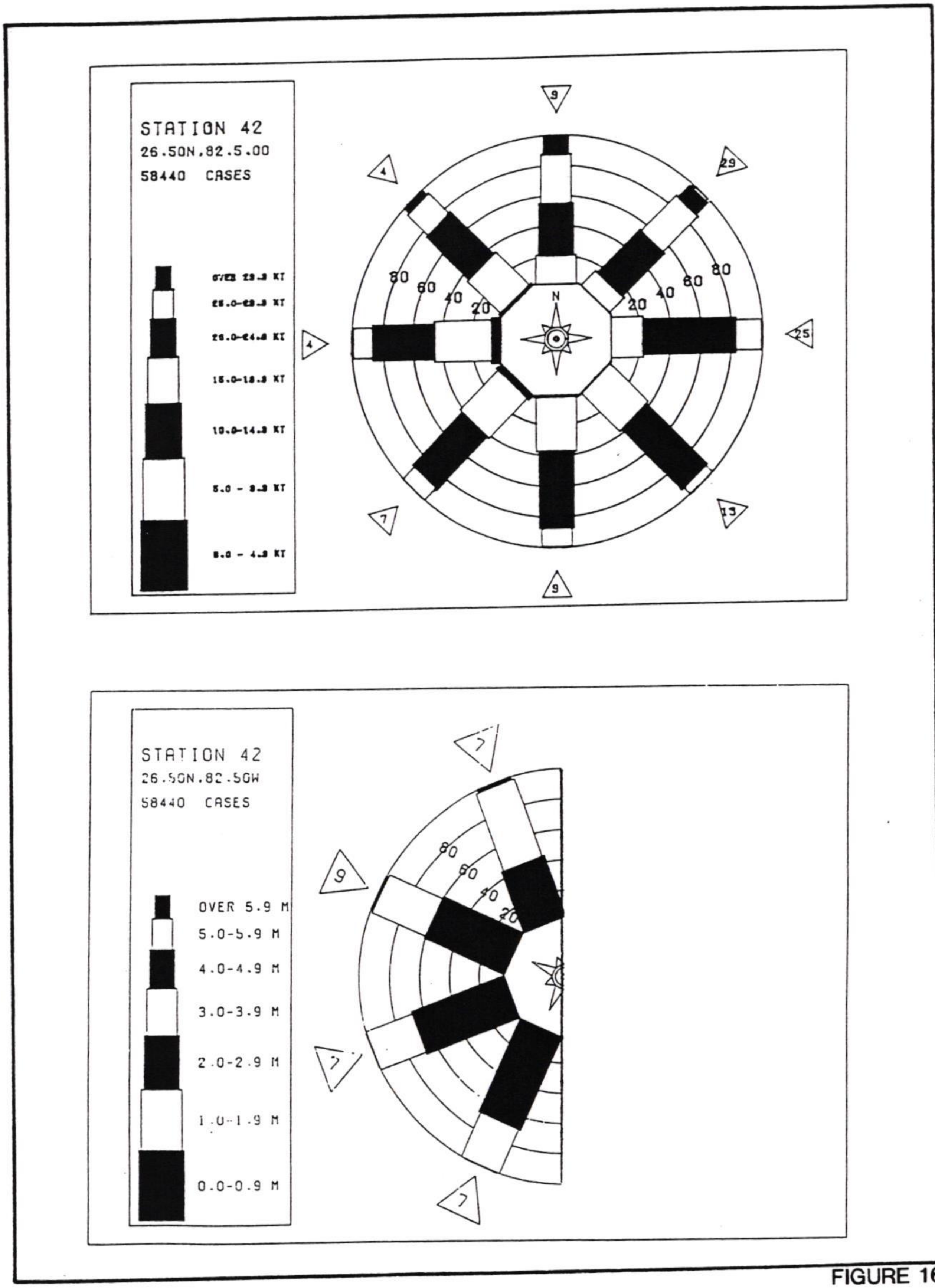


FIGURE 16

WIND AND WAVE DATA (WIS 1982)

into shallow water. "Sea" conditions indicate locally generated waves while "swell" conditions indicate waves generated further afield. With the generation of waves from Station 42 in deep water into shallow water adjacent to Redfish Pass, a twenty year wave data set for waves occurring at the 10 meter contour was analyzed.

Figure 16 is a wind rose indicating the magnitude and directional attributes of the wind in the local area. The larger percentage of winds are blowing offshore. This compares well with what is known to occur throughout the southwest coast of Florida.

Waves generated directly from these wind characteristics can be grouped into different segments, depending on the magnitude of the wave height and the wave direction (Figure 16). Only waves that contribute to beach erosion (onshore waves) are shown. A large percentage of the waves approach from the northwest, aiding in the transport of sediment in a southward direction. However, waves shown approaching from the southwest are significant as well. Though the magnitude of these southwest waves is not as great, they do transport sand, leading to a high monthly variability in longshore sediment transport.

The mean significant wave height and near peak wave period is 0.9 feet and 4.8 seconds, respectively. The highest percentage of the waves are migrating towards shore from the northwest. Because the standard deviation of the wave heights is small (0.3 meters), this indicates that similar wave heights are encountered throughout the year. The largest significant wave heights and wave periods are 3.1 meters (10.2 feet) and 9.1 seconds, respectively. As expected, the average directions associated with these large wave heights are 258 degrees from the north (approaching from the northwest). Table 12 presents monthly average wave heights for all twenty years of WIS wave data (Station 42).

I. Astronomical Tides and Currents

This section discusses currents and tides in the vicinity of Redfish Pass. Most of this section refers to a study of Captiva Island conducted in 1974 by the Coastal and Oceanographic Engineering Department at the University of Florida. Conclusions are based on the field study presented in the 1974 report. Because there have been no large scale changes in the channel dimensions in recent years, it was concluded that the findings in this previous report give a good indication of the present situation.

The Captiva Island region is made up of tides ranging from mixed semi-diurnal to mixed diurnal. At Captiva Island, the average range in tides is 1.8 feet and the spring range is 2.4 feet. A field study was conducted at Redfish Pass in 1973 during the time periods of March 29-31, July 17-20, and November 27-30. During these time periods, the range of tide on the Gulf side of Captiva Island as well as directly inside Redfish Pass was measured. The results gave a mean Gulf range of 1.75 feet and a mean bay range of 1.50 feet (Bay/Gulf ratio ≈ 85%). These results indicate that Redfish Pass is an efficient inlet for tidal flushing of sediments from its channel. A low phase lag between the ocean and bay tides (1-1½ hours) further confirms this efficiency.

TABLE 12

WIS WAVE DATA, 1956—1975

OFFSHORE OF REDFISH PASS (SATION 42)

	MONTH											
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1956	1.2	0.9	0.9	1.0	0.8	0.7	0.6	0.6	0.9	1.0	1.2	1.0
1957	0.9	0.9	1.0	0.9	0.7	0.7	0.6	0.7	0.8	1.0	1.0	1.2
1958	1.4	1.2	1.0	1.0	0.8	0.8	0.7	0.7	0.8	1.0	1.0	1.1
1959	1.1	0.9	1.0	0.9	0.8	0.6	0.6	0.8	0.9	0.9	1.2	1.2
1960	1.0	1.2	1.0	0.9	0.6	0.7	0.6	0.8	0.8	0.9	1.0	1.2
1961	1.1	1.0	0.9	1.0	0.7	0.7	0.6	0.6	0.9	1.2	1.0	1.0
1962	1.1	0.9	1.1	0.9	0.7	0.6	0.5	0.6	0.7	1.0	1.1	1.0
1963	1.1	1.1	0.9	0.8	0.7	0.6	0.6	0.6	0.7	1.2	1.1	1.1
1964	1.1	1.1	1.0	0.9	0.7	0.6	0.6	0.7	1.0	1.3	1.0	1.1
1965	1.0	1.1	1.0	0.8	0.8	0.8	0.6	0.6	1.0	0.9	1.0	1.1
1966	1.2	1.1	1.0	1.0	0.8	0.8	0.6	0.7	0.7	0.9	1.2	1.1
1967	1.0	1.0	0.9	0.8	0.8	0.5	0.5	0.6	0.8	1.0	1.1	1.0
1968	1.1	1.1	1.1	0.8	0.7	0.7	0.6	0.7	0.7	1.0	1.0	1.1
1969	1.1	1.1	1.1	0.9	0.8	0.6	0.6	0.7	0.8	1.0	1.2	1.1
1970	1.1	1.3	1.1	0.8	0.9	0.6	0.6	0.7	0.7	0.9	1.0	0.9
1971	1.0	1.1	1.0	0.8	0.7	0.6	0.6	0.7	0.8	0.8	1.1	1.0
1972	1.0	1.2	1.0	0.8	0.8	0.9	0.8	0.7	0.8	1.1	1.0	1.3
1973	1.1	1.2	1.1	1.1	0.7	0.6	0.6	0.7	0.8	1.1	1.0	1.2
1974	0.9	1.1	0.9	0.9	0.7	0.7	0.6	0.7	0.8	1.2	1.0	1.0
1975	1.1	0.9	1.0	0.9	0.6	0.6	0.6	0.7	0.8	0.9	1.1	1.1
MEAN	1.1	1.1	1.0	0.9	0.7	0.7	0.6	0.7	0.8	1.0	1.1	1.1

AVERAGE WAVE HEIGHT IN METERS

Between the period of March 29-April 1, tidal currents (semi-diurnal tide) were measured by a current meter located in 15 feet of water between North Captiva and Captiva Island. Maximum currents that were recorded during flood tide and ebb tide were as high as 2.8 feet/second and 2.3-2.4 feet/second, respectively.

Similar measurements were made over a 14 hour period during neap tide on July 12, 1957. Maximum current was recorded to be 3.2 feet/second for both flood and ebb currents. The tide was semi-diurnal (two high tides per 24 hour period) with a Gulf tidal range of 1.7 feet.

Some conclusions made during each of the three field trips in 1973 are mentioned below:

(1) The high bay/Gulf ratio establishes that Redfish Pass is capable of exchanging a large volume of water as well as sediment, influencing the shoreline development of the north end of Captiva Island and the south end of North Captiva Island.

(2) During this first field trip, there was strong wave activity out of the southeast at Captiva Island.

(3) Also during this period of time, currents in the surf zone (littoral currents) were 0.5 to 1.0 feet per second in the northward direction (Figure 17).

(4) A dye study during both flood and ebb tides was conducted at Redfish Pass, in hopes of further investigating the current patterns in the vicinity of Redfish Pass. The results of the study are presented in Figure 18. The lengths of the arrows are proportional to the current velocity. The dashed arrows are not measured currents but estimates. The circles indicate stagnant conditions in which there was zero velocity. Because wave activity was minimal, the velocities shown are strictly due to tidal currents rather than nearshore wave induced longshore currents.

Conclusions from these photographs are as follows:

(a) During both flood and ebb tide, sand from both Captiva and North Captiva Island was flowing into Redfish Pass.

(b) The separation of flow effects occurring in the north outer tip of Captiva Island resulted in a reversal of flow or nodal point.

(5) Longshore current measurements taken on November 29 showed that a nodal point (zero longshore velocity) was present along the northern portion of Captiva island during the period of time waves were approaching out of the northwest quadrant. This nodal point which is a by-product of the tremendous ebb shoal offshore of Redfish Pass, shifts

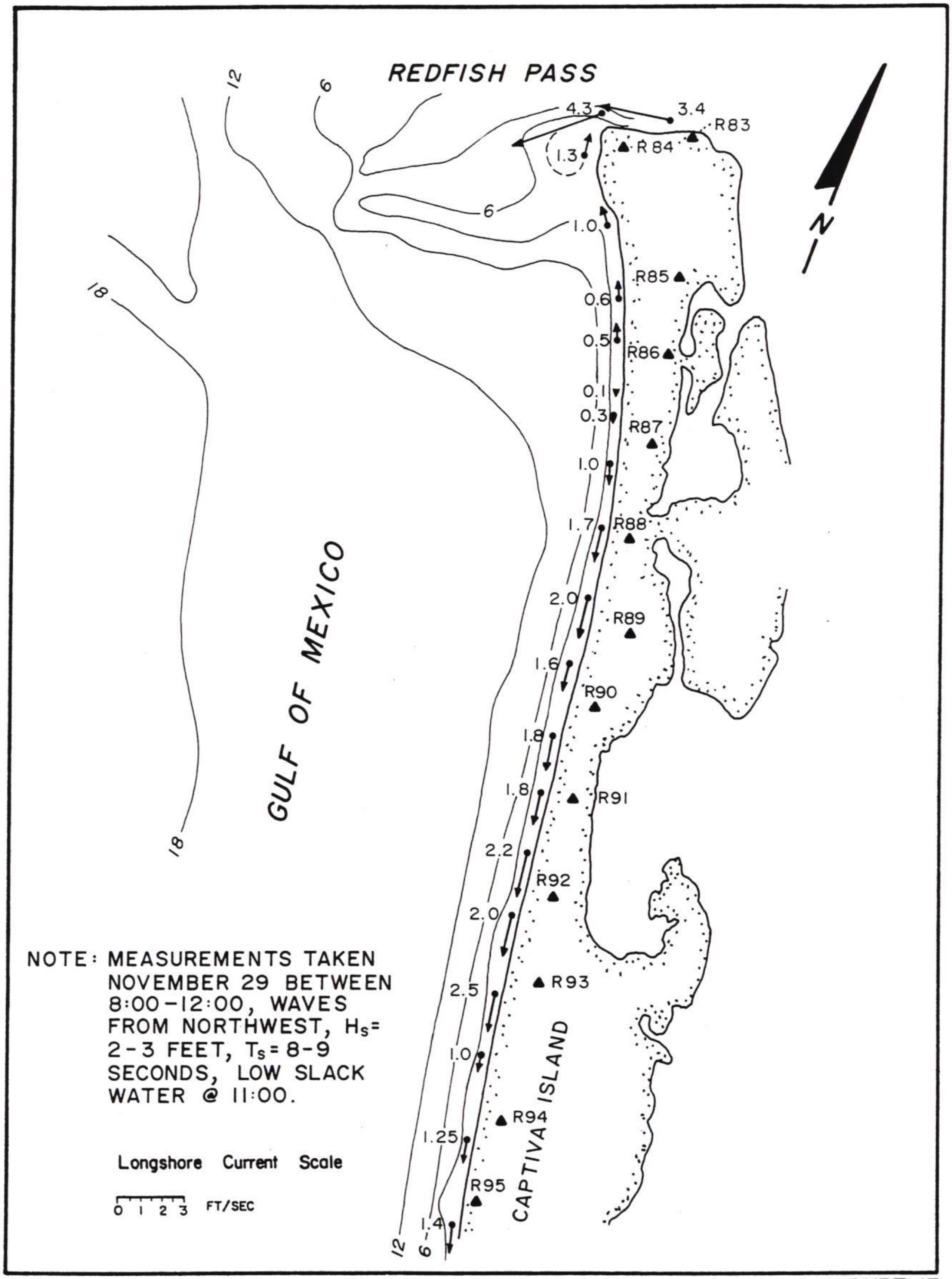
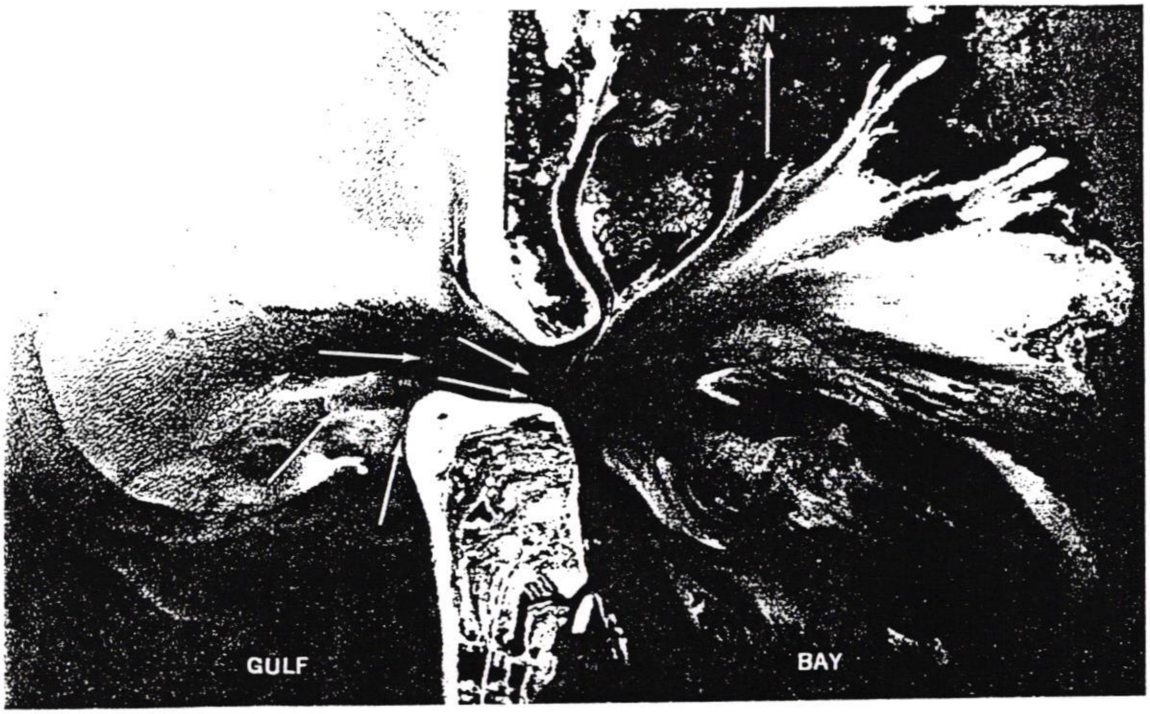


FIGURE 17

LONGSHORE CURRENT MEASUREMENTS
SOUTH OF REDFISH PASS



REDFISH PASS FLOW PATTERNS ON FLOOD CURRENT

REDFISH PASS FLOW PATTERNS ON EBB CURRENT

FIGURE 18

in conjunction with the dominant wave direction. Presented in Figure 17 is the result of the longshore current measurements south of Redfish Pass.

J. Structures

Since the Captiva Erosion Prevention District (CEPD) was established in 1959 by an act of the Florida Legislature, several types of structures and beach fill have been constructed to control erosion. A description of the previous measures that were sponsored by the CEPD and local interests to control erosion along the shores of Captiva island is provided in Table 13. To date, no protective coastal structures have been built along the section of North Captiva Island considered in this analysis.

The most significant structure in the vicinity of Redfish Pass is the terminal groin just to the south of the inlet. Initial construction on the terminal groin was begun in 1977, and it was completed to its current length in 1981.

The terminal groin at the north end of Captiva Island has been beneficial to the Gulf front shoreline by reducing erosion. The amount of sand savings attributable to the terminal groin is difficult to identify. The annual volumetric changes for the Mile 1 sector of Captiva Island shows a decrease in erosion between 6,000 and 19,000 cubic yards per year in comparison of the periods without the terminal groin (Table 7). In the first five years after the 1981 groin extension and nourishment project, the shoreline 1,500 feet south of the groin gained an average of 14,300 c.y./yr. From April 1989 to April 1992, the first 1650 feet of shoreline south of the terminal groin advanced an average of 35 feet.

The existing groin is relatively small and porous, and has the potential (if upgraded) to trap and hold more material. The University of Florida (1974) suggested that 37% of the erosion losses from Captiva Island were due to longshore transport which moved north into Redfish Pass. In the 18-Month Monitoring Report (Tackney, 1983), 30% of the erosion to the 1981 nourishment project showed up as accretion at the north tip of Captiva Island, beyond the terminal groins location.

The area immediately south of the groin has been stable since the groin's extension in 1981, with some temporary and spot erosion problems. The terminal groin's benefit is estimated to be 13,000 cubic yards per year.

K. Special Erosion Problem - North End of Captiva Island

1. Introduction

The erosion on the north tip of Captiva Island has become a major concern. Severe erosion was experienced during the winter of 1992 in the quarter mile of shoreline northeast of the terminal groin. South Seas Plantation officials reported the emergency access road to the Land's End Village Condominium destroyed and

Table 13

Coastal Structures of Captiva Island

Year	Protective Measure
7/7/59	Groin field permitted by the TIIF.
1961	134 "dog-bone" groins were installed along the length of the island.
1962	7,000 cubic yards of sediment from Roosevelt Channel on the bayside were placed on the center portion of the island.
1963	50,000 cubic yards of sediment were pumped to the area of Post Office Road.
1964	Extensive rock revetments and seawalls were installed by private owners.
1965	Two timber groins were installed by CEPD along the center of the island and 50,000 cubic yards of sediment was pumped form the bayside between the two groins.
1964-1967	50,000 - 100,000 cubic yards of sand were trucked in by Lee County for the Post Office Road area. 17,000 cubic yards was brought in to repair the County highway after Hurricane Gladys.
1972	Lee County installed the terminal groin at Blind Pass.
1977	CEPD, with South Seas Plantation, constructs short terminal groin on Redfish Pass.
1979	Two experimental projects permitted by DNR, Beaches and Shores Division. Projects were a perched beach and offshore segmented breakwater.
1981	South Seas Plantation, a privately-held development, funded a beach nourishment project for the northern 1.8 miles of the island. The project consisted of 655,500 cubic yards of material from the Redfish Pass ebb tidal shoal. A short terminal structure was extended 200 feet on the northwest tip of the island on Redfish Pass.
1986	Six experimental perpendicular stabilizers were installed at the north end of the road section.
1987-1988	Lee County was required to repair rock revetment after road washouts caused by several storms.

Table 13

Coastal Structures of Captiva Island
(cont.)

Year	Protective Measure
1988-1989	The terminal groin at Blind Pass was extended 100 feet between October and November 1988. A beach nourishment project was constructed along the entire length of the island and consisted of placement of 1.6 million cubic yards of material from the Redfish Pass ebb tidal shoals. The six experimental perpendicular stabilizers and two timber groins were removed prior to beach placement. Dune vegetation was planted along the entire island between August and October 1989.
1992	Emergency protection placed on Redfish Pass south interior shoreline.

the golf course severely threatened. The drain field for the municipal wastewater system was also threatened. Emergency protective measures were taken by South Seas Plantation to provide temporary protection.

This section will identify the extent of the recent erosion problem, outline the historic evolution of this area, and discuss those inlet features that may contribute to the problem.

The Redfish Pass south interior shoreline's erosion is confined to a 1,000 foot segment northeast of the terminal groin, between DNR monument R83 and R84. This area is exposed to wave action from the Gulf of Mexico.

Since the 1981 Captiva Island nourishment project, the interior shoreline has seen periods of erosion and accretion. During the 18 months after the first nourishment project (October 1981 - May 1983), the interior shoreline accreted 37,000 cubic yards (Tackney, 1983). From March 1985 through September 1986, accretion continued, with the shoreline advancing an average of 11 feet (Table 14). During this period of accretion the shoreline was seaward of the terminal groin (Figure 19).

From September 1986 to the next maintenance nourishment project, January 1989, the interior shoreline experienced its greatest retreat, losing 27,300 cubic yards and receding an average of 97 feet. From January 1989 to December 1991, after the 1989 maintenance nourishment project, the interior shoreline showed a small accretional trend of 3,800 cubic yards. From December 1991 to April 1992, erosion again accelerated, when 11,700 cubic yards were lost (see profiles in Appendix B).

From 1986 to 1992, the interior shoreline has eroded a total of 31,600 cubic yards and receded an average of 109 feet. At the point of greatest recession, the shoreline retreated 163 feet. From April 1992 to April 1993, the shoreline showed some recovery, gaining 6,500 c.y.

The accretion from 1981-1983 balances with the erosion since 1986, at about 34,000 cubic yards. Gaps in data do not allow for rigorous comparisons for the entire period.

After Redfish Pass opened in 1921, the shoreline along the northern tip of Captiva Island receded rapidly. By 1941 the southern shoreline of Redfish Pass was 400 feet south of its current position (see Figures 2 and 19). From 1941 to 1972, the southern shoreline of Redfish Pass advanced north. A prominent sand spit formed as seen in Figure 2 and Photographs 5 and 6.

TABLE 14A
MHW SHORELINE CHANGES FOR REDFISH PASS
SOUTH INTERIOR SHORELINE
(FEET)

PROFILE NAME	APR 85 SEP 86	SEP 86 JAN 89	JAN 89 DEC 91	DEC 91 APR 92	APR 92 OCT 92	OCT 92 APR 93	DEC 91 APR 93
	BETWEEN SURVEYS OF:						
R-83	-1	37	-8	7	-8	-16	-17
83.5				-40	-16	22	-33
83.7				-95	23	27	-45
R-84 10'	24	-176	53	-84	44		-41
R-84 35'	11	-150	-17	-19	47	7	35
OL84 35'				3	5	-7	1
R-84 80'*	-42	-23	21	9	-14	7	2
AVG. CHG.:	11.4	-96.5	9.3	-37.9	15.8	6.6	-16.7

* GULF SHORELINE

TABLE 14B
VOLUMETRIC CHANGES FOR REDFISH PASS
SOUTH INTERIOR SHORELINE
(CUBIC YARDS)

PROFILE NAME	EFFECTIVE DISTANCE (FEET)	SEP 86 JAN 89	JAN 89 DEC 91	DEC 91 APR 92	APR 92 OCT 92	OCT 92 APR 93	JAN 89 APR 93
		BETWEEN SURVEYS OF:					
R-83	123	5,083	-1,153	452	-1,070	-475	-2,246
83.5	252			-2,559	-1,272	1,709	-2,122
83.7	175			-4,800	1,197	2,457	-1,146
R-84 10'	105	-18,262	4,417	-2,740	1,204	0	2,880
R-84 35'	159	-14,111	565	-1,860	2,271	90	1,066
OL84 35'	190			-208	1,161	-803	150
R-84 80'*	91	-1,591	-10,892	-859	1,200	-79	-10,630
AVG. VOL. CHG.:		-27,290	3,828	-11,714	3,491	2,978	-1,417

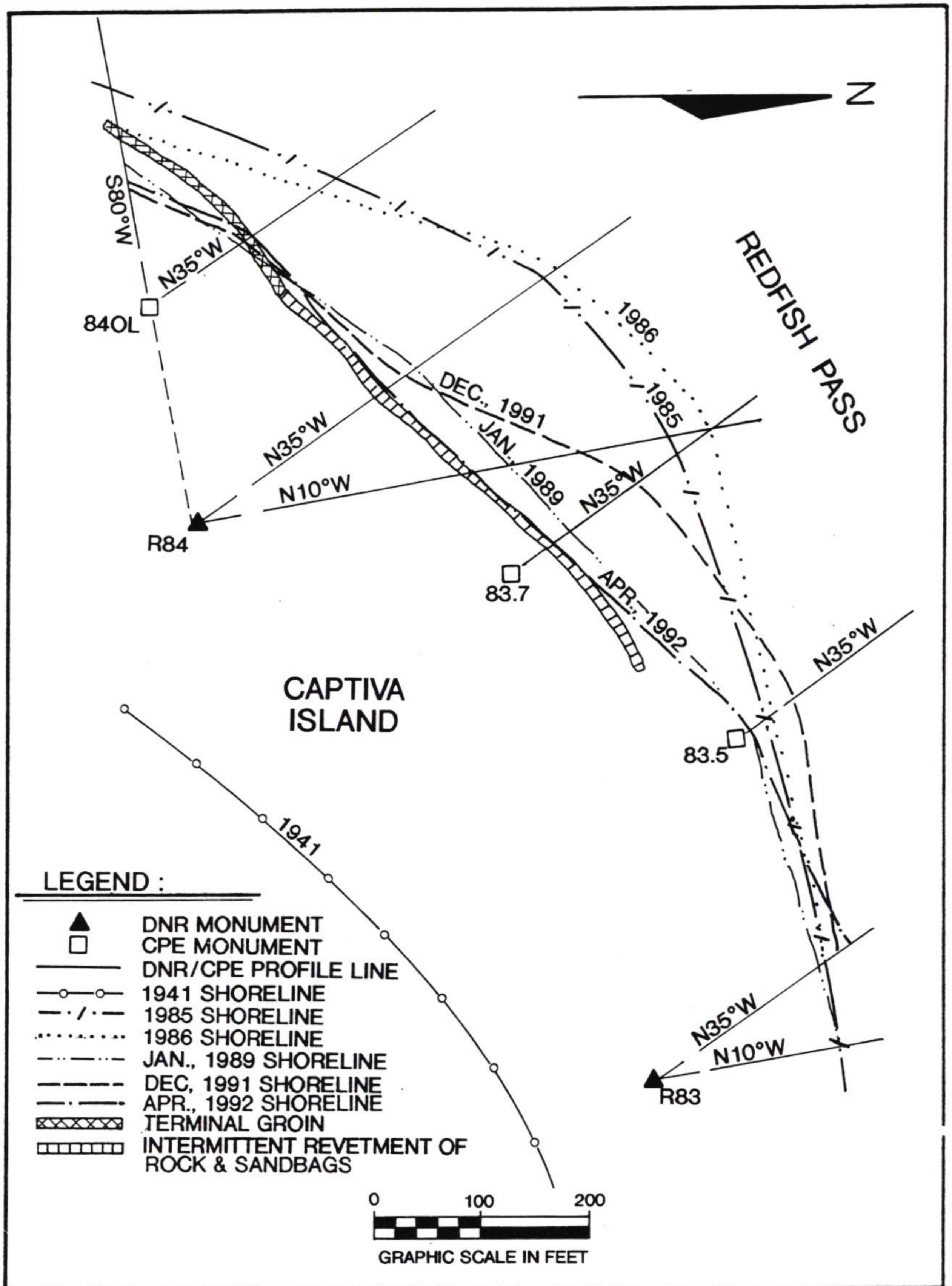


FIGURE 19

INLET SHORELINE CHANGES CAPTIVA ISLAND

Between 1972 and 1978, this spit eroded about 250 feet. This erosion was most likely due to the impact of Hurricane Agnes in 1972. The shoreline recovered these losses by the mid 1980's. Today's shoreline is similar to that in the mid 1960's and mid 1970's.

Two coastal process theories can explain this evolution of the north tip of Captiva Island. The first states that the northern portion of Captiva Island is fed by a net northern alongshore transport of sand from the nodal point. The longshore transport reversal at the nodal point is caused by ebb shoal induced wave refraction.

A more recent theory by Galvin (1992) proposed another rationale. He states that offsets are caused by the protective effects of the ebb shoal. Since the downdrift shore (Captiva Island) has greater protection from the dominate northwesterly waves than the updrift shore (North Captiva Island) it erodes slower, thereby creating the offset. The earlier creation of the mild offset (prior to 1955) is best explained by Galvin's rationale, while recent accretional trends are probably fed by transport reversal north of the nodal point.

The direct cause of erosion on the interior shoreline at South Seas Plantation is due to bluffline recession caused by direct attack of Gulf waves during periods of elevated water levels. This recession is characterized by a storm scarp, as seen in Photograph 8. Most of the sand which erodes from the onshore portion of the profile during the formation of the storm scarp is transported seaward and deposited along the nearshore portion of the profile. On a normal gulf front beach, this material will be transported back to the onshore part of the beach profile by wave action in the subsequent months following the wave attack. This recovery will not happen at the interior shoreline, because tidal forces remove the sand from the nearshore region before it can recover to the onshore area.

Indirectly, inlet features such as the ebb shoal changes, natural inlet migrations or the terminal groin contribute to the interior shoreline erosion problem. The borrow area for the 1981 and 1989 nourishment of Captiva Island decreased the ebb shoal volume by 2.25 million cubic yards. This change in the ebb shoal may have affected shoreline processes.

An evaluation was made to determine if the removal of portions of the ebb shoal may have increased the size of the waves reaching portions of the interior shoreline. The shallowest portion of the nearshore ebb shoal was left in place (not dredged) during the 1988/89 beach nourishment project. The protection provided by the nearshore shoal can be seen in the steepening and breaking of waves in Photograph 9 (April 1992).

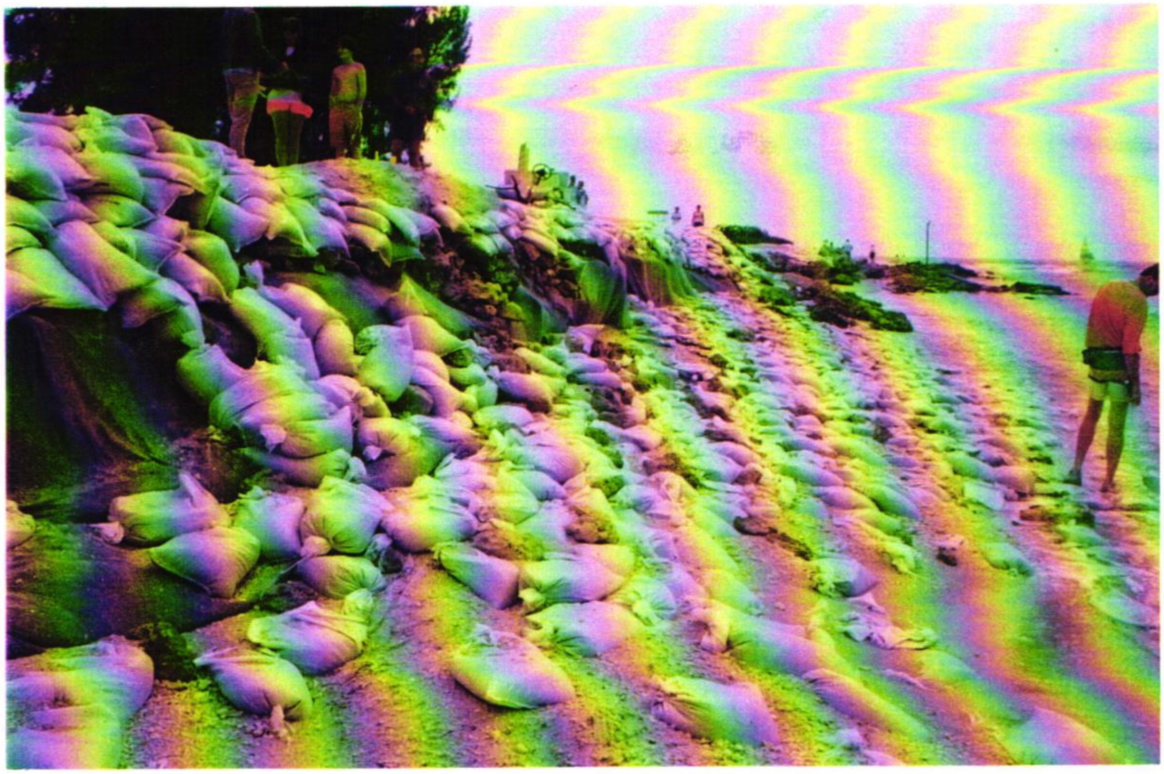


Photo No. 8: (4/1/92)

Erosion along south shore of Redfish Pass
due to northwest waves.

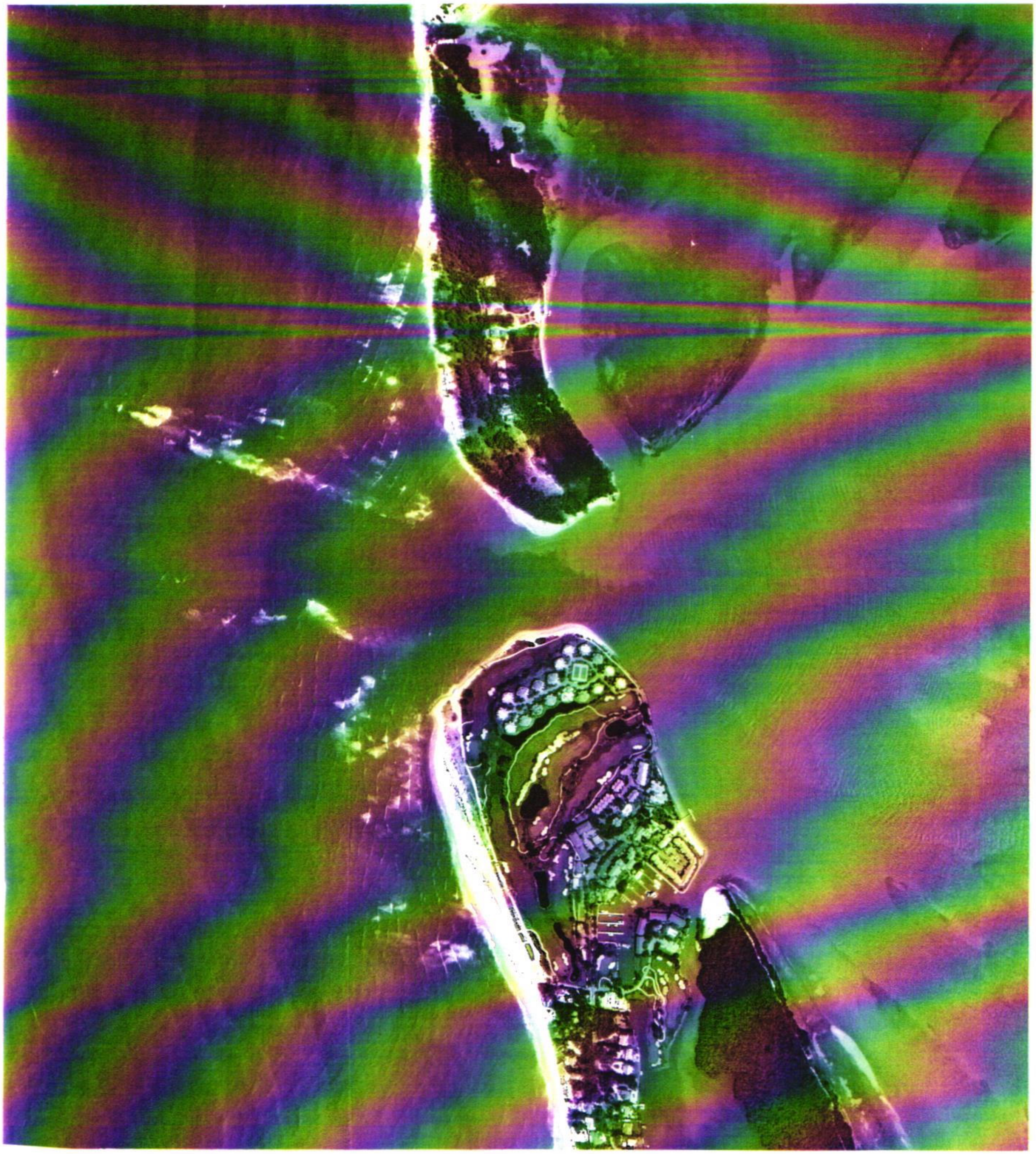


Photo No. 9: Aerial View Redfish Pass (4/92).

Note the steepening and breaking waves by the ebb shoal.
Note the terminal groin is exposed.

An examination of offshore profiles shows that the nearshore shoal adjacent to northern Captiva Island has undergone significant changes since 1961. Three profiles were constructed from bathymetric charts to show these changes (see Appendix E). The profiles show the recent evolution of the ebb shoal and are located within the first 1000 feet of Captiva Island south of Redfish Pass.

An analysis of these profiles suggests that the recent recession of the southern shoreline of Redfish Pass is primarily caused by the realignment of the channel to the northwest. This allows waves to move directly into the channel and impact the south shore of Redfish Pass. This realignment occurred before the 1988/89 beach nourishment project. The largest retreat of the shore took place prior to the nourishment project, too. Recent inlet changes are discussed by feature below.

The dredging of the offshore shoals has intensified the erosion problem and reduced the level of mitigation provided by the fill. The depth of water directly offshore of the groin and along the inlet channel alignment has increased; this allows larger waves to impact the northern shore from the west and northwest. These larger waves increase the level of erosion during storm events and reduce the movement of sand from the nourishment project to the inlet shore.

The condition of wave intensification along the channel will decrease as the ebb shoal near the mouth of the inlet rebuilds. From 1989 through 1991 this area of the shoal has rebuilt the fastest, shallowing as much as 4 feet since the dredging in 1989 (see shoal map, Figure 10).

From 1961 to 1979, the ebb shoal showed a moderate migration toward shore and increased in depth approximately 1/2 foot. Deeper shoals provide less wave protection. The movement of the shoal during this period was likely part of a natural cycle. Since 1979, through two dredgings as a borrow area, the ebb shoal has tightened against the shoreline and increased in depth about 2 feet. This situation allows larger waves to reach the shore.

Physical changes in the inlet's size and location could contribute to the erosion experienced at the Redfish Pass south interior shoreline. Any movement of the inlets south bank will impact the shoreline.

Historic changes in the inlet's location can be seen in Figure 2. From 1941 to 1972, the width of the inlet decreased, with both shorelines of the inlet advancing towards each other. From 1972 to 1978, the inlet width grew, mostly by the retreat of the North Captiva shoreline to the north.

The inlet throat size has also experienced changes. From 1960 to 1988, the inlet throat area decreased from 13,400 ft^2 to 10,790 ft^2. Recently, the throat area expanded back up to 12,630 ft^2. Changes in throat size are known to vary up to

10% over the course of a year (USACE, 1984). The recent enlargement of the throat size may also be due to increased inlet velocities brought on by a smaller ebb shoal.

The throat is located at the narrowest part of the inlet, which appears to be at profile R83. The south channel bank at R83 has moved north 44 feet at the 10 foot depth from 1985 to 1992 (see Appendix B). The rate of movement has slowed in recent years. The northward movement of the inlet has been a long term trend. Walton and Dean (1976) noted a 20-year northward trend and Dexter Bender (USACE Public Hearing, 1976) reported the inlet moving 600 feet north from 1926 to 1957.

Gulfward of the throat, the inlet gorge (thalweg) has rotated north 22 degrees from 1961 to 1991. Twelve (12) degrees of this rotation occurred prior to 1979, and little has occurred since 1988.

The rotation of the inlet mouth is significant when taken with the offshore ebb shoal changes. Prior to dredging, the inlet throat was protected by the curved north lobe of the ebb shoal, which diminished the size of waves in the inlet. Currently, northwest waves can advance down the inlet channel undiminished by shoals. The rotation of the inlet allows these waves a more direct line toward the interior shoreline.

The last major inlet feature to consider is the groin at the north end of Captiva Island. This terminal groin was built in 1977. There is a causal relationship between shoreline freeboard at the groin and accretion on the interior shoreline.

Figure 19 shows shoreline beyond the groin in 1985, with attendant accretion east of the groin. The 1986 shoreline is tangent to the groin, which begins the largest recent erosion period for the interior shoreline.

After both the 1981 and 1989 nourishment projects, the interior shoreline accreted. The supply of sand for the interior shoreline appears directly related to the supply of sand on the adjacent Gulf shoreline. Northward longshore transport not only supplies sand to the beach south of the terminal groin, but moves sand around the groin and along the interior shoreline, when the terminal groin does not act as a barrier.

The terminal groin's performance was predicted in a University of Florida study (1974) which concluded "The concept of building a terminal groin structure should recognize that holding the beach material on the front side of the island, although desirable, would also cut off material (to some extent) that is causing the accretion on the south side (interior shoreline) of Redfish Pass." The study further concluded that the groin's effect could lead to "possible southward migration of the pass."

The recent erosion along the Redfish Pass south interior shoreline is not unique. The magnitude of the erosion was similar to that experienced after Hurricane Agnes in 1972. The current shoreline location is similar to the shoreline of the mid 1960's and mid 1970's.

The current erosion trend most likely will continue until a source of sand is available to nourish the interior shoreline. Significant natural nourishment might not occur until the next beach nourishment, although recent profiles have shown some accretion between 1992 and 1993 (Table 14). Continued erosion in this area may initiate a southward migration of the inlet, as concluded in the 1974 University of Florida study. A southward migration is evident in a comparison of 1986 and 1992 channel profiles at R84 N 10° W and R84 N 35° W (Appendix B). At a -10 foot NGVD depth, these profiles retreated 50 and 150 feet, respectively. Whether this trend will continue will require further monitoring.

At first, this southward migration of the inlet channel appears in conflict to previous reports of a northward migration, but close examination of the profiles can explain this apparent conflict. First, the evidence of southward migration is located approximately 1000 feet seaward of the inlet throat. The reports of northward movement are smaller and recorded at the inlet throat (vic. R-83).

The erosion on the interior shoreline is caused by the combination of a number of forces. The lead cause is the increased occurrence of larger waves reaching the shoreline due to the change in the inlet channel orientation. Even though there is a causal relationship between the terminal groin freeboard and the incidence of erosion on the interior shoreline, the groin is not the prime cause of the erosion. The larger northwest waves, which can now reach this area, sweep over the groin and transport sand downcoast. This can be seen by examining the shoreline and wave pattern visible in Photograph No. 9.

L. South End of North Captiva Island

Homeowners on the south end of North Captiva Island are concerned that the 1988 dredging of Redfish Pass accelerated erosion on their gulf shoreline. Their concern about gulf shoreline erosion is well justified, but the 1988 dredging of Redfish Pass was not the cause.

Development on southern North Captiva Island is recent. A May 1993 aerial photograph (Photo No. 10) shows a dozen buildings located within 2500 feet of Redfish Pass. Photo No. 7 (page 16) taken in August 1988 shows little development. A December 1988 aerial photograph (FDNR 1991) shows only two buildings in this region. Most of the construction on southern North Captiva Island occurred well after the 1988 dredging of Redfish Pass.

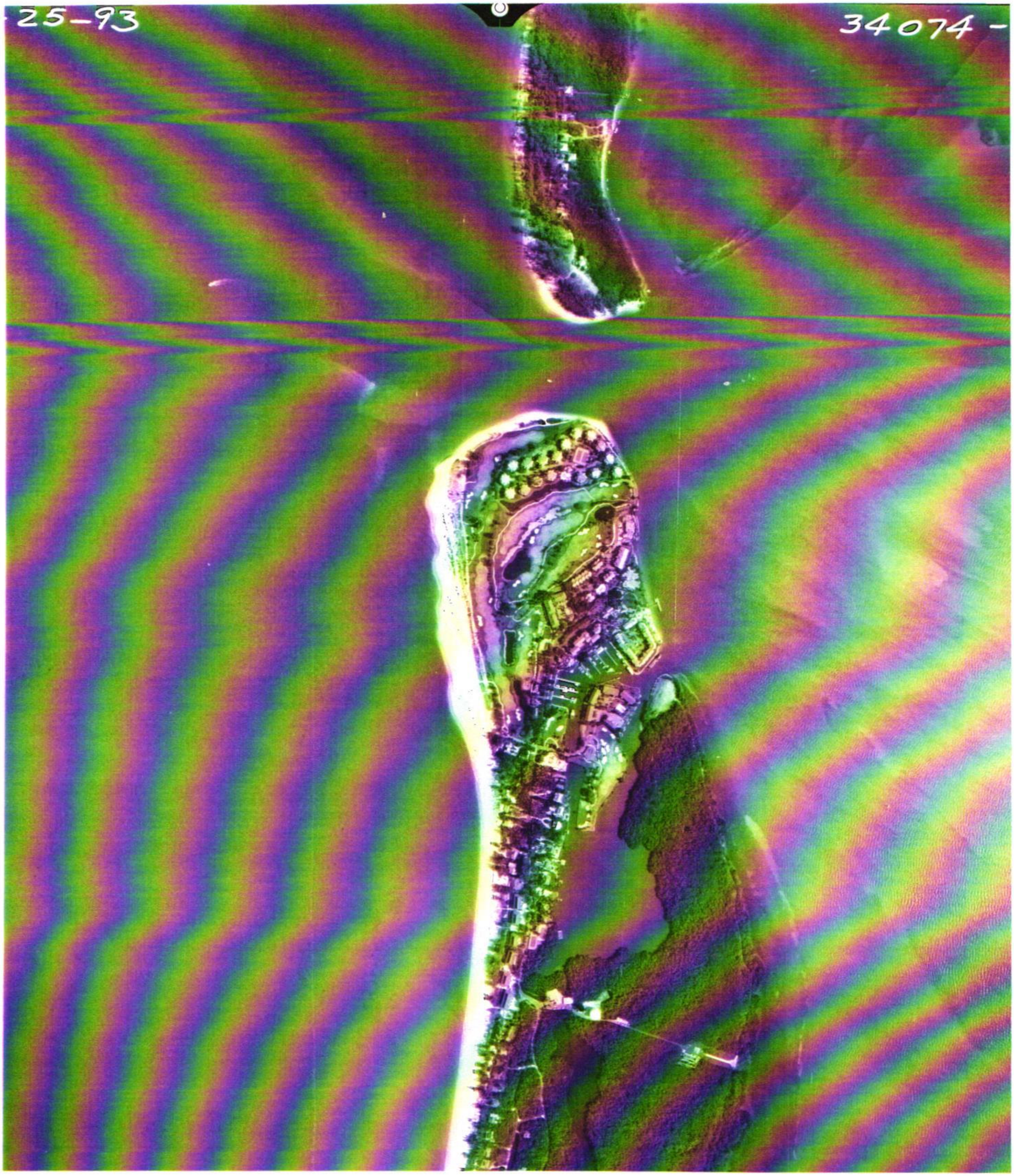


Photo No. 10: Aerial view of Redfish Pass (5/25/93).

Note the recent development on North Captiva Island.

The erosion on southern North Captiva Island is not new. The mile of shoreline immediately north of Redfish Pass (R79A-R82) receded an average of 226 feet (-16.1 feet/year) between 1941 and 1955. The first 2000 feet of shoreline north of the inlet (R81A to R82) has shown less erosion in this mile segment, retreating an average of 161.1 feet (-11.5 ft./yr.) since 1941. In more recent years (1982 to 1991), erosion in this mile segment persisted at an average of 106 feet (-11.8 ft./yr.). The first 2000 feet of shoreline north of the inlet retreated an average of 234 feet (-26 ft./yr.). Shoreline retreat before and after 1988 was comparable. The sediment budget (Figures 14a and 14b) shows that losses into Redfish Pass from North Captiva Island have decreased with time, even after the pass was dredged.

The main cause of this erosion stems from a dearth of sediment transport from the updrift (north) segments of North Captiva Island, which is characteristic of drumstick barrier islands (see Section II.C.4.). The downdrift end of a drumstick barrier island is not suitable for development. Davis (1989) in his paper "Management of Drumstick Barrier Islands" concluded,

> "The narrow and low, downdrift end of the barrier is also not suitable for development because of its elevation, its high rate of beach erosion and its susceptibility to breaching. There is no portion of this area that is high enough or stable enough for development."

The recent development on North Captiva Island occurred on the downdrift end of a drumstick barrier island. Davis' conclusions are borne out by the coastal construction control line (CCCL) established for North Captiva Island (FDNR 1991). All the houses at the south end of the island are seaward of the CCCL.

Coastal Planning & Engineering, Inc. (Appendix G) conducted a combined wave refraction and sediment transport study of Redfish Pass. The study analyzed wave refraction and sediment transport at Redfish Pass based on pre and post-1988 dredging bathymetrics of Redfish Pass. Results of this study indicate that sediment transport patterns on southern North Captiva Island changed very little. As a contrast, sediment transport patterns changed significantly on northern Captiva Island, reversing direction in a 5000 foot reach south of Redfish Pass.

The erosion threat to development on southern North Captiva Island is characteristic of drumstick barrier islands. Restrictions to future development may be warranted, but will not resolve the threat to existing houses. Homeowners on North Captiva Island should be given favorable consideration by Florida state agencies in implementing protective measures to reduce the erosion threat.

III. NATURAL RESOURCES

A. General

Redfish Pass was formed in the early to mid 1920's as a result of hurricane activity. Since that time, the pass has had a history of slow migration and tidal shoaling. The pass cuurently connects Pine Island Sound with the Gulf of Mexico.

Both the marine and estuarine environments surrounding Redfish Pass are directly influenced by the presence of the pass. The presence of the pass allows for the mixing of gulf and estuarine waters. The tides which occur at the pass greatly influence the currents, water quality, water circulation and salinity and temperature regimes within the pass and the surrounding estuarine waters. The pass also provides migratory marine-estuarine species with ready access to their spawning and nursery grounds. It is clear that the methods used to maintain the pass in the future will affect the surrounding environment.

The natural resources surrounding Redfish Pass are comprised of three major resource classifications. These classifications include the beach and dune system, and upland areas; the estuarine wetlands; and the nearshore Gulf of Mexico.

The following description of the natural resources was developed from available reference materials, aerial photographs and limited field investigations. Preliminary field investigations were conducted on December 6, 1991. More detailed site investigations of areas likely to be impacted by the inlet management plan were conducted on April 1, 1992. Figure 20 illustrates the natural resources adjacent to Redfish Pass.

B. Beach and Dune System, and Upland Areas

The Gulf shoreline of North Captiva Island is approximately 4 miles long. The island ranges in width from 200 feet, approximately 1 mile north of Redfish Pass, to 2500 - 3000 feet in the northern portion of the island.

Since access to North Captiva Island is limited (access by boat only), most of the island remains rural and undeveloped. Upland development on North Captiva Island consists of a few single-family residences and a restaurant. Exotic vegetation, primarily Australian pines (<u>Casuarina</u> <u>equisetifolia</u>), dominates most of the undeveloped uplands and dune areas north of Redfish Pass. Erosion, development and encroachment by exotic vegetation have eliminated most of the native vegetation north of the pass. Nevertheless, some red, white and black mangroves, and buttonwood are present along the southeastern shore of North Captiva Island.

The narrowest portion of North Captiva Island (approximately one mile north of the pass) has experienced severe erosion and periodic overwash of the remaining beach and dune ecosystems. This has resulted in the loss of most of the native vegetation and has left

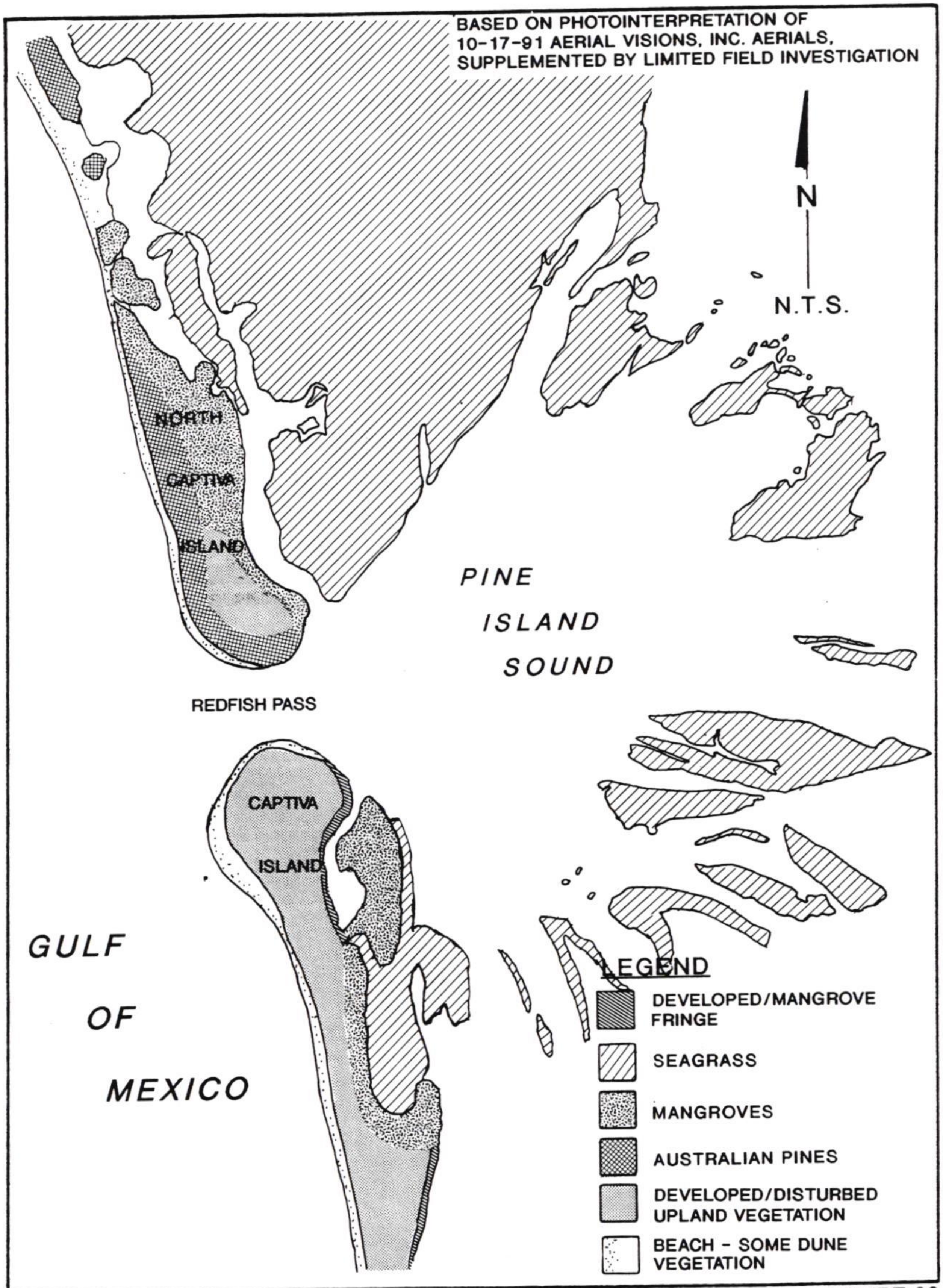


FIGURE 20

HABITATS ADJACENT TO REDFISH PASS

the area open to invasion by opportunistic exotic vegetation. Meanwhile, recent aerial photographs suggest that sand from the overwash area is impacting the adjacent seagrasses in Pine Island Sound.

Captiva Island ia approximately 5 miles long. The island ranges in width from 200 feet near the south end, to about 2000 feet between the center and northern end of the island. Natural ground elevations are generally under 10 feet NGVD.

A majority of the dune and upland areas south of Redfish Pass have been developed (Figure 20). Development along the northern third of Captiva Island consists of a planned, full amenity resort community. Development along the remainder of Captiva Island consists of low-density single-family residences, along with some commercial and multi-family uses.

Although most upland areas south of Redfish Pass have been developed, some native vegetation still remains. The most commonly observed upland species include sea grape (Coccoloba uvifera), cabbage palm (Sabal palmetto) and gumbo limbo (Bursera simaruba). In addition, mangroves still line the undeveloped portions of the estuarine shoreline.

Upland development and beach erosion have eliminated a majority of the natural dune system south of Redfish Pass. Nevertheless, portions of the dune on Captiva Island have been re-established. A sea oat community was established on the northern end of Captiva Island as part of the 1981 South Seas Plantation beach restoration project. Additional dune vegetation (80% sea oats, 20% other dune species) was planted along the entire island, between October and December 1989. In 1990, the CEPD removed Australian pine seedlings from the new vegetation and replanted sea oats at the southern end of the project. Dune species observed on the northern portion of Captiva Island include sea oats (Uniola paniculata), sea purslane (Sesuvium portulacastrum), salt grass (Distichlis spicata), dune sunflower (Helianthus debilis), Scaveola sp., prickly pear cactus (Opuntia compressa), sea grape (Coccoloba uvifera), railroad vine (Ipomoea pes-caprae) and Spanish bayonet (Yucca aloifolia).

The remaining native upland vegetation and re-established dune vegetation provide some limited habitat for wildlife. Adaptable species, such as raccoons and squirrels, are commonly observed on the islands surrounding Redfish Pass. A list of the mammals which are reported to occur in the vicinity of Redfish Pass is presented in Table 15.

The beach ecosystem provides habitat for a variety of organisms. Common beach organisms include a variety of polychaetes, amphipods and crabs, including the common ghost crab. Other wildlife, such as rodents, snakes, birds, lizards and insects, may inhabit the beach for all, or a portion of their lives.

Table 15

Terrestrial and Semi-terrestrial
Mammals Reported in the Vicinity of Redfish Pass

Common Name	Scientific Name
Armadillo	Dasypus novemcinctus
Black rat	Rattus rattus
Bobcat	Lynx rufus
Cotton mouse	Peromyscus gossypinus
Eastern cottontail	Sylvilagus floridanus
Eastern fox squirrel	Sciurus niger
Eastern mole	Scalopus aquaticus
Eastern yellow bat	Lasiurus intermedius
Evening bat	Nycticeius humenalis
Florida longtail weasel	Mustela frenata peninsulae
Florida water rat	Neofiber alleni
Florida mink	Mustela vison lutensis
Florida mouse	Podomys floridanus
Gray fox	Urocyon cinereoargenteus
Hispid cotton rat	Sigmodon hispidus
House mouse	Mus musculus
Least shrew	Cryptotis parva
Marsh rabbit	Sylvilagus palustris
Mexican freetail bat	Tadarida brasiliensis
Opossum	Didelphis virginiana
Raccoon	Procyon lotor
Sanibel Island rice rat	Oryzomys palustris sanibeli
River otter	Lutra canadensis
Shorttail shrew	Blarina carolinensis (=brevicauda)
Southeastern big-eared bat	Plecotus rafinesquii
Spotted skunk	Spilogale putorius
Striped skunk	Mephitis mephitis
Whitetail deer	Odocoileus virginianus

Source: J.N. "Ding" Darling National Wildlife Refuge - Mammal List.

Many species of birds are also known to forage in the project area, particularly on North Captiva Island. Shorebirds, including gulls, terns, sandpipers, plovers and stilts, use the intertidal beach for foraging, while other birds, such as the eastern brown pelican (Pelecanus occidentalus carolinensis) and the double-crested cormorant (Phalacrocorax auritus), forage in the nearshore waters (Continental Shelf Associates, 1987). No shorebirds are known to nest on the beaches adjacent to Redfish Pass (Lindblad, 1995, personal communication). Table 16 lists some of the most common bird species reported in the vicinity of Redfish Pass.

The beaches in the study area also provide nesting habitat for the Atlantic loggerhead turtle (Caretta caretta). Other sea turtles reported to occur in the vicinity of Redfish Pass include the Atlantic green turtle (Chelonia mydas), Atlantic hawksbill turtle (Eretmochelys imbricata), Atlantic Ridley turtle (Lepidochelys kempi) and Atlantic leatherback turtle (Dermochelys coriacea).

Prior to the 1988 Captiva Island beach restoration project, continuing beach erosion and the construction of shoreline protection structures had resulted in the loss of most of the sea turtle nesting habitat south of Redfish Pass (LeBuff, 1990). Following the 1988 Captiva Island beach restoration project, both the number of nests and the number of nests/emergence, or nesting success, increased (LeBuff, 1990) (Table 17). Studies prior to the beach project documented an average of 19 nests/year for the 5 mile beach, with an average nesting success of 36.5%. In contrast, the average number of nests from 1988 to 1994 was 74.6 nests, or a 292% increase over pre-restoration averages. This was in spite of the fact that the data for 1989 were incomplete (collection of the 1989 sea turtle nesting data did not begin until July 1, almost two months after nesting began). The nesting success for the 1988, and 1990 to 1994 nesting seasons averaged 46.0%. Nesting success data were not available for the 1989 nesting season.

Although some sea turtle nesting occurs on North Captiva Island (Lindblad, 1995, personal communication), sea turtle activities on the island are not monitored. Therefore, the actual number of nests laid and the nesting success for North Captiva Island are not known.

Table 16

Birds Commonly Observed in the Vicinity of Redfish Pass

Common Name	Scientific Name
Pied-billed grebe	Podilymbus podiceps
American white pelican	Pelecanus erythrorhynchos
Brown pelican	Pelecanus occidentalis
Double-crested cormorant	Phalacrocorax auritus
Anhinga	Anhinga anhinga
Least bittern	Ixobrychus exilis
Great blue heron	Ardea herodias
Great egret	Casmerodius albus
Snowy egret	Egretta thula
Little blue heron	Egretta caerulea
Louisiana heron	Egretta tricolor
Reddish egret	Egretta rufescens
Cattle egret	Bubulcus ibis
Green-backed heron	Butorides striatus
Black-crowned night-heron	Nycticorax nycticorax
Yellow-crowned night-heron	Nycticorax violaceus
White ibis	Eudocimus albus
Mottled duck	Anas fulvigula
Northern pintail	Anas acuta
Blue-winged teal	Anas discors
Northern shoveler	Anas clypeata
American wigeon	Anas americana
Lesser scaup	Aythya affinis
Red-breasted merganser	Mergus serrator
Black vulture	Coragyps atratus
Turkey vulture	Cathartes aura
Osprey	Pandion haliaetus
Red-shouldered hawk	Buteo lineatus
American kestrel	Falco sparverius
Clapper rail	Rallus longirostris
King rail	Rallus elegans
Common moorhen	Gallinula chloropus
Black-bellied plover	Pluvialis squatarola
Snowy plover	Charadrius alexandrinus
Wilson's plover	Charadrius wilsonia
Semipalmated plover	Charadrius semipalmatus
Piping plover	Charadrius melodus
Killdeer	Charadrius vociferus
Greater yellowlegs	Tringa melanoleuca
Lesser yellowlegs	Tringa flavipes

Table 16

Birds Commonly Observed in the Vicinity of Redfish Pass (Continued)

Common Name	Scientific Name
Willet	Catoptrophorus semipalmatus
Sanderling	Calidris alba
Short-billed dowitcher	Limnodromus griseus
Laughing gull	Larus atricilla
Ring-billed gull	Larus delawarensis
Royal tern	Sterna maxima
Sandwich tern	Sterna sandvicensis
Black skimmer	Rynchops niger
White-winged dove	Zenaida asiatica
Mourning dove	Zenaida macroura
Common ground-dove	Columbina passerina
Mangrove cuckoo	Coccyzus minor
Smooth-billed ani	Crotophaga ani
Common barn-owl	Tyto alba
Eastern screech-owl	Otus asio
Great horned owl	Bubo virginianus
Red-bellied woodpecker	Melanerpes carolinus
Common flicker	Colaptes auratus
Pileated woodpecker	Dryocopus pileatus
Great crested flycatcher	Myiarchus crinitus
Gray kingbird	Tyrannus dominicensis
Blue jay	Cyanocitta cristata
Fish crow	Corvus ossifragus
Carolina wren	Thryothorus ludovicianus
American robin	Turdus migratorius
Gray catbird	Dumetella carolinensis
Northern mockingbird	Mimus polyglottos
European starling	Sturnus vulgaris
White-eyed vireo	Vireo griseus
Prairie warbler	Dendroica discolor
Common yellowthroat	Geothlypis trichas
Northern cardinal	Cardinalis cardinalis
Rufous-sided towhee	Pipilo erythrophthalmus
Red-winged blackbird	Agelaius phoeniceus
Boat-tailed grackle	Quiscalus major
Common grackle	Quiscalus quiscula
House sparrow	Passer domesticus

Compiled from:Emerson, 1984; Robbins, Bruun, and Zim, 1983.

Table 17

Sea Turtle Nesting Data
For
Captiva Island[1]
(5 Miles)

	1975	1976	1988	1989[2]	1990	1991	1992	1993	1994
Nests	26	12	44	39	73	71	75	112	108
False Crawls	45	21	67	Not Available	85	86	99	125	104
% Nesting Success	36.6	36.4	39.6	Not Available	46.2	45.2	43.1	47.3	50.9

[1] Beach was nourished fall 1988 to spring 1989.
[2] Incomplete data (only July 1 - August 31).

Compiled from: LeBuff, Jr., 1990
Lindblad, 1992, personal communication.
Lindblad, 1995, personal communication.

C. Estuarine Wetlands

The estuarine wetlands adjacent to Redfish Pass are located within the Pine Island Sound Aquatic Preserve. Estuarine wetland communities within Pine Island Sound include seagrass and algal beds, mangrove forests, salt marshes and oyster beds. These communities provide both habitat and food for a variety of organisms. In addition, these communities function in nutrient and sediment recycling.

The submerged aquatic vegetation adjacent to Redfish Pass consists of seagrass beds, attached algae and drift algae. The seagrass beds contained within the sound are made up primarily of shoalgrass (Halodule wrightii), turtlegrass (Thalassia testudinum) and manatee grass (Syringodium filiforme). These seagrass beds serve as important nursery grounds for snapper, grouper, drum, shrimp, blue crab (Callinectes sapidus) and Florida spiny lobster (Panulirus argus) (Continental Shelf Associates, 1987). Terns, egrets, ibises, pelicans, gulls and herons forage upon the small crustaceans, gastropods, annelids and fishes found in the tidal flats surrounding Redfish Pass.

Mangrove forests fringe much of the undeveloped shoreline east of Redfish Pass. Areas frequently inundated by normal tidal action are generally inhabited by red (Rhizophora mangle) and black (Avicennia germinans) mangroves. White mangroves (Laguncularia racemosa) and buttonwood (Conocarpus erectus) are found in areas where tidal inundation is less frequent. These fringing mangrove communities serve as habitat and food source for fiddler crabs, mangrove snapper and a variety of wading birds, such as herons and egrets. These mangroves also act as a nursery habitat for a wide variety of marine and estuarine fishes and invertebrates.

The last two estuarine communities found in Pine Island Sound include the salt marshes and oyster beds. Salt marsh plants such as black needlerush (Juncus roemerianus) and cordgrass (Spartina alterniflora) are found along some portions of the undeveloped estuarine shoreline. Oyster (Crassostrea virginica) bars are commonly found throughout the sound, especially near freshwater sources (Continental Shelf Associates, Inc., 1987). Figure 20 delineates the estuarine habitats adjacent to Redfish Pass.

West Indian manatees (*Trichechus manatus*) and bottlenosed dolphin (*Tursiops truncatus*) are also commonly observed in the waters surrounding Redfish Pass. Although the endangered West Indian manatee is a common year-round resident along the Lee County coast, there are no major concentrations of manatee in proximity to Redfish Pass (Beeler and O'Shea, 1988). Manatee are, however, occasionally observed in the estuarine and nearshore Gulf waters surrounding Redfish Pass. Manatee have been sighted in the gulf waters near the north end of Captiva Island and outside of Redfish Pass, and in the estuarine waters east of North Captiva Island, Redfish Pass, and at two locations east of Captiva Island (Beeler and O'Shea, 1988).

D. Nearshore Gulf of Mexico

Based on aerial photographs and field investigations, no significant hardbottom formations exist in proximity to Redfish Pass. The gulf floor surrounding Redfish Pass consists of unconsolidated sediments, primarily sand.

The nearshore Gulf of Mexico resource classification includes biotic communities mainly associated with two zones: littoral (intertidal) and sublittoral (offshore). The littoral zone is inhabited by several species of polychaete worms, sand bugs, isopods, ostracods, mysids and amphipods. Large numbers of wedge shells, mole crabs and coquina clams are also found in the intertidal zone. On the other hand, the sublittoral zone contains the largest variety of species. Organisms common to the sublittoral zone include sand dollars, sea urchins, scallops and other pelecypod mollusks, sea hares, spider crabs, barnacles, crabs, hermit crabs, sponges, tunicates, cnidarians and various species of shrimps, polychaetes and mollusks.

The offshore gulf waters also provide habitat for adult and juvenile fishes (Table 18). Estuarine-dependent species which use the offshore and pass waters for spawning include red drum (Sciaenops ocellatus), spotted seatrout (Cynoscion nebulosus), snook (Centropomus undecimalis), Atlantic croaker (Micropogonias undulatus), southern flounder (Paralichthys lethostigma), Florida pompano (Trachinotus carolinus), striped mullet (Mugil cephalus), Gulf menhaden (Brevoortia patronus), tarpon (Megalops atlanticus) and bonefish (Albula vulpes) (Continental Shelf Associates, Inc., 1987). Reef fishes in the area include red grouper (Epinephelus morio), jewfish (Epinephelus itajara), gag grouper (Myceteroperca microlepis), scamp (Mycteroperca phenax), red snapper (Lutjanus campechanus) and mangrove snapper (Lutjanus griseus) (Continental Shelf Associates, Inc., 1987).

The coastal waters offshore of Captiva and North Captiva islands also contain a wide variety of commercial and sport fishes. A review of recent marine fisheries annual landings summaries indicates that significant commercial fisheries for mullet, red grouper, spotted sea trout, blue crab and pink shrimp exist in Lee County (DNR, 1990). Although some commercially valuable fishes do frequent the waters adjacent to Redfish Pass, commercial fisheries in the vicinity of Redfish Pass are generally limited to seasonal mullet fisheries (Listowski, personal communication). No known commercial concentrations of scallops or shrimp exist in the immediate study area (Listowski, personal communication).

E. Endangered Species

A list of the endangered, threatened, rare or species of special concern which are reported to occur in the vicinity of Redfish Pass is presented in Table 19. Additional threatened, endangered or rare species which have been sighted in the waters adjacent to Redfish Pass include the Atlantic bottlenosed dolphin, short-finned pilot whale, right whale, blue whale, sei whale, fin whale, humpback whale and sperm whale.

Table 18

Fish Species Reported to Occur
in the Vicinity of Redfish Pass

Scientific Name	Common Name
Ginglymostoma cirratum	nurse shark
Carcharhinus limbatus	blacktip shark
Sphyrna tiburo	bonnethead shark
Rhinobatos lentiginosus	Atlantic guitarfish
Narcine brasiliensis	lesser electric ray
Raja eglanteria	clearnose skate
Dasyatis sp.	stingray
Dasyatis sayi	bluntnose stingray
Gymnura micrura	smooth butterfly ray
Aetobatus narinari	spotted eagle ray
Rhinoptera bonasus	cownose ray
Elops saurus	ladyfish
Brevoortia sp.	menhaden
Etrumeus teres	round herring
Opisthonema oglinum	Atlantic thread herring
Harengula jaguana	scaled sardine
Sardinella aurita	Spanish sardine
Anchoa hepsetus	striped anchovy
Anchoa mitchilli	bay achovy
Synodus foetens	inshore lizardfish
Bagre marinus	gafftopsail catfish
Hyporhamphus unifasciatus	halfbeak
Strongylura marina	Atlantic needlefish
Tylosurus crocodilus	houndfish
Membras martinica	rough silverside
Menidia sp.	silverside
Hippocampus erectus	lined seahorse
Centropomus undecimalus	snook
Pomatomus saltatrix	bluefish
Rachycentron canadum	cobia
Caranx hippos	crevalle jack
Chloroscombrus chrysurus	Atlantic bumper
Oligoplites saurus	leatherjacket
Selene vomer	lookdown
Trachinotus carolinus	pompano
Trachinotus falcatus	permit
Decapturus punctatus	round scad
Eucinostomus sp.	mojarra
Lagodon rhomboides	pinfish
Archosargus probatocephalus	sheepshead

Table 18

Fish Species Reported to Occur
in the Vicinity of Redfish Pass
(continued)

Scientific Name	Common Name
Cynosion arenarius	sand seatrout
Leiostomus xanthurus	spot
Menticirrhus littoralis	gulf kingfish
Menticirrhus saxatilis	northern kingfish
Pogonias cromis	black drum
Chaetodipterus faber	Atlantic spadefish
Mugil cephalus	striped mullet
Mugil curema	white mullet
Scomberomorus cavalla	king mackerel
Scomberomorus maculatus	Spanish mackerel
Peprilus alepidotus	harvestfish
Paralichthys albigutta	gulf flounder
Chilomycterus schoepfi	striped burrfish

Source: Phillips and Sprinkel, 1989.

Table 19

List of Endangered, Threatened, Rare or Species of Special Concern Which Are Reported to Occur in the Vicinity of Redfish Pass

Common Name	Scientific Name	Status FGFWFC	Status USFWS	Status FDA
BIRDS				
Arctic peregrine falcon	Falco peregrinus tundrius	E	T	
Brown pelican	Pelecanus occidentalis	SSC		
Bald eagle	Haliaeetus leucocephalus	T	E	
American oystercatcher	Haematopus palliatus	SSC		
Least tern	Sterna antillarum	T		
Reddish egret	Egretta rufescens	SSC		
Roseate spoonbill	Ajaia ajaja	SSC		
Little blue heron	Egretta caerulea	SSC		
Snowy egret	Egretta thula	SSC		
Louisiana heron	Egretta tricolor	SSC		
Wood stork	Mycteria americana	E	E	
Grasshopper sparrow	Ammondramus savannarum	E	E	
Marsh wren	Cistothorus palustris	SSC		
Piping plover	Charadrius melodus	T	T	
Sandhill crane	Grus canadensis pratensis	T		
Southeastern American kestrel	Falco sparverius paulus	T		
White ibis	Eudocimus albus	SSC		
REPTILES				
Atlantic green turtle	Chelonia mydas mydas	E	E	
Atlantic hawksbill turtle	Eretmochelys imbricata imbricata	E	E	
Atlantic ridley turtle	Lepidochelys kempi	E	E	
Atlantic loggerhead turtle	Caretta caretta	T	T	
Leatherback turtle	Dermochelys coriacea	E	E	
American alligator	Alligator mississippiensis	SSC	T (S/A)	
American crocodile	Crocodylus acutus	E	E	
Eastern indigo snake	Drymarchon coracis couperi	T	T	
Gopher turtle	Gopherus polyphemus	SSC		
MAMMALS				
West Indian manatee	Trichechus manatus latirostris	E	E	
Sanibel Island rice rat	Oryzomys palustris sanibeli	SSC		
Florida mouse	Podomys floridanus	SSC		

Table 19

List of Endangered, Threatened, Rare or Species of Special Concern Which Are Reported to Occur in the Vicinity Of Redfish Pass (Continued)

Common Name	Scientific Name	Status FGFWFC	Status USFWS	Status FDA
MOLLUSCS				
Florida tree snail	Liguus fasciatus	SSC		
FISHES				
Common snook	Centropomus undecimalis	SSC		
Saltmarsh topminnow	Fundulus jenkinski	SSC		
PLANTS				
Beach creeper	Ernodia littoralis			T
Wild cotton	Gossypium hirsutum			E
Joewood	Jacquinia keyensis			T
Whisk fern	Psilotum nudum			T
Inkberry	Scaevola plumieri			T
Bay cedar	Suriana maritima			E
Shoestring fern	Vittaria lineata			T
Golden leather fern	Acrostichum aureum			E
Giant leather fern	Acrostichum danaeifolium			T
Geiger tree	Cordia sebestena			E
Coconut Palm	Coco nucifera			T

T = Threatened
SSC = Species of special concern
E = Endangered
T (S/A) = Threatened due to similarity of appearance

Compiled From:
Florida Game and Fresh Water Fish Commission.
Emerson, 1984.
J. N. "Ding" Darling National Wildlife Refuge - Mammal List.
Morrill and Harvey, 1980.
Lindblad, 1992, personal communication.

IV. ENGINEERING ALTERNATIVES

A. Introduction

This section of the management plan involves the evaluation of engineering alternatives that solve problems caused by natural and man made inlet features. The design of alternatives is preliminary and sufficient to develop an estimate of the cost of each alternative. The cost estimates include contingencies and engineering costs. Alternative plans that include fill to be placed at the same time as Captiva's maintenance nourishment include cost sharing to the inlet management plan for mobilization/demobilization. For purpose of comparison, each alternative's costs are annualized over a 50-year project life. Annualized costs are determined using an interest rate of 3%. The advantages and disadvantages of each system and their impact on the inlet-beach system are discussed.

The primary inlet impact is a deficiency of natural bypassing, which contributes to the erosion on Captiva Island. The dredging of the ebb shoal, natural inlet migration and the construction of a terminal groin on Captiva Island have produced lesser impacts. These impacts may include a reduction in the protective features of the ebb shoal and increased erosion along the south bank of the inlet.

B. Goals

1. The alternatives are considered on how well they achieve the following goals.

    (1) Mitigate erosion on Captiva Island Gulf shores caused by the inlet.
    (2) Re-establish longshore transport to downdrift beaches that are being affected by the inlet's existence.
    (3) Develop plans that interfere as little as possible with the natural function of the inlet.
    (4) Control erosion in the immediate vicinity of the inlet to protect property and infrastructure.
    (5) Maintain existing ebb shoal protective features of the inlet.
    (6) Maintain natural navigation and flushing features of the inlet.
    (7) Accomplish above goals addressing long term environmental impacts.
    (8) Accomplish above goals in an economically responsible manner.
    (9) Identify impacts of natural and man made inlet features.
    (10) Develop local program to implement Inlet Management Plan.

2. The considered alternatives are classified as either relating to closing Redfish Pass or sand bypassing (as required by State format). The Captiva Island Beach Nourishment Program is assumed to be ongoing for all alternatives, unless otherwise stated. The alternatives are:

    a. Close the Inlet (Remove Groin and Fill Inlet).

b. Inlet Bypassing Systems.

1. Status Quo (Continue Beach Maintenance Program and Leave Groin in Place).
2. No Action (Stop Beach Maintenance).
3. Remove Terminal Groin.
4. Change Borrow Area.
5. Add Feeder Beach to Beach Nourishment Project.
6. Construct Deposition Basin.
7. Nourish Beach on South Interior Shoreline.
8. Revet South Interior Beach.
9. New South Terminal Groin.
10. New Terminal Groin and Revetment Construction.
11. Modify Terminal Groin (Shorten 75 Feet).
12. Monitor Only.
13. Experimental System: Jet Pump with Fluidized Bypassing Plant.
14. Construct terminal groin on North Captiva Island.

3. Alternatives

A. Close the Inlet

This alternative involves the removal of the terminal groin and the physical closure of Redfish Pass. The inlet will not close without significant human assistance. The inlet would be closed by the construction of a sheet pile structure and back filled with 100,000 cubic yards of sand (Figure 21).

Once closed, the gulf side inlet channels should fill with sand as waves move the ebb shoal ashore. There is sufficient sand in the ebb shoal to fill the channels and bring the shores into equilibrium. The main advantage of this option is that bypassing would be reinitiated once the old inlet channels fill significantly. Until that time, the shoal remnant would provide material to the beach. The initial cost of this alternative is $1,784,000 and the annual cost is $69,336 over the project life.

While this option would bypass the full amount of longshore transport to Captiva Island, water quality problems could result in Pine Island Sound near the inlet. In addition, the Redfish Pass tidal prism would redistribute to Captiva and Blind Pass, creating unforseen changes. In the future, this tidal prism in conjunction with a large storm could open a pass at an unpredictable location - perhaps at the location of recent overwash events north or south of Redfish Pass. It could take a decade or two before the inlet channels are filled sufficiently and natural bypassing establishes itself. Initial shoreline response would include erosion. Closing the inlet is neither natural or favorable to navigation. This alternative is not recommended.

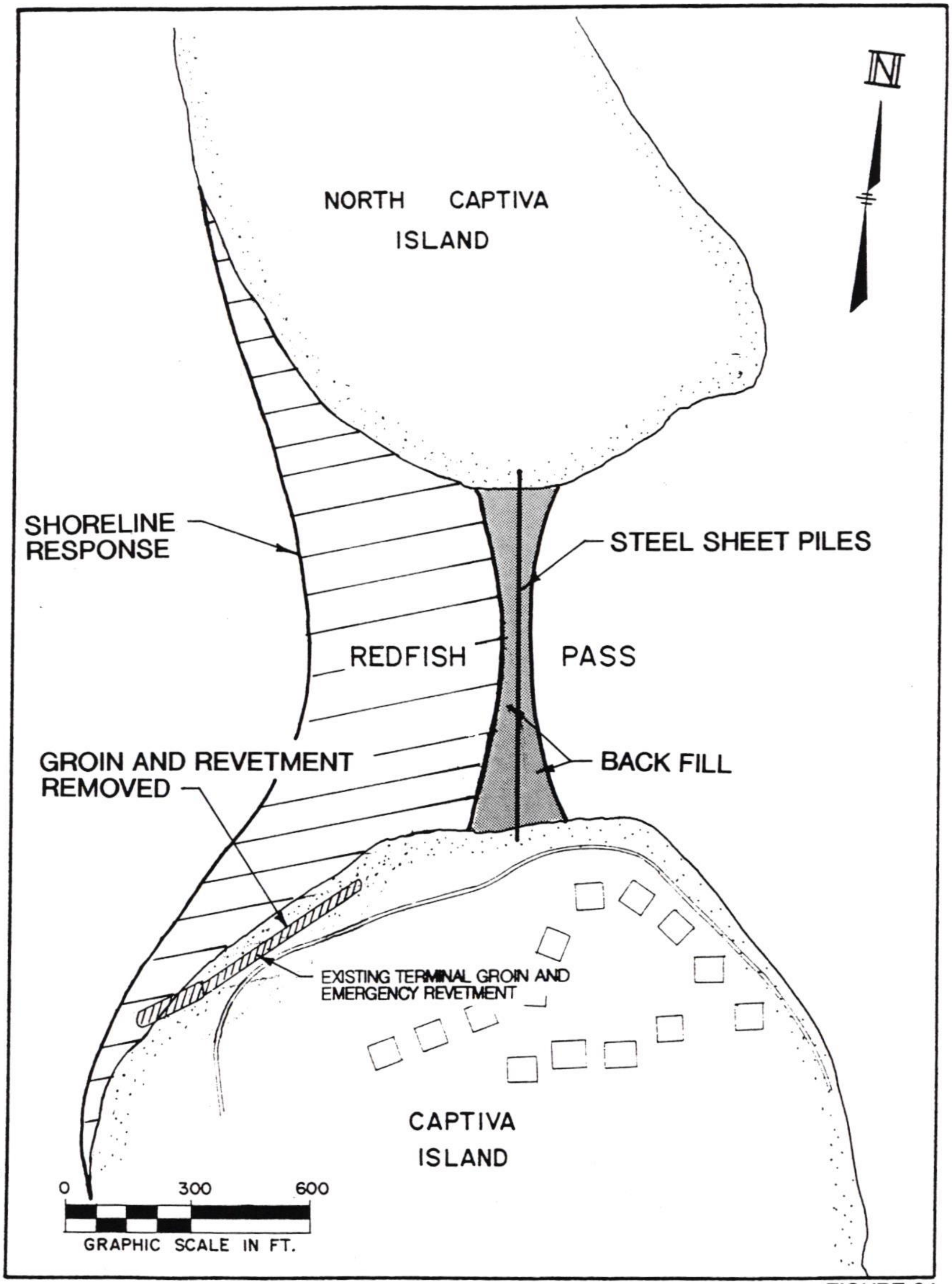


FIGURE 21

ALTERNATIVE A
CLOSE THE INLET

B. Inlet Bypassing Systems

B-1. Status Quo (Continue Beach Maintenance Program and Leave Terminal Groin in Place).

This alternative involves no action as part of the Inlet Management Plan, but calls for a continuation of the Captiva Island beach maintenance program and retaining the terminal groin in place. The Captiva Island nourishment program calls for renourishment every six to eight years to replace sand lost to erosion. The next nourishment is scheduled for 1996, and will require approximately 750,000 c.y. of fill. The advantage of this plan is that it requires no further action by local, state and federal agencies. In addition, the beach maintenance program provides storm protection and erosion control for the gulf shores on Captiva Island. The status quo alternative has no cost to the inlet management plan. The disadvantages of maintaining the status quo, is that erosion in the immediate vicinity of the inlet is not addressed, nor is bypassing re-established. For this reason this alternative is not recommended as the sole solution.

B-2. No Action and Discontinue Captiva Island Beach Maintenance Program

This alternative entails discontinuing maintenance of all erosion control projects on Captiva and North Captiva Island, including periodic renourishment, terminal groins and private protective structures. The advantage of this alternative is that it allows the littoral environment to seek its natural configuration and ultimately establish natural bypassing.

There is no cost to the Inlet Management Plan. The disadvantages to this alternative are many, but most significantly this alternative will lead to increased property loss and damage, and it will neither mitigate or re-establish bypassing in the near future. The ebb shoal will need to grow by millions of cubic yards before significant natural bypass can be established. For these reasons, this alternative is not considered further.

B-3. Remove the Terminal Groin

This alternative involves the removal of the terminal groin and associated temporary revetment on the south interior shore of Redfish Pass. Removal of the terminal groin would re-establish the continuous movement of sand between the gulf shoreline and the interior shoreline. The terminal groin currently impedes this movement, which is driven by tidal and wave forces. The shoreline response would be a recession south of the groin and accretion northeast of the groin (Figure 22). The initial cost of removing the groin would be $130,422, and it would require no further action after the initial year. Annual project cost would be $5,069.

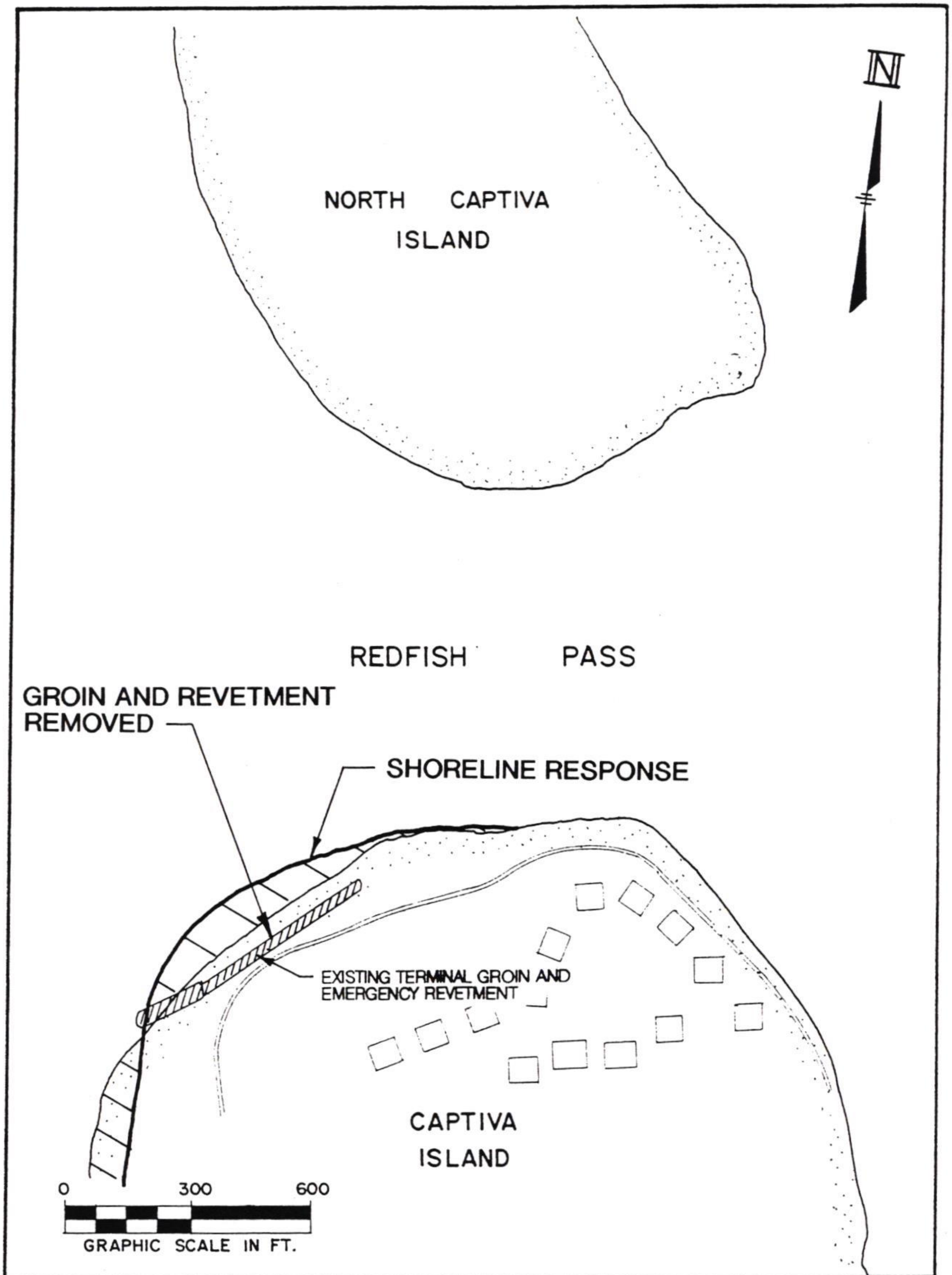


FIGURE 22

ALTERNATIVE B-3
REMOVE TERMINAL GROIN

The disadvantage of this alternative is that it would remove the stabilizing effects of the groin against end losses on the gulf beaches. The groin prevents at least 13,000 cubic yards in losses annually. Without the terminal groin, net losses of sand from Captiva Island would increase.

B-4. Change the Borrow Area

This alternative involves abandoning the Redfish Pass ebb shoals as a sand source for the Captiva Island maintenance nourishment program and the inlet management plan. South Seas Plantation and residents on North Captiva Island have expressed concerns that dredging the ebb shoal contributes to erosion on the adjacent shorelines. The advantage of this alternative is that it would allow the ebb shoal to grow to its potential size, thereby establishing natural bypassing and the full protective features of the shoals. The shoal currently impounds enough material to nourish Captiva Island every third renourishment. Renourishments are programed every six to eight years, and the ebb shoal is growing at an annual rate of 28,000 c.y./yr.

The cost of abandoning the ebb shoal as a source is the cost difference between this source and the best borrow source alternatives. Future nourishment of Captiva Island has been estimated to cost $7.9 million if the Site III borrow area is used, and $5.64 million if the ebb shoal borrow area (naturally refilled) is used. The cost assumes a renourishment quantity of 750,000 c.y. The cost difference between using the ebb shoal borrow area (IV) and borrow area III (Figure 31) is $2,260,000 per event (CPE, 1992). Assuming that the ebb shoal would be used for renourishment again in 2008, the annual cost for a 50-year life cycle would be $112,216.

The major disadvantage of abandoning the ebb shoal as a borrow source is cost. Secondly, it could take the shoal almost a century to reach its potential and natural size, and foregoing current benefits for an uncertain future gain is not advantageous.

The wave refraction analysis shows that dredging the ebb shoal had no significant detrimental impacts on the adjacent shorelines. Abandoning the ebb shoal as a future borrow area is not recommended.

B-5. Add a Feeder Beach to the Captiva Island Maintenance Nourishment Project

The objective of this alternative is to add a feeder beach to the northern portion of the Captiva Island maintenance nourishment projects to mitigate and mimic natural sand bypassing of the inlet. The inlet is responsible for a 32,000 cubic yards/year in bypassing deficit to Captiva Island. The existing beach maintenance program includes advanced nourishment which compensates for uniform background erosion along the island. A feeder beach built south of the nodal point (2,000 to 5,000 feet south of Redfish Pass) with a volume equal to the sand bypassing deficit would substitute for natural sand bypassing at the inlet and reduce the erosion of the Captiva project. When constructed in conjunction with the major maintenance nourishment project, the feeder beach would consist of 256,000 cubic yards (8 years x 32,000 c.y./yr.) and extend 6,000 to 10,000 feet alongshore. The material for the feeder beach would come from the same source as sand for the maintenance nourishment project. Initial cost to the Inlet Management Plan in cycle with the renourishment project would be $2,104,960. The annualized project cost is $314,270.

The addition of a feeder beach would have several advantages. It would re-establish the natural longshore transport and it is identified up front as mitigation for the inlet effects. Material placed near the nodal point will also provide material to the north tip of Captiva Island, and allow longer natural nourishment of the inlet shoreline around the terminal groin.

Feeder beach material quantities count one for one against nourishment sand requirements in support of the Captiva Island maintenance nourishment program.

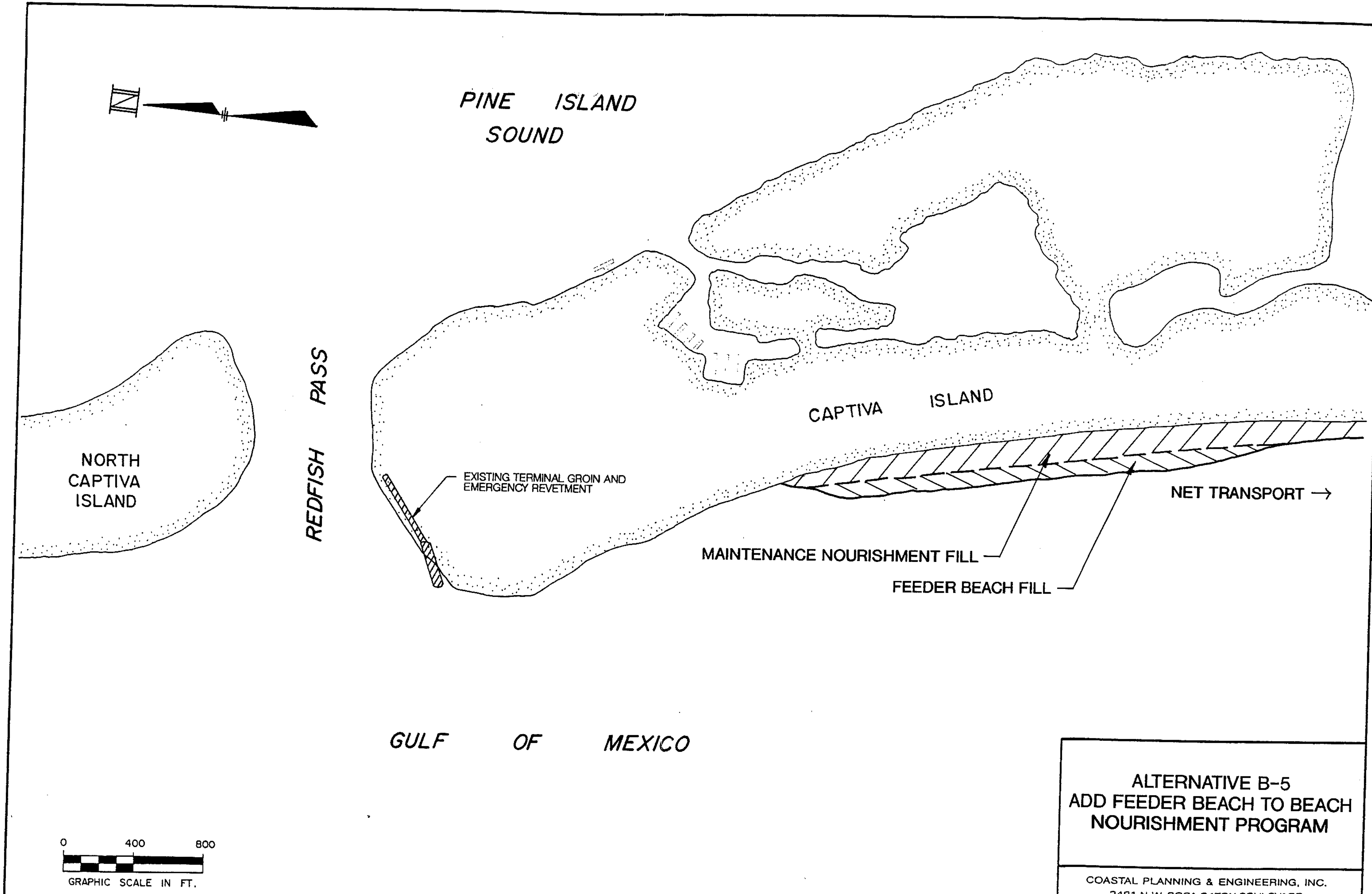
B-6. Construct Deposition Basin

This alternative calls for the construction of a deposition basin (sand trap) designed to intercept littoral material prior to its loss to the tidal shoals. A deposition basin is sized so that it maximizes impoundment of material in a location where material can be readily removed. The best potential site for a deposition basin would be in the nearshore ebb shoal of Captiva or North Captiva Island (Figure 24). The basin could trap up to 32,000 cubic yards/year. Transfer would be by dredging. The material will be placed south of the Captiva Island nodal point, at the location of the proposed feeder beach.

A major advantage is that a semi-permanent source of material is reserved to mitigate erosion on Captiva Island. Deposition basin material quantity will replace beach renourishment quantities one for one.

The cost of transfer of this material at 3-year intervals will be $903,514 when combined with the nourishment project and $1,555,950 out of cycle. Annual cost at 3% over a 50-year project life is $405,696. The cost would be $493,350 more per renourishment cycle than the renourishment program alone.

There are two major disadvantages to a deposition basin besides cost. First, dredging a basin near the North Captiva shoreline may cause excessive dry beach erosional impacts. Secondly, deposition basins have a low success rate, especially when subject to open coast waves and unfixed by hardened structures, such as jetties. Most of the material trapped in the basin would be available in



ALTERNATIVE B-5
ADD FEEDER BEACH TO BEACH NOURISHMENT PROGRAM

COASTAL PLANNING & ENGINEERING, INC.
2481 N.W. BOCA RATON BOULEVARD.
BOCA RATON, FL 33431

FIGURE 23

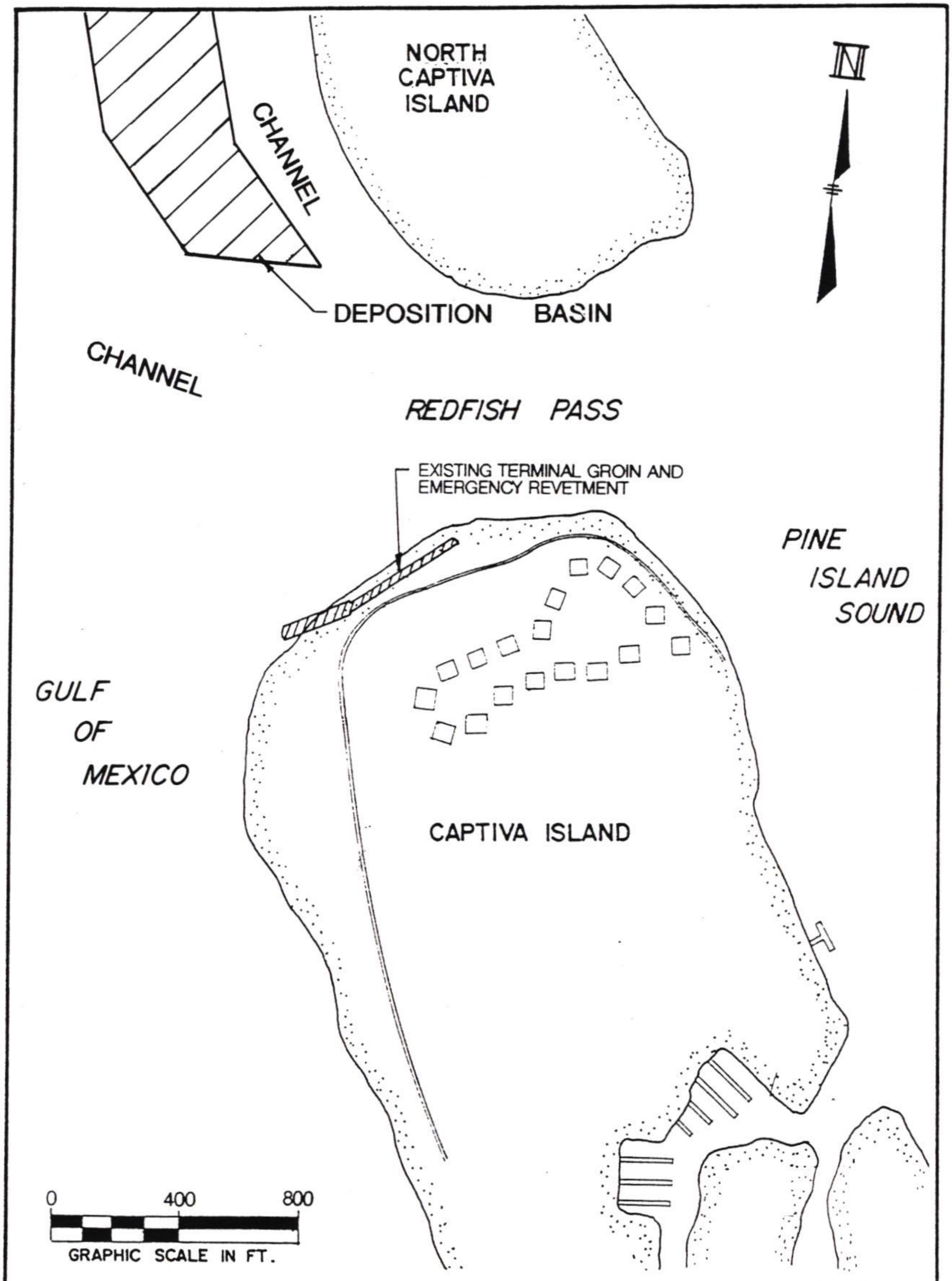


FIGURE 24

ALTERNATIVE B-6
CONSTRUCT DEPOSITION BASIN

the shoals, when they are used as a borrow source. Because of these disadvantages, this alternative is not recommended.

B-7. Beach Nourishment of Interior Shoreline

This alternative involves the restoration of 1,000 feet of interior shoreline, beginning at the terminal groin (Figure 25). Fill would be placed to realign the shoreline to its pre-1986 configuration. It is estimated that 34,000 cubic yards of sand would be required at the time of renourishment of Captiva Island and an additional 24,000 cubic yards at year four. The initial quantity is derived from 10,000 cubic yards for a protective beach and two years advance nourishment at 12,000 c.y./yr. During the first two years of the project, the beach would be nourished by littoral sand movement around the terminal groin. The size of this beach is limited by the inlet channel, therefore 2 years of advance nourishment would be needed at year four. The need for an interim nourishment project will be climate dependent and may be required earlier or not at all between major renourishment cycles.

The initial cost of this alternative in 1996 with the next nourishment cycle would be $320,000. The annual cost at 3% interest over a 50-year project life is $94,700. Out of cycle nourishment will use the most cost effective sand source, either in the flood or ebb shoal.

The advantages of this alternative are two-fold. It allows the terminal groin to remain intact, as a benefit to the gulf shore beach, and it restores the inlet shoreline more naturally without hardened structures.

The major disadvantages are the cost of mobilizing a small project out of cycle of the major renourishment project and the risk attendant with small beach fills. The durability of small beach nourishment is low and may perform poorly due to natural variability in climate and inlet migration.

B-8. Revet Interior Shoreline

This alternative calls for revetment construction on 1,050 feet of inlet shoreline east of the terminal groin. This alternative would replace the existing emergency revetment of sand bags and rocks. The revetment would protect against waves and currents that eroded the inlet frontage. The advantage of this alternative is that it allows the terminal groin to remain in place, providing benefits to the gulf beach. It also provides protection to property and infrastructure along the inlet (Figure 26). Infrastructure protected includes an access road and drain field belonging to the South Seas community.

The initial cost of constructing this 1,050 foot revetment, using existing and new rock, is $1,535,198. Construction will include 10,000 c.y. of backfill. Periodic

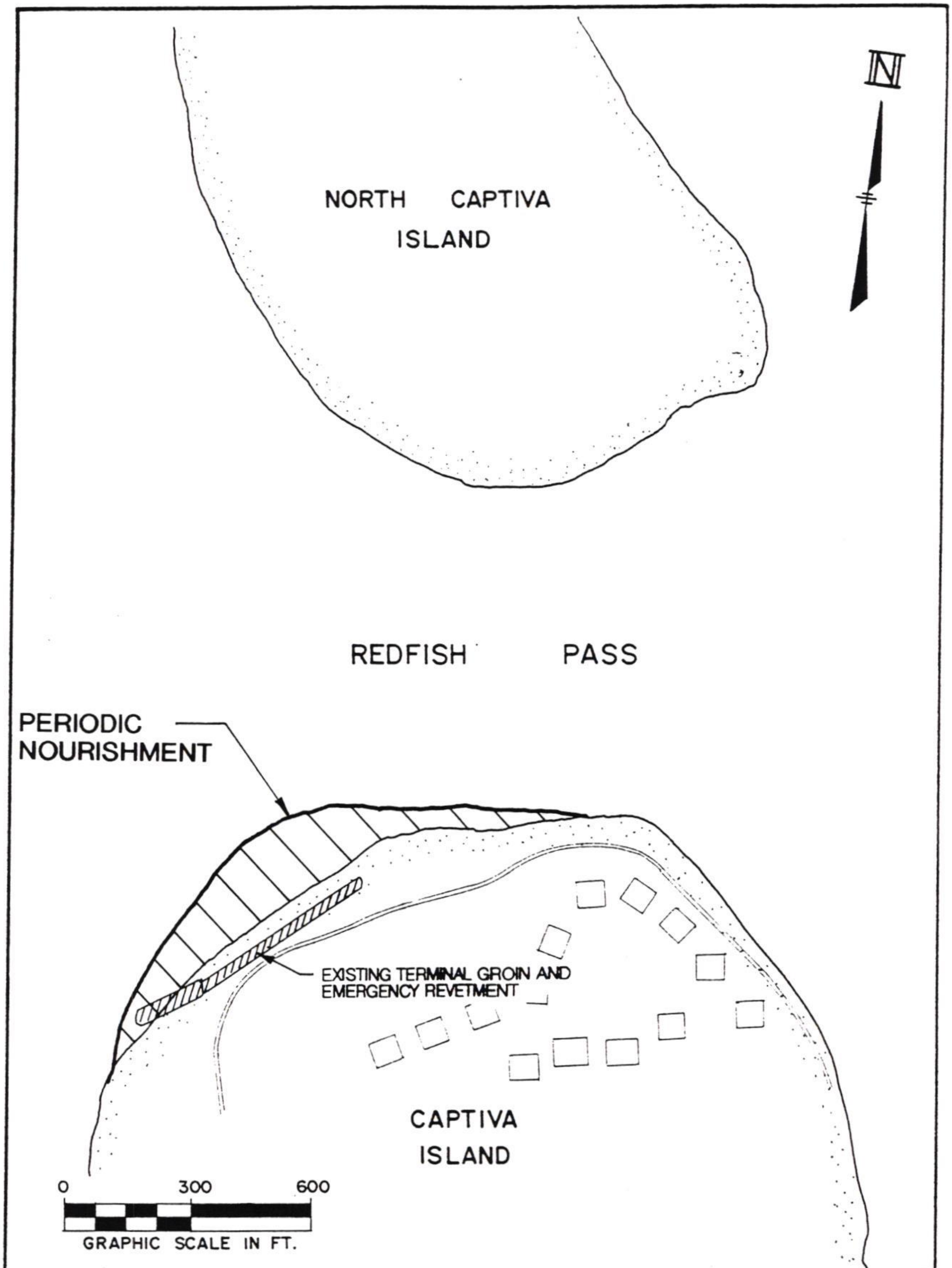


FIGURE 25

ALTERNATIVE B-7
BEACH NOURISH SOUTH INTERIOR SHORELINE

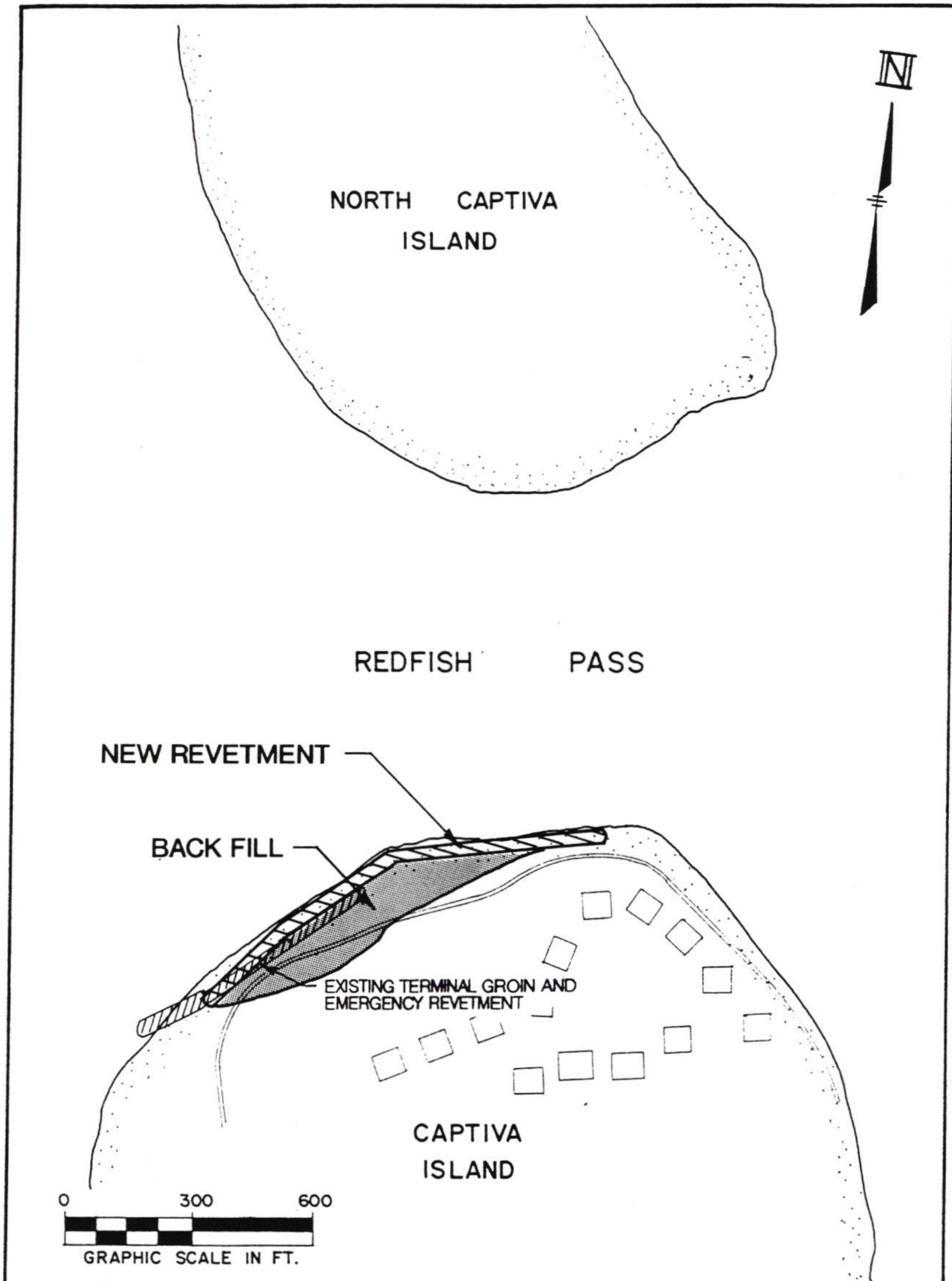


FIGURE 26

ALTERNATIVE B-8
REVET SOUTH INTERIOR SHORELINE

maintenance will cost $328,438 at 20-year intervals. Annual cost at 3% interest for a 50-year project life will be $70,647.

The disadvantage of hardening of the inlet is that the natural sandy interior shoreline would be eliminated. A rubble mound or sheet pile seawall could be a viable alternative to a revetment.

B-9. <u>New South Terminal Groin</u>

This alternative calls for the upgrading of the terminal groin (Figure 27). The groin would have the same benefits and functions as the existing terminal groin. It would be designed not only to impede longshore transport and retard erosion, but to provide a control structure to tidal flow and stabilize inlet migration. The new groin would consist of larger rock and have a deeper foundation in order to hold up against adjacent tidal flow, scour, and large wave attack. The existing terminal groin is not designed to survive in direct contact with the main inlet channel and gulf waves. In addition, the groin does not diminish wave overtopping, which is impacting the beach south of the inlet.

The new groin would be constructed using new and existing material (rock), and would require periodic maintenance. It would be similar in design to the terminal groin at Blind Pass. The seaward extent of the new structure would be the same as the existing groin, but would be extended 50 feet landward.

Initial cost would be $1,090,097 and maintenance at 20-year intervals would cost $268,180. The annual project cost at 3% interest would be $51,333.

The disadvantages of this alternative are the same as for the groin; it would impede movement of material to the interior shoreline and not solve interior shoreline erosion.

B-10. <u>New Terminal Groin and Revetment Construction</u>

This alternative calls for the combination of alternatives B-8 and B-9. The project would consist of a continuous terminal groin and revetment structure along the entire inlet frontage (Figure 28).

The advantages and disadvantages are similar to those for alternatives B-8 and B-9. In addition, the structure would be built without major discontinuities and bows that exist in the current structure. Wave forces can concentrate at these discontinuities and lead to early structural damage.

The new groin and revetment structure would cost $2,562,046 for initial construction and $533,362 for periodic maintenance at 20-year intervals. The annual project cost at 3% interest would be $117,407.

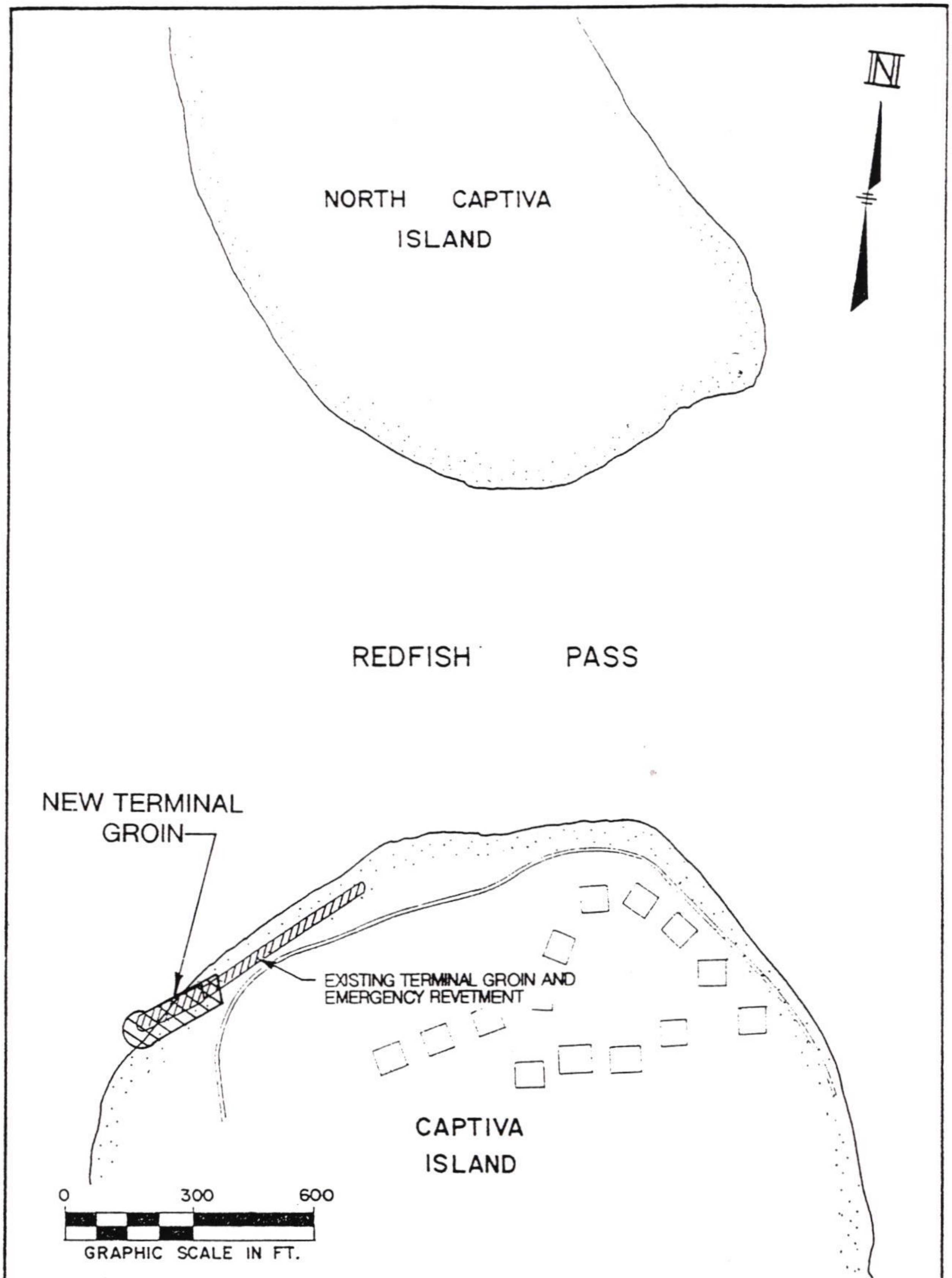


FIGURE 27

ALTERNATIVE B-9
NEW SOUTH TERMINAL GROIN CONSTRUCTION

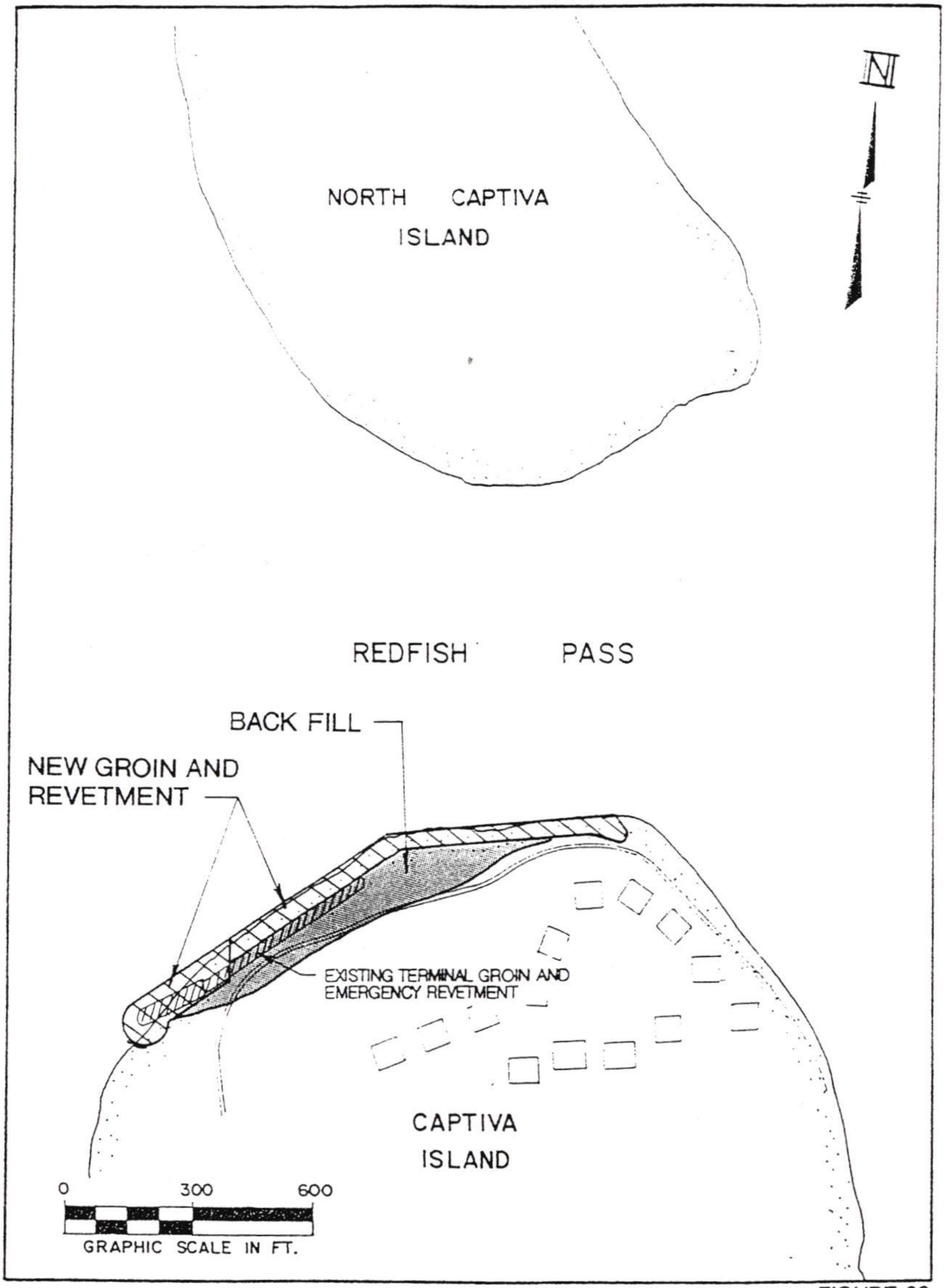


FIGURE 28

ALTERNATIVE B-10
NEW GROIN AND REVETMENT CONSTRUCTION

B-11. Modify Terminal Groin

This alternative calls for the shortening of the terminal groin by 75 feet on the seaward end (Figure 29). The extra rock could be used to strengthen other portions of the groin and increase its landward extension. The advantage of this alternative is that it provides increased passage of littoral material to the interior shoreline. The increased material may add to the life span of the interior shoreline by four versus two years between renourishment cycles. In conjunction with nourishment of the interior shoreline (Alternative B-7), this would provide a protective shoreline without the need for out of cycle nourishment. This alternative would have a one-time cost of $113,534, which gives an annualized cost of $4,413.

The disadvantage of this alternative is that it would decrease beach width immediately south of the inlet an average of 75 feet between renourishment cycles. In addition, it does not address the groin's susceptibility to increased wave and tidal forces, and it would increase the net loss of material from the dry sand beaches of Captiva Island.

B-12. Monitor Only

This alternative entails delaying implementation of the inlet management plan until more years of monitoring are complete. The last few years have been characterized by unique events that may have caused uncharacteristic impacts on the shoreline. It may be possible to draw the wrong conclusion and implement a plan that would address only part of the problem.

The major advantage to this alternative is that excessive implementation cost can be avoided until basic coastal processes and changes are better quantified, and the resultant plan narrowed to address the specific long term problems. Cost will be the additional cost of monitoring and updating the Inlet Management Plan, or about $25,000. The disadvantage of this alternative is that immediate corrective action may be delayed, allowing damage to property and infrastructure to continue.

B-13. Experimental System: Jet Pump with Fluidizer Collector

The choices for a fixed or mobile bypassing system at Redfish Pass are limited. It is best to position pumping and excavation facilities on the updrift side of the inlet. At Redfish Pass this would be an expensive option, since North Captiva Island is isolated without the utilities and access needed for a large cost effective pumping plant. The best alternative is a plant on Captiva Island, using a jet pump system with a fluidizer collector.

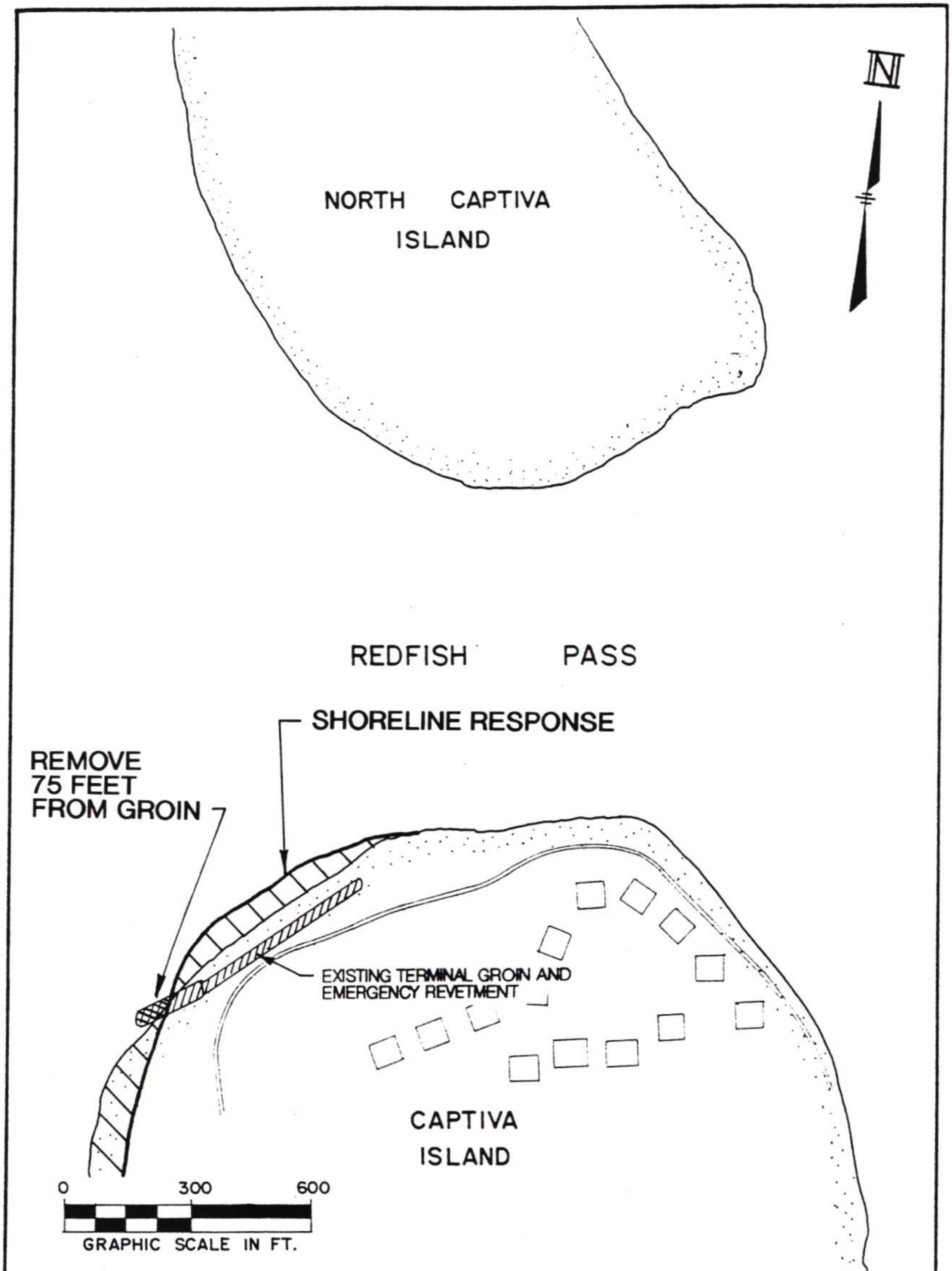


FIGURE 29

ALTERNATIVE B-11
MODIFY TERMINAL GROIN

The jet pump system is intended to mechanically bypass sand from the Redfish Pass ebb shoal to the gulf shores of Captiva Island. The jet pump is placed in the ebb shoal, where it can intercept sediment transport into the inlet. The system would then pump the sand slurry under the inlet and down the beach for discharge on Captiva Island.

In order to expand the area in which the pump can capture sand, a system of four 200-foot fluidizing pipes can be installed to move sand to the submerged jet pump (Figure 30). The fluidizing pipes operate by having water pumped through them and out small jet ports. The water exiting the ports liquifies the sand and allows gravity to move the liquified material to the jet pump for transfer. The fluidizing pipes are installed on a slope toward the pump.

The jet pump and fluidizer would be supplied with clear water from a pumphouse on the north shore of Captiva Island, and another pump would transport the slurry to multiple discharge points, 2,000 to 3,500 feet south of the pass.

This system would mitigate erosion and re-establish longshore transport to downdrift beaches, which was interrupted by the inlet. While this system is technically feasible, it has had only limited use. The Corps of Engineers is operating a system in Oceanside Harbor, California and it is considered experimental. In addition, this system would transport material at higher costs than the ongoing beach renourishment program. The aesthetics of the island would be changed by the introduction of a pumping plant and associated pipelines on the gulf beaches. Although the location of the jet pump and pump house are optional for many reasons, the pumping distance between the two is too long for practical operations. Therefore, this system is not recommended.

The initial cost of the system, including the first year of operation is $3.13 million. Annual operation and maintenance will be $337,000 per year. The total annual cost of this system at 3% interest is $460,000 per year.

B-14. <u>Construct Terminal Groin on North Captiva Island</u>

Homeowners on southern North Captiva Island have expressed recent concern about the erosion threat to their property. A terminal groin may be the solution to their concerns. This alternative entails the construction of a terminal groin on North Captiva Island north of Redfish Pass but just south of the last house on North Captiva Island. The terminal groin would control erosion on the southern sector of North Captiva Island, decreasing end losses into Redfish Pass and stabilize recessional trends on the Gulf front shoreline. The terminal groin would be similar in design to the Blind Pass groin and approximately 250 feet long. The groin would be constructed to allow bypassing of some material for nourishment of the inlet frontage.

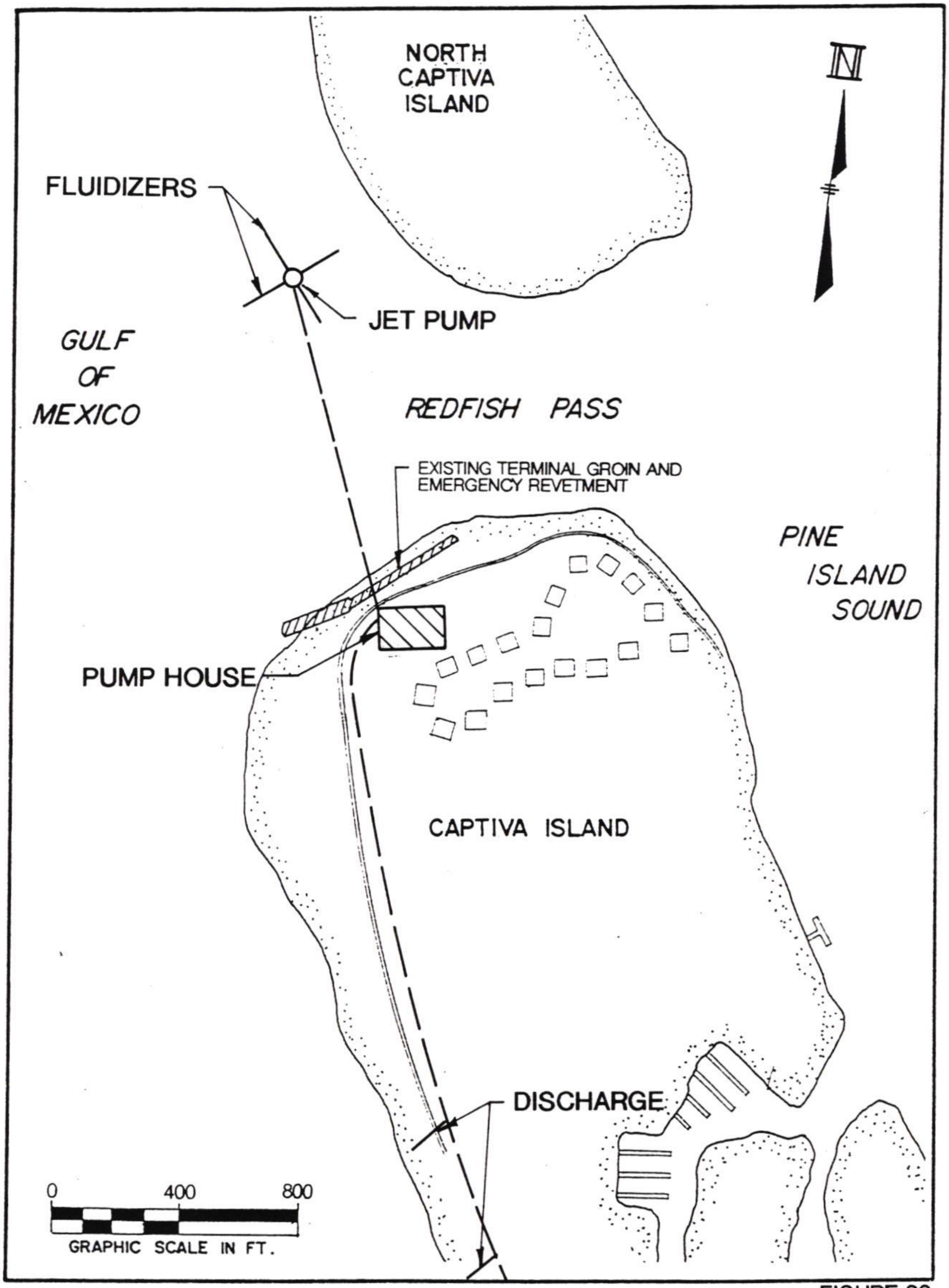


FIGURE 30

ALTERNATIVE B-13
JET PUMP WITH FLUIDIZER SYSTEM

Initial cost to implement this project would be $1,038,000 for the structure and $304,900 every 20 years for a periodic maintenance. Average annual costs are $50,500.

North Captiva Island is relatively undeveloped and the addition of a terminal groin would substantially change its natural setting. The groin may also contribute to erosion on the north interior shoreline and accelerate the northward migration of the inlet. The erosion problem on southern North Captiva Island is primarily caused by coastal processes from the updrift end of the island, although the inlet might be a contributing force. This alternative is recommended for further consideration.

The construction of a terminal groin on North Captiva Island would be beneficial for erosion control with little downdrift impacts. Favorable consideration should be given to the homeowners, if they desire to implement a local erosion control project.

Table 20 shows a comparison of the inlet management alternatives. Technical feasibility, permittability, cost, bypassing, erosion control, inlet impacts, environmental concerns and funding are addressed. The recommended plan will be a composite of the best features of the individual alternatives. Environmental assessments of each alternative are in Appendix D.

TABLE 20a
REDFISH PASS (LEE COUNTY) MANAGEMENT PLAN
COMPARISON OF ALTERNATIVES

NUMBER NAME OF ALTERNATIVE	TECHNICAL FEASIBILITY (YES/NO)	PERMIT-ABILITY (YES/NO)	INITIAL CONSTRUCTION COST($)	ANNUAL PROJECT COST @ 3.0%	RE-ESTAB. LITTORAL DRIFT (DIR/IND)	EROSION CONTROL/ MITIGATION (FREQUENCY	MAINTAIN NATURAL INLET FEATURES	OTHER SIGNIFICANT COMMENTS/ IMPACT
			(4)		(2 & 6)	(3)	(7)	
A. CLOSE THE INLET AND REMOVE THE TERMINAL GROIN	YES	MAYBE	$1,784,000	$69,336	YES-D	YES-C&G	NO	BENEFICIAL EFFECTS IN DISTANT FUTURE
B. INLET BYPASSING SYSTEMS								
1 STATUS QUO (CONTINUE BEACH MAINTENANCE PROGRAM AND LEAVE GROIN)	YES	YES	$0	$0	NO	SOME	YES	BENEFITS DERIVED FROM NOURISHMENT PROJECT WITH SAND IN KIND.
2 NO ACTION (STOP BEACH MAINTENANCE)	YES	YES	$0	$0	NO	NO	YES	NATURAL BYPASSING WILL TAKE ABOUT A CENTURY TO ESTABLISH.
3 REMOVE TERMINAL GROIN	YES	YES	$130,422	$5,069	NO	SOME-P&I	YES	TRADE OFF BETWEEN GULF AND INLET SHORE EROSION.
4 CHANGE BORROW AREA	YES	YES	$840,327	$41,725	NO	NO	YES	BENEFICIAL EFFECTS IN DISTANT FUTURE
5 ADD FEEDER BEACH TO BEACH RENOURISHMENT PROGRAM	YES	YES	$2,104,960	$314,270	YES-I	YES-C&G	YES	NOTE 1
6 CONSTRUCT DEPOSITION BASIN	YES	MAYBE	$903,514	$405,696	YES-D	YES-C&G	MOSTLY	NOTE 1. MAY IMPACT SOUTHERN NORTH CAPTIVA ISLAND SHORELINE.
7 BEACH NOURISHMENT OF INTERIOR SHORELINE	YES	MAYBE	$320,000	$94,700	SOME-I	YES-P&I	YES	NOTE 5
8 REVET INTERIOR SHORELINE	YES	MAYBE	$1,535,198	$70,647	NO	YES-S&I	NO	TRADE OFF FOR BENEFITS TO GULF SHORELINE.
9 NEW SOUTH TERMINAL GROIN CONSTRUCTION	YES	MAYBE	$1,090,097	$51,333	NO	HELPS-S&G	SOME	UPGRADED TERMINAL GROIN TO WITHSTAND DIRECT OPEN COASTAL FORCES.
10 NEW TERMINAL GROIN AND REVETMENT CONSTRUCTION	YES	MAYBE	$2,562,046	$117,407	NO	HELPS-S,I&G	SOME	SEE B-8 AND B-9
11 MODIFY TERMINAL GROIN (SHORTEN 75 FEET)	YES	YES	$113,534	$4,413	SOME-I	YES-P&I	YES	WILL ALLOW ADDITIONAL SAND TRANSPORT FROM GULF TO INLET SHORELINE.
12 MONITOR ONLY	YES	YES	$25,000	$972	NO	NO	NO	DELAYS IMPLEMENTATION FOR FURTHER SURVEYS AND ANALYSIS FOR IMP.
13 JET PUMP WITH FLUIDIZER	EXPERIMENTAL	EXPERIMENTAL	$3,132,000	$460,000	YES-D	YES-C&G	SOME	LOW AESTHETICS
14 TERMINAL GROIN ON NORTH CAPTIVA ISLAND	YES	MAYBE	$1,037,543	$50,517	NO	YES-C	SOME	VERY LOW DEVELOPMENT DENSITY PROVIDE EROSION CONTROL

NOTES: ALL COST INCLUDE CONTINGENCIES (15%) AND ENGINEERING (10%) COSTS EXCEPT SAND TRANSFER SYSTEM COSTS ,WITH CONTINGENCIES (25%) AND ENGINEERING (10%) COSTS.
NOTE 1: THESE ALTERNATIVES INCLUDE A DIRECT TRADE OFF BETWEEN BEACH NOURISHMENT QUANTITIES AND SAND QUANTITIES INCLUDED IN THE ALTERNATIVE.
NOTE 2: D=DIRECT AND I=INDIRECT
NOTE 3: C=CONTINUOUS, P=PERIODIC, I=INLET SHORELINE, G=GULF SHORELINE, AND S=STRUCTURE
NOTE 4: CAPTIVA IS. NOURISHMENT PROGRAM CONSIDERED A SEPARATE PROGRAM.
NOTE 5: INITIAL CONSTRUCTION IN 1993 & 1995.
NOTE 6: WITHIN A 50 YEAR PROJECT LIFE.
NOTE 7: NAVIGATION, FLUSHING, EBB SHOAL, AND SOFT SHORELINE.

BOLD RECOMMENDED

TABLE 20b
REDFISH PASS (LEE COUNTY) MANAGEMENT PLAN
COMPARISON OF ALTERNATIVES

NUMBER	NAME OF ALTERNATIVE	ENVIRONMENTAL CONCERNS	RECOMMEND (YES/NO)
A.	CLOSE THE INLET AND REMOVE THE TERMINAL GROIN	DIMINISHED WATER QUALITY & STAGNATION IN ESTUARY INCREASED DRY BEACH ECOSYSTEM	NO
B.	INLET BYPASSING SYSTEMS		
1	STATUS QUO (CONTINUE BEACH MAINTENANCE PROGRAM AND LEAVE GROIN)	LOSS OF BEACH ECOSYSTEM NORTHEAST OF GROIN NOTE 1	NO
2	NO ACTION (STOP BEACH MAINTENANCE)	LOSS OF BEACH ECOSYSTEM, DUNE VEGETATION AND SEA TURTLE NESTING HABITAT	NO
3	REMOVE TERMINAL GROIN	DECREASE IN BEACH ECOSYSTEM & DUNE VEGETATION	NO
4	CHANGE BORROW AREA	NO ADDITIONAL EFFECTS	NO
5	ADD FEEDER BEACH TO BEACH RENOURISHMENT PROGRAM	NOTE 1 INCREASE DRY BEACH ECOSYSTEM	YES
6	CONSTRUCT DEPOSITION BASIN	SMALL DECREASE IN DRY BEACH ECOSYSTEM & SEA TURTLE HABITAT ON NORTH CAPTIVA	NO
7	BEACH NOURISHMENT OF INTERIOR SHORELINE	NOTE 1	NO
8	REVET INTERIOR SHORELINE	LOSS OF DRY BEACH NORTH OF REVETMENT POTENTIAL HABITAT FOR MARINE ORGANISMS	NO
9	NEW SOUTH TERMINAL GROIN CONSTRUCTION	SMALL DECREASE IN BEACH ECOSYSTEM BORDERING PASS POTENTIAL HABITAT FOR MARINE ORGANISMS	NO
10	NEW TERMINAL GROIN AND REVETMENT CONSTRUCTION	LOSS OF DRY BEACH ECOSYSTEM NORTH OF JETTY POTENTIAL HABITAT FOR MARINE ORGANISMS	YES
11	MODIFY TERMINAL GROIN (SHORTEN 75 FEET)	POTENTIAL LOSS OF DRY BEACH ECOSYSTEM & DUNE VEGETATION	NO
12	MONITOR ONLY	SAME AS B-1	NO
13	JET PUMP WITH FLUIDIZER	INCREASE TURBIDITY IN EBB SHOAL	NO
14	TERMINAL GROIN ON NORTH CAPTIVA ISLAND	INCREASE OF DRY BEACH ECOSYSTEM NORTH OF GROIN	YES

NOTE 1: TEMPORARY LOSS OF INFAUNA AT DREDGE AND SAND PLACEMENT SITE.

V. SAND SOURCES

A number of potential sources of sand have been investigated for the construction of the Captiva Island beach nourishment project and feeder beach portion of the inlet management plan. These sources include offshore material as well as inland borrow material and portions of the flood and ebb tidal shoals of Redfish Pass.

Intensive offshore investigations were performed by the Captiva Erosion Prevention District between 1990 and 1993 to locate offshore sand sources for the Captiva nourishment project (CPE 1990, 1991, 1992). A number of borrow sources were identified which could be used to nourish the beaches of Captiva Island (Table 21 and Figure 31). For the 1996 project, a borrow area has been recommended which sits directly offshore from Captiva Island (approximately 5 miles offshore). This area has been identified as the western borrow area or Site III. It contains about 1.9 million cubic yards of sand with a grain size of 0.37 mm and a silt content of 3.5%. This sand can be used for sand requirements of the Inlet Management Plan.

Table 21

SAND CHARACTERISTICS OF POTENTIAL BORROW AREAS NEAR REDFISH PASS

Borrow Areas	Mean (mm)	Silt (%)	Volume Available (1,000 c.y.)	Overfill[1] Factor
Native Beach - Captiva	0.43	1.5		1.00
Site I (Eastern Offshore)	0.29	16.6	6,870	1.78
Site II (Middle Offshore)	0.19	9.0	1,970	3.50
Site III (Western Offshore)	0.37	3.5	1,900	1.26
Site IV-A (RFP Ebb Shoal)	0.20	6.6	1,300	3.17
Site IV-B (RFP (Ebb Shoal)	0.36	3.6	100	1.28
Site V (RFP Flood Shoal)	0.31	13.5	1,000	1.61
Site V (RFP Flood Shoal)	0.49	3.5	350	1.00

(1) Overfill factor reflects the additional fill required to compensate for slope adjustment and higher erosion rates due to grain size differences.
(2) All percent values are by weight.

The ebb shoal of Redfish Pass has been depleted of 2.25 million cubic yards of material and has an estimated 1.4 million cubic yards of suitable material remaining in borrow areas IV A (1,300,000 c.y.) and IV B (100,000 c.y.). Neither site is suitable (cost or quantity) to support current nourish requirements on Captiva Island, but could be considered to implement smaller portions of the Inlet Management Plan. The ebb shoal is growing at a rate of 28,000 cubic

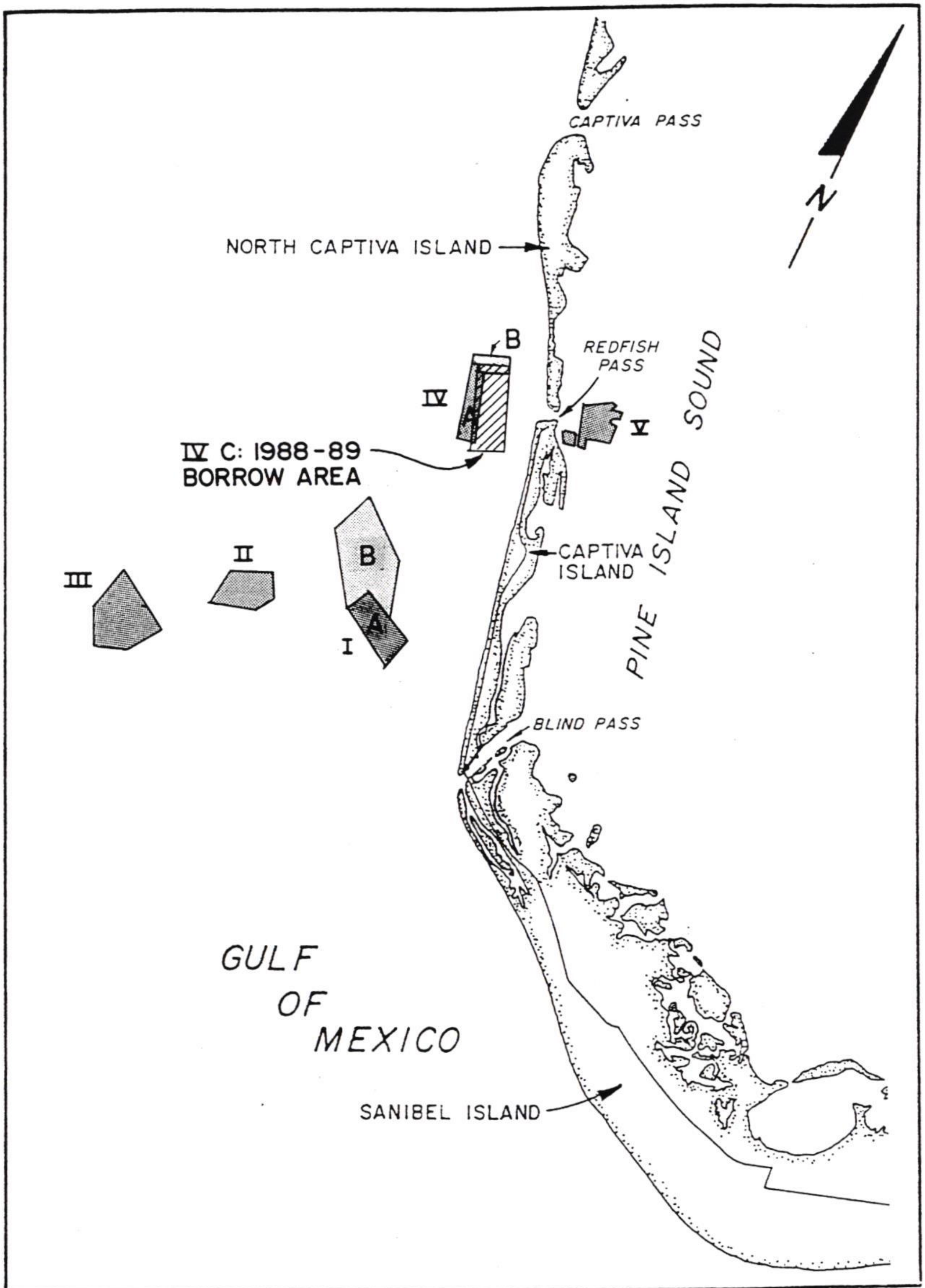


FIGURE 31

CAPTIVA ISLAND

PHASE II SAND SEARCH POTENTIAL BORROW AREAS

COASTAL PLANNING & ENGINEERING, INC. • BOCA RATON • SARASOTA • JACKSONVILLE

yards/year (1961-1991) and it will be a decade before significant suitable material is impounded to support a larger project.

Approximately 1,000,000 cubic yards have been identified within the flood shoals inside Redfish Pass. There is concern that this material has significant coverage of seagrass, high silt content and provides feeding areas for aquatic life. Limiting dredging on the flood shoal to 3.5 feet will improve the quality of sand, increasing grain size and decreasing silt content, but quantity would be limited to 350,000 cubic yards. Since the amount of sand in this flood shoal is limited, and because of the potential environmental problems, the flood shoal sand is not identified as a viable sand source for the next nourishment project. If continued shoaling occurs within the inlet, some limited dredging might be approved to supplement an alternate source in support of beach nourishment or aspects of the inlet management plan.

The Redfish Pass flood shoal is located in an aquatic preserve. For a project which significantly degrades water quality or is within Outstanding Florida Waters, permits must provide reasonable assurance that the project is clearly in the public interest. Permitting dredge and fill operations in an aquatic preserve would be similar if not more stringent. Permitting flood shoal use would be difficult.

Inland sand sources are available which can be used by trucking sand across the causeway. High quality beach nourishment sand is located at Ortona. This borrow pit mines coarse grained sand with low silt quantities. Sand from this pit has been used by the Lee County Department of Transportation during periods of high erosion on Captiva Island to protect portions of the road there. The cost of this material is high, from $15 to $20 per cubic yard in place. It may not represent an economically viable borrow source for that reason.

Four engineering studies of potential borrow sources have been completed by Coastal Planning & Engineering, Inc. between 1990 and 1993. These borrow source studies provide a detailed analysis of the suitability and availability of sand to support the 1996 Captiva Island maintenance nourishment project and elements of the inlet management plan. Borrow sites offshore of North Captiva Island and in the vicinity of Captiva Pass hold high potential for future projects and the Redfish Pass shoals will eventually trap sufficient suitable material to again become a viable source.

The small quantities of good sand available in the Redfish Pass ebb and flood shoals must be considered for small quantity needs in support of Inlet Management Plan options. Cost in alternatives where small quantities of sand are needed, assumed that material would be provided from these nearby sources in the shoals. In particular, the following alternatives requiring 100,000 cubic yards or less should look to the shoals for material: A, B-7, B-8, and B-10.

Composite grain size distributions for Captiva Island native beach, Site I and the ebb shoal (Site IV) borrow areas are shown in Figure 32. These curves were developed from investigations conducted by the Corps of Engineers (1969), Tetra-Tech, Inc. (1979), and reflect pre-nourishment conditions. Additional geotechnical information is provided in Appendix F.

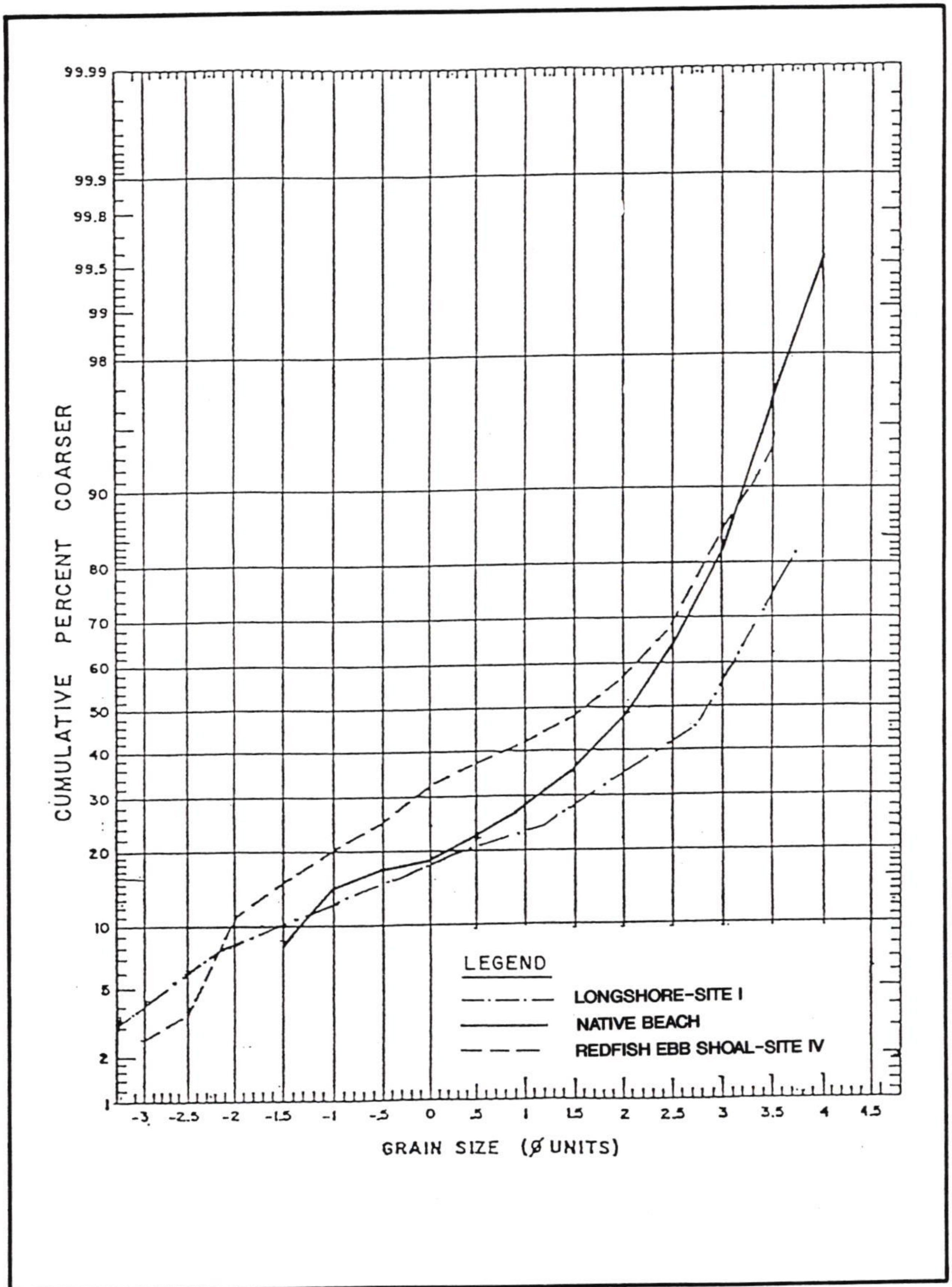


FIGURE 32

COMPOSITE GRAIN SIZE DISTRIBUTION

VI. REFRACTION AND SEDIMENT TRANSPORT ANALYSIS

A refraction and sediment transport study was conducted to evaluate the impact of inlet dredging on adjacent shorelines. The Redfish Pass ebb shoal was dredged in 1988 and 1989 in support of the Captiva Island nourishment project. Dredging removed 1,595,000 c.y. of sand. Property owners and regulators are concerned that the dredging may have intensified erosion on the adjacent shorelines. The results of the refraction analysis show that dredging of the inlet had negligible impact on North Captiva Island and was actually beneficial to Northern Captiva Island. The results of this analysis were used to finalize the sediment budget.

The results of the analysis are presented in Figure 33. The figure shows the longshore transport (LST) patterns at the inlet before and after the 1988/89 dredging of the inlet. The pre-dredge conditions are based on a 1988 inlet bathymetry and the post-dredging conditions are abased on a 1992 bathymetry. The curves represent the relationship between net-longshore transport potential and distance from the inlet centerline. The results were linearized to clarify the long term transport patterns at the inlet. The curves were linearized with a regression line or average value through each distinct region. The unlinearized curves are very uneven and reflect the transitory variations in the offshore bathymetry and the shoreline, which change daily under wave and current actions. The unlinearized results and a complete discussion of the analysis technique are discussed in Appendix G.

The wave refraction results were used to calculate potential longshore energy flux in the surf zone (PLS). Longshore transport rates were determined by comparing PLS values to the sediment budget at selected points. This analysis shows that a -40 ft-lb/sec/ft corresponds to approximately 20,000 c.y./yr. in net longshore transport to the south. Both PLS and LST are listed on Figure 33. The analysis does not quantify on or offshore sand transport, or sand transport due to tidal currents.

The longshore transport curve can be divided into two regions, the region within and outside the direct influence of the inlet. On North Captiva Island the inlet's influence extends to the invert of the curve, or approximately 2800 feet north of the inlet. The curve shows an increasing net southern littoral drift between range 5000 and 2800, followed by a region of decreasing net longshore drift between range 2800 and the inlet. The results show that there is virtually no difference in the transport pattern before and after dredging. The curve for NCI is unusual and warrants a further explanation. The region of decreasing littoral drift between range 2600 and the inlet is caused by the shape of the ebb shoal. The pre-1988 inlet gorge allowed relatively large southwest waves to reach this region, while the north lobe of the ebb shoal diminishes northwest wave forces. This combination leads to a decrease in net southern littoral drift as the inlet is approached, which is a benefit to southern North Captiva. In essence, southwest waves hold sand on the beaches.

In the region between range 2800 and 5000 north of the inlet, longshore transport is increasing from a near zero value at range 5000 to a peak value of 35,000 c.y./yr. at range 2600. This is a region where constant longshore drift would be expected. This phenomena is caused by an

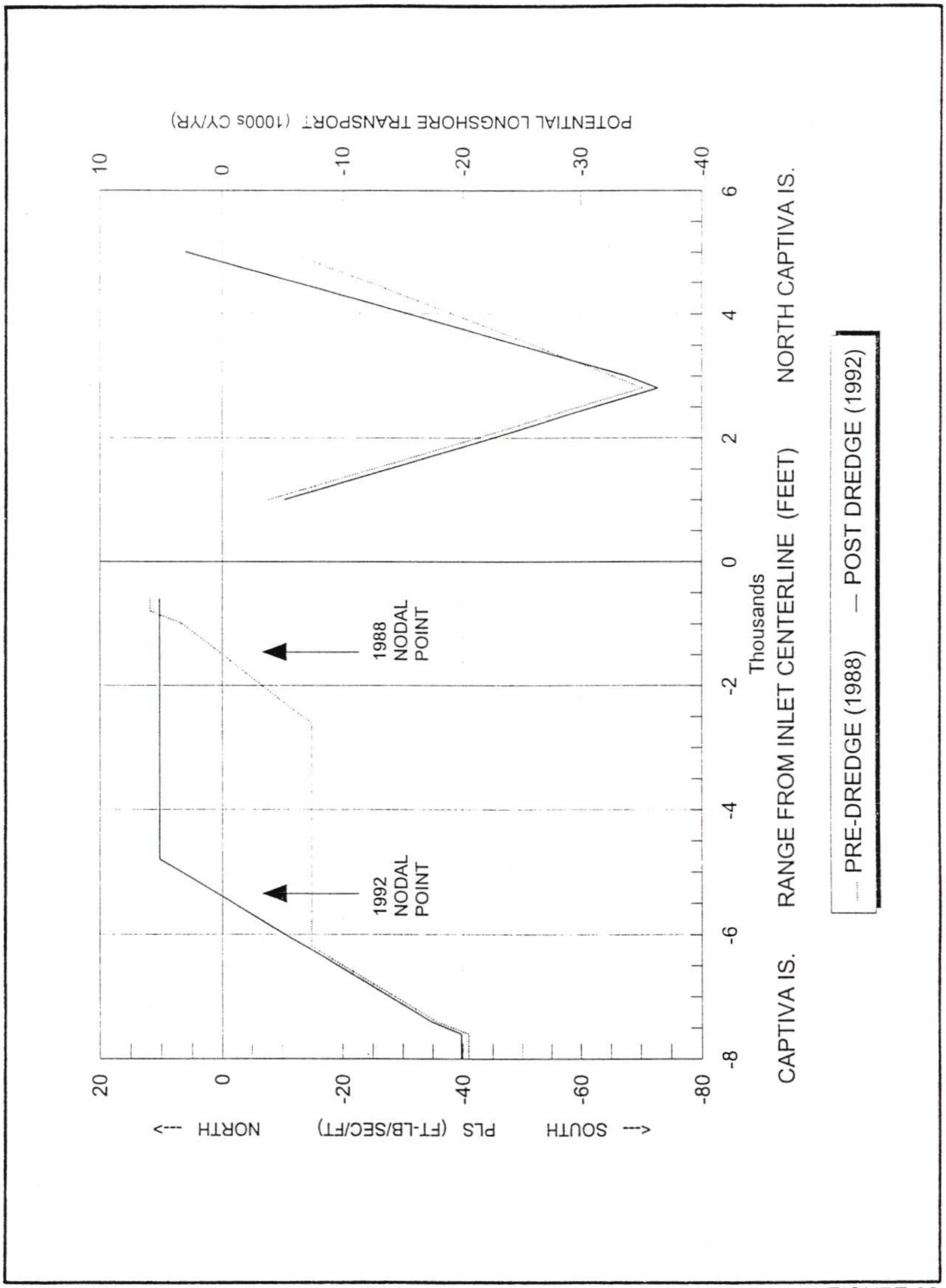


FIGURE 33

LINEARIZED LONGSHORE TRANSPORT
REDFISH PASS, FLORIDA

offshore feature located approximately one mile north of the inlet. The analysis shows that the net southern longshore transport on North Captiva decreased by 11% after dredging occurred.

South of the inlet, the longshore transport patterns have changed significantly. The inlet's influence extends approximately 7600 feet south of the inlet center line, where the longshore transport curve flattens out. Between range -8000 and -6200 the before and after dredging transport curves are similar.

The most striking difference is the location of the nodal point, where the longshore drift divides. Sand moves towards the inlet north of the nodal point and to the south beyond the nodal point. In 1988, the nodal point was located approximately 1600 feet south of the inlet centerline. In 1992, the nodal point moved to a point approximately 5400 feet south of the inlet. The change in the nodal point is due to the shape of the 1988 borrow area, which extended south of the inlet (see figure G-2).

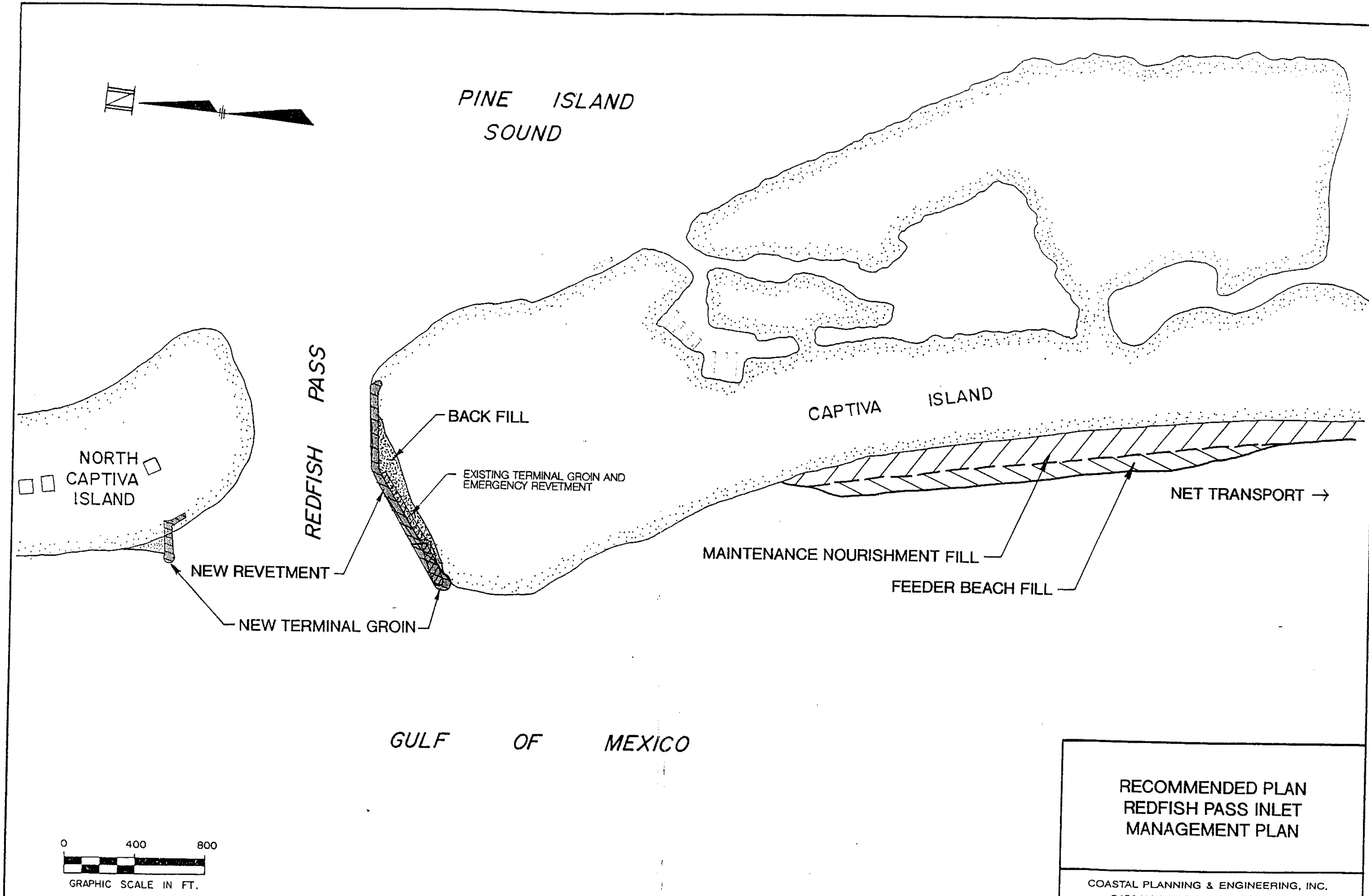
The change in nodal point has been beneficial to Captiva Island by moderating erosion along the northern 8000 feet of shoreline, as demonstrated by a decrease in average net southern longshore transport by 87%. This region has one of the lowest erosion rates on Captiva Island based on the most recent monitoring studies (CPE, Dec. 1994).

The 1988 inlet dredging has changed the patterns of sand transport near the inlet, but has not created adverse erosion conditions on the adjacent shorelines. The sediment transport study shows that inlet influences extend 2800 feet north of the inlet and 7600 feet to the south, with the nodal point located 5400 feet south of the inlet. The 1988 inlet dredging has had a negligible impact on North Captiva Island and has been beneficial to the northern mile of Captiva Island.

VII. COMPREHENSIVE INLET MANAGEMENT PLAN

The recommended plan for Redfish Pass inlet management is a comprehensive plan addressing storm protection, erosion control, sand bypassing, inlet stabilization and (to a lesser extent) navigation. The plan is a composite of alternatives B1, B-5, B-10 and B14, designed to meet physical requirements and local desires. The recommended plan (Figure 34) consists of a feeder beach to be placed on northern Captiva to increase sand bypassing. The feeder beach will consist of 256,000 cubic yards every 8 years, in conjunction with the Captiva Island nourishment program. The terminal groin will be upgraded to provide erosion control on the gulf beaches, anchor the inlet channel and provide storm protection. A 1050-foot revetment will be constructed along the south interior shoreline of Redfish Pass (R-83 to R-84) to provide storm protection, erosion control and further stabilize the inlet from a southward migration. A terminal groin will be constructed north of the inlet to provide erosion control.

A more detailed explanation of the individual components of the plan follows:



RECOMMENDED PLAN
REDFISH PASS INLET
MANAGEMENT PLAN

COASTAL PLANNING & ENGINEERING, INC.
2481 N.W. BOCA RATON BOULEVARD,
BOCA RATON, FL 33431

FIGURE 34

A. Storm Protection Element

A revetment or like structure will be constructed along 1050 feet of the Redfish Pass interior shoreline (Figure 32) in 1997 to provide protection to upland property. The storm protection element will also upgrade the terminal groin built by South Seas Plantation in 1977 and 1981. This action will create a durable structure to control losses from the gulf shores beach, thus improving storm protection. Municipal facilities will be protected by the structures.

B. Mitigation for Past Inlet Improvement Effects

There is no mitigation as part of this plan other than a secondary benefit of the sand bypassing element.

C. Sand Bypassing Element

To increase sand bypassing from North Captiva to Captiva Island, a feeder beach will be placed near the northern end of Captiva Island which will increase sand bypassing around the inlet. This feeder beach is intended to mitigate future potential impacts of the inlet system to the south beaches. The feeder beach would be placed every eight years as part of the Captiva Island nourishment program. The feeder beach would consist of 32,000 cubic yards per year, or 256,000 cubic yards in 1996 and 256,000 cubic yards every eight years thereafter. This material quantity will be deducted from the maintenance nourishment program.

D. Erosion Control Element

Erosion at the interior shoreline (R83 to R84) has been 31,600 cubic yards between 1986 and 1992. The 1050 foot long revetment will prevent erosion along the interior shoreline, and the new terminal groin will control erosion on the gulf side beaches (south of R84).

E. Navigation and Flushing Element

Part of the navigation and flushing element is to upgrade the terminal groin. This will provide a structure able to withstand direct wave forces and strong currents. The groin will anchor the pass against southward migration and promote a natural navigation channel. Benefits to navigation and flushing elements of the plan are minimal. The inlet should be monitored for changes which may call for increased efforts in support of navigation and flushing.

F. Stabilization of Inlet Migration

There are indications that the main inlet channel has begun a southern migration near the site of the terminal groin. The combined new terminal groin and revetment system will stabilize the south interior shoreline of Redfish Pass and prevent any tendency of the inlet to migrate south.

G. Environmental Elements

The recommended plan will enhance upland areas of northern Captiva Island. Feeder beach sand and the end loss prevention of the new terminal groin will provide better protection to the upland areas. The plan also foregoes dredging in the flood shoal, maintaining the environmental quality of this feature.

H. Cost Estimates

Table 22 shows the projected costs of the inlet management plan over a 50-year project life at an interest rate of 3%. Implementation of the plan is tentatively scheduled over a three year period. In 1996, the feeder beach will be constructed concurrently with the nourishment of Captiva Island. The feeder beach will cost $2,191,300.

In 1997, the groin and revetment can be constructed along the south interior shoreline of Redfish Pass, at a cost of $2,562,000. In 1998, North Captiva can build a terminal groin at a cost of $1,037,500.

Periodic maintenance of the feeder beach and structures will be required. Table 22 reflects renourishment of the feeder beach every eight years and maintenance of the structures every 20 years.

I. Implementation Schedule

A three year implementation schedule is proposed. The feeder beach will be constructed concurrently with the 1996 Captiva Island nourishment project. Planning and permitting is well underway for the nourishment project.

The structural components of the inlet management plan are still in the planning phase. Design and permitting activities have not yet begun. If severe erosion persists on the inlet frontage, the new groin and revetment should be constructed in the near future. The schedule proposes a 1997 construction date. On North Captiva Island, the planning for a terminal groin is still in the conceptual stage. If severe erosion persists, the North Captiva groin should be built in 1998. Funding requests to State and Federal agencies have been submitted for the feeder beach and structures on the south side of Redfish Pass. The County and the residents of North Captiva Island should initiate detailed planning for the terminal groin north of Redfish Pass.

The recommended structural protection for the interior shoreline need not be implemented all at once. A low-risk interim solution is feasible. An 800 foot revetment or steel sheet pile seawall along the most critically eroded section will provide interim erosion control and storm protection. Delaying full implementation of the new terminal

TABLE 22
REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING COST ESTIMATE

RECOMMENDED PLAN:
CAPTIVA: FEEDER BEACH, NEW TERMINAL GROIN & REVETMENT
NORTH CAPTIVA: TERMINAL GROIN

CONTINGENCY	15%	FEEDER BEACH:	$2,104,960
E&D&S&A	10%	S. TERMINAL GROIN (300 LF) & REVETMENT (1050 LF)	$2,562,046
		N. TERMINAL GROIN (250 LF)	$1,037,543
		SOUTH STR. MAINT @ 20 YR	$421,630
		NORHT STR. MAINT @ 20 YR	$304,865

YEAR	FUTURE WORTH	WORTH FACTOR	PRESENT WORTH	VOLUME (CY)	NOTE:
1996	$2,104,960	1.00000	$2,104,960	256,000	FEEDER BEACH
1997	$2,562,046	0.97087	$2,487,423	10,000	S. STRUCTURES
1998	$1,037,543	0.94260	$977,984		N.STRUCTURES
1999	$0	0.91514	$0	0	
2000	$0	0.88849	$0	0	
2001	$0	0.86261	$0	0	
2002	$0	0.83748	$0	0	
2003	$0	0.81309	$0	0	
2004	$2,104,960	0.78941	$1,661,675	256,000	FEEDER BEACH
2005	$0	0.76642	$0	0	
2006	$0	0.74409	$0	0	
2007	$0	0.72242	$0	0	
2008	$0	0.70138	$0	0	
2009	$0	0.68095	$0	0	
2010	$0	0.66112	$0	0	
2011	$0	0.64186	$0	0	
2012	$2,104,960	0.62317	$1,311,741	256,000	FEEDER BEACH
2013	$0	0.60502	$0	0	
2014	$0	0.58739	$0	0	
2015	$0	0.57029	$0	0	
2016	$0	0.55368	$0	0	
2017	$421,630	0.53755	$226,647	0	S. STRUCTURE MAINT.
2018	$304,865	0.52189	$159,107	0	N. STRUCTURE MAINT.
2019	$0	0.50669	$0	0	
2020	$2,104,960	0.49193	$1,035,501	256,000	FEEDER BEACH
2021	$0	0.49193	$0	0	
2022	$0	0.46369	$0	0	
2023	$0	0.45019	$0	0	
2024	$0	0.43708	$0	0	
2025	$0	0.42435	$0	0	
2026	$0	0.41199	$0	0	
2027	$0	0.39999	$0	0	
2028	$2,104,960	0.38834	$817,434	256,000	FEEDER BEACH
2029	$0	0.37703	$0	0	
2030	$0	0.36604	$0	0	
2031	$0	0.35538	$0	0	
2032	$0	0.34503	$0	0	
2033	$0	0.33498	$0	0	
2034	$0	0.32523	$0	0	
2035	$0	0.31575	$0	0	
2036	$2,104,960	0.30656	$645,290	256,000	FEEDER BEACH
2037	$421,630	0.29763	$125,489	0	S. STRUCTURE MAINT.
2038	$304,865	0.28896	$88,094	0	N. STRUCTURE MAINT.
2039	$0	0.28054	$0	0	
2040	$0	0.27237	$0	0	
2041	$0	0.26444	$0	0	
2042	$0	0.25674	$0	0	
2043	$0	0.24926	$0	0	
2044	$2,104,960	0.24200	$509,398	256,000	FEEDER BEACH
2045	$0	0.23495	$0	0	

SUM OF PRESENT WORTHS	$12,150,742
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$472,245

groin and revetment system will allow monitoring of evolving coastal processes and delay full implementation cost. There is a chance that the interior shoreline will recover after the next nourishment project. The interim solution does not eliminate the need for the full recommended plan. The new terminal groin and revetment system is the only solution that has a high assurance of long-term success.

J. Preliminary Assessment of the Recommended Plan

The Florida Department of Natural Resources conducted a preliminary review of the Redfish Pass recommended plan (Clarke, July 1992). They reviewed the plan for permittability, fundability and appropriateness as part of the plan. The feeder beach and terminal groin would most likely be justified as part of the final inlet management plan. The revetment would be more problematic. As a coastal protection structure, the revetment would be a private benefit and not eligible for state funding. If the revetment is proposed to protect against inlet migration, it may be justified. Since this preliminary assessment by DNR, clear evidence has come to light showing the inlet is migrating south. Profile surveys enclosed in Appendix B show the main inlet channel has moved south between 1986 and 1992. The DNR review stated that if a revetment were justified, its final configuration and type may need further refinement.

In November 1994, a meeting was held at the DEP office in Tallahassee to re-assess the preliminary findings of the agency. The conclusions of the meeting summarized in a letter by Mr. Thomas J. Campbell (Nov. 18, 1994) are as follows:

a. A **feeder beach** on Captiva Island is proposed to mitigate the effects of Redfish Pass on Captiva Island; the cost of fill for the feeder beach should qualify for State funding.

b. There appeared to be sufficient justification for rebuilding the **terminal groin** at the north end of **Captiva Island** and for **reveting** the inlet shoreline to protect the drain field for the municipal wastewater system there. The terminal groin currently protects the beach fill project and would be reconstructed in place, in a more substantial fashion.

c. **A terminal groin** would be recommended on the north shore of Redfish Pass on **North Captiva Island** to pin the shoreline there and to help reduce the high levels of erosion that are occurring on the beachfront properties. The North Captiva terminal groin would be a conceptual part of the plan which could be implemented by the County or some other local sponsor but would not be specifically proposed by the Captiva Erosion Prevention District.

VII. FUNDING/GOVERNMENTAL ANALYSIS

Governmental Analysis

The purpose of this section is to establish sponsorship and funding of the inlet management plan. The implementation of the inlet management plan will be undertaken by a local sponsor(s) with funding assistance from the State of Florida. Since no one government agency has total responsibility for Redfish Pass it may be appropriate to share the duties of the local sponsor between the following local governments:

A. Lee County
B. Captiva Erosion Prevention District (CEPD)
C. West Coast Inland Navigation District (WCIND)
D. South Seas Plantation
E. North Captiva Island

While each government may participate financially in the plan, it would be appropriate for one government to take the lead in the administration of the program. Each government agency has a vested interest in seeing inlet improvements as follows:

A. Lee County - The County is responsible for coastal management countywide and is interested in maintaining the passes and bays. The County should provide the local funding for the sand bypassing, navigation and flushing, environmental and public use element when and if they are developed. They should represent the interests of property owners on south North Captiva Island, and provide the government framework needed to implement the North Captiva Island portion of the inlet management plan.

B. CEPD - The CEPD is responsible for erosion control on Captiva Island. In 1988-89 an erosion control project was constructed which restored the beach and extended a terminal groin near Blind Pass. CEPD should take the lead role in implementation of the Inlet Management Plan on Captiva Island to include managing portions of the plan affecting South Seas Plantation. CEPD will not implement any portion of the plan outside the limits of Captiva Island.

C. WCIND - The WCIND is responsible for navigation and boating in Lee, Charlotte, Sarasota and Manatee Counties. The WCIND collects taxes in the four county area for use by navigation and marine-related public projects. The WCIND should participate in the navigation and flushing elements, when and if they are developed.

D. South Seas Plantation - The 1981 nourishment program and the construction of the terminal groin at Redfish Pass were implemented in support of the needs of South Seas Plantation. South Seas Plantation should look to CEPD to represent their interest for implementation of the Inlet Management Plan.

E. North Captiva Island - The residents on southern North Captiva Island are in the unincorporated region of Lee County. The residents should take the lead in implementing their portion of the inlet management plan with the assistance of Lee County.

Table 23 shows a schedule of costs, broken down by element, for the inlet management plan implementation. Table 24 shows the estimated percentage of funding to be provided by the various governments that will share in the costs of the program. DNR could provide up to 75% for qualifying project elements. The local government shares are based on the benefits and responsibilities of the governments as described previously. Table 25 presents the levels of funding to be provided by each government for implementation of the inlet management plan. These cost sharing figures are estimates. Costs are dependent on each agency's final approval.

Elements of the Inlet Management Plan may be eligible for Federal cost sharing as part of the approved beach erosion control project. Qualification for Federal cost sharing may require reformulation of the authorized Federal plan. The level of Federal cost sharing will be dependent on current Federal regulations and analysis by the Corps of Engineers.

TABLE 23
SUMMARY OF COSTS FOR THE INLET MANAGEMENT PLAN

	1996	1997/98	1998	2004	TOTAL
INLET MANAGEMENT PLAN					
A. STORM PROTECTION AND EROSION CONTROL ELEMENT					
1. S. REVETMENT & NEW GROIN	0	$2,562,046	$0	$0	$2,562,046
2. NORTH TERMINAL GROIN	$0	0	$1,037,543	0	$1,037,543
B. SAND BY PASSING ELEMENT	$2,104,960	$0	$0	$2,104,960	$4,209,920
FEEDER BEACH			$0		
C. NAVIGATION ELEMENT	$0	$0	$0	$0	$0
D. ENVIRONMENTAL ELEMENT	$0	$0	$0	$0	$0
CAPTIVA ISLAND NOURISHMENT	$5,795,040	$0	$0	$5,795,040	$11,590,080
TOTAL COST	$7,900,000	$2,562,046	$1,037,543	$7,900,000	$19,399,589

TABLE 24
FUNDING LEVELS FOR SPONSORS
REDFISH PASS INLET MANAGEMENT PLAN

	STATE	LEE COUNTY	CEPD	WCIND	N. CAPTIVA & COUNTY	FEDERAL
INLET MANAGEMENT PLAN						
A. STORM PROTECTION AND EROSION CONTROL ELEMENT						
1. S. REVETMENT & NEW GROIN	75.0%	0.0%	25.0%	0.0%	0.0%	0.0%
2. NORTH TERMINAL GROIN	75.0%	0.0%	0.0%	0.0%	25.0%	0.0%
B. SAND BY PASSING ELEMENT FEEDER BEACH	63.7%	5.3%	16.0%	0.0%	0.0%	15.1%
C. NAVIGATION ELEMENT	75.0%	0.0%	0.0%	25.0%	0.0%	0.0%
D. ENVIRONMENTAL ELEMENT	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
CAPTIVA ISLAND NOURISHMENT	19.1%	13.2%	40.0%	0.0%	0.0%	27.7%

NOTE: ESTIMATED PERCENTAGES BY ELEMENT SUBJECT TO CHANGE BY AGENCY

TABLE 25
COST SHARING ESTIMATE TO IMPLEMENT PROJECT 1996-1998
JETTY AND REVETMENT CONSTRUCTION

	STATE	COUNTY	CEPD**	WCIND	N. CAPTIVA & COUNTY	FEDERAL
INLET MANAGEMENT PLAN						
A. STORM PROTECTION AND EROSION CONTROL ELEMENT						
1. S. REVETMENT & NEW GROIN	$1,921,535	$0	$640,512	$0	$0	$0
2. NORTH TERMINAL GROIN	$778,157	$0	$0	$0	$259,386	$0
B. SAND BY PASSING ELEMENT FEEDER BEACH	$1,341,105	$110,968	$336,068	$0	$0	$316,820
C. NAVIGATION ELEMENT	$0	$0	$0	$0	$0	$0
D. ENVIRONMENTAL ELEMENT	$0	$0	$0	$0	$0	$0
CAPTIVA ISLAND NOURISHMENT	$1,105,805	$765,257	$2,317,594	$0	$0	$1,606,385
SUB-TOTAL	$5,146,602	$876,224	$3,294,173	$0	$259,386	$1,923,205
TOTAL	$11,499,589					

**INCLUDES SOUTH SEAS PLANTATION

REFERENCES

Applied Environmental Services. "Environmental Monitoring Captiva (South Seas) Beach Restoration, Part I: Benthic Macroinvertebrate and Abiotic Monitoring, Special Report No. 1 On Borrow Sites Nine Months After Dredging." September 15, 1982.

Applied Environmental Services. "Environmental Monitoring Captiva (South Seas) Beach Restoration, Part I: Benthic Macroinvertebrate, Seagrass and Abiotic Monitoring, Interim Report No. 3 For the Three Month After Dredging Sampling Interval." March 15, 1982.

Applied Environmental Services. "Environmental Monitoring Captiva (South Seas) Beach Restoration, Part I: Benthic Macroinvertebrate, Seagrass and Abiotic Monitoring, Final Report." May 15, 1984.

Applied Environmental Services. "Environmental Monitoring Captiva (South Seas) Beach Restoration, Part I: Benthic Macroinvertebrate, Seagrass and Abiotic Monitoring, Interim Report No. 5 For the Nine Month After Dredging Sampling Interval." March 15, 1982.

Applied Environmental Services. "Environmental Monitoring Captiva (South Seas) Beach Restoration, Part I: Benthic Macroinvertebrate, Seagrass and Abiotic Monitoring, Interim Report No. 1 For the Predredge Sampling Interval."

Applied Environmental Services. "Environmental Monitoring Captiva (South Seas) Beach Restoration, Part I: Benthic Macroinvertebrate, Seagrass and Abiotic Monitoring, Interim Report No. 4 For the Six Month After Dredging Sampling Interval." June 15, 1982.

Applied Environmental Services. Environmental Monitoring Captiva (South Seas) Beach Restoration, Part I: Benthic Macroinvertebrate, Seagrass and Abiotic Monitoring, Interim Report No. 7 For the Fifteen Month After Dredging Interval." March 25, 1983.

Applied Environmental & Engineering Services. "Environmental Monitoring Captiva (South Seas) Beach Restoration, Part I: Benthic Macroinvertebrate, Seagrass and Abiotic Monitoring, Interim Report No. 8 For the Eighteen Month After Dredging Interval." June 25, 1983.

Applied Environmental Services. "The Rate of Recolonization of the Captiva (South Seas) Borrow and Fill Sites, Interim Report." December 16, 1981.

Applied Technology and Management, Inc. "Comprehensive Beach and Shore Preservation Plan," 1987.

Austin, R. J. *An Archaeological Site Inventory and Zone Management Plan for Lee County, Florida*. Piper Archaeological Research, Inc., November 1987.

Balsillie, J. H., Memorandum, subject "Redfish Pass IMP," Comments on CPE January 5, 1994 comment letter and November 1993 Draft IMP.

Beeler, I.E. and T. J. O'Shea, "Distribution and Mortality of the West Indian Manatee (*Trichechus manatus*) in the Southeastern United States: A Compilation and Review of Recent Information, Volume Two: The Gulf of Mexico Coast," U.S. Army Corps of Engineers, Jacksonville District, 1988, 613 pp.

Bodge, K. R., and E. J. Olsen. "Beach Management Plan for Lee County." Olsen Associates, Inc., Jacksonville, FL (for the Division of Beaches and Shores, Florida Department of Natural Resources, 1987.

Bowen, P.R., and G. A. Marsh. "Benthic Faunal Colonization of an Offshore Borrow Pit in Southeastern Florida." Miscellaneous Paper D-88-5, U.S. Army Corps of Engineers, Washington, D.C. October, 1988. 73 pp.

Campbell, Thomas J. Letter to Mr. Lonnie Ryder, DEP, subject Captiva Island State Funding for Redfish Pass Inlet Management Plan, November 18, 1994.

Clarke, Ralph, Florida Department of Natural Resources. Memorandum Subject" CPE Letter of July 14, 1992, Redfish Pass Preliminary Recommendations." July 22, 1992.

Coastal Engineering Consultants, Inc. "Report of Terminal Groin Construction at Redfish Pass," September 1977.

Coastal Planning & Engineering, Inc. "Captiva Island Beach Monitoring Study." June 1985.

Coastal Planning & Engineering, Inc. "Captiva Island Beach Monitoring Study." October 1985.

Coastal Planning & Engineering, Inc. "Third Captiva Island Beach Monitoring Study Report, September 1985 through March 1986," (with annual summaries). April 1986.

Coastal Planning & Engineering, Inc. "Fourth Captiva Island Beach Monitoring Study Report, March 1986 through September 1986" (with seventeen-month summaries). September 1986.

Coastal Planning & Engineering, Inc. "Lee County, Florida, Beach Erosion Control Project, Captiva Island Segment, General & Detailed Design Memorandum." July 1989.

Coastal Planning & Engineering, Inc. "Captiva Island Beach Nourishment Project Phase I Sand Search Report." June 1990.

Coastal Planning & Engineering, Inc. "Captiva Island Beach Nourishment Project Phase II Sand Search Report." April 1991.

Coastal Planning & Engineering, Inc. "Captiva Island Beach Nourishment Project Phase II Sand Search Report, Addendum I." 1992.

Coastal Planning & Engineering, Inc. "Captiva Island Beach Nourishment Project Phase III Sand Search Report," 1993.

Coastal Planning & Engineering, Inc. "Blind Pass Inlet Management Plan (Draft Report)." March 1992.

Coastal Planning & Engineering, Inc. "Captiva Island Beach Monitoring Study 36 Month Follow-Up Report." June 1992.

Coastal Technology Corporation. "Conceptual Engineering Report - Erosion Control Alternatives for North Captiva Island, Lee County, Florida." June 1989.

Continental Shelf Associates, Inc. "Lee County Beach Management Plan Environmental Analysis." March 30, 1987.

Continental Shelf Associates, Inc. "Pre-Construction Benthic Monitoring Report, Captiva Beach Restoration Plan." March 21, 1988.

J. N. "Ding" Darling National Wildlife Refuge - Mammal List. 1 pg.

Davis, Richard A. "Management of Drumstick Barrier Islands." *Proceedings of Sixth Symposium on Coastal and Ocean Management*, ASCE, July, 1989.

Davis, Richard A. and James C. Gibeaut. *Historical Morphodynamics of Inlets in Florida, Models for Coastal Zone Planning*, Florida Sea Grant, Technical Paper 55. 1990.

Dean, R.G. et. al. *Combined Total Storm Tide Frequency Analysis for Lee County, Florida*, Florida State University. July 1990.

Dormer, E. M. "The Sea Shell Islands," *A History of Sanibel and Captiva.* Tallahassee, FL, 1979.

Emerson, K.C., ed. Check-list of Birds for the Area of Sanibel, Captiva and Adjacent Islands. Published by Sanibel - Captiva Audubon Society, Sanibel - Captiva Conservation Foundation, and Ding Darling Wildlife Society. 1984. 2 pp.

Endangered Species Act of 1973. United States Code Title 16 - Conservation, Chapter 35 Endangered Species.

Escoffier, E. F., "Hydraulics and Stability of Tidal Inlets," *GITI Report 13*, U.S. Army Corps of Engineers Coastal Engineering Research Center. August 1977.

Florida Administrative Code 16B-41. Regulation of Coastal Construction Seaward of Mean High Water.

Florida Department of Natural Resources. "Lee County Coastal Construction Control Line." May 30, 1991.

Florida State Statute 370.12. Marine Animals; Regulation.

State of Florida, District IV, Department of Natural Resources, Division of Beaches and Shores. *Florida's Beach Restoration Management Plan for Beach Management Planning*. September 1987.

Florida Game and Fresh Water Fish Commission. Official Lists of Endangered and Potentially Endangered Fauna & Flora in Florida. 1 April 1991. D.A. Woods, compiler, 23 pg.

Foster, E.R., P.E., State of Florida, Department of Natural Resources, Division of Beaches and Shores, Bureau of Coastal Data Acquisition. *Northern Sanibel Shoreline Erosion Report*. April 4, 1991.

Foster, Emmett R. and Rebecca J. Savage. "Methods of Historical Shoreline Analysis," *Proceedings of Coastal Zone '89 ASCE*, Vol. 5. 1989.

Futch, C. R., Unpublished. State of Florida Program of Marine Turtle Research and Management. Florida Department of Natural Resources, Division of Marine Resources. Letter dated September 12, 1991. 7 pp.

Galvin, Cyril. "Simple Conceptual Explanation of Down-Drift Offset Inlets," (closure by S. L. Douglass), *Journal of Waterway, Port and Coastal and Ocean Engineering*, ASCE, New York. Vol. 118, No. 3. May/June 1992.

Godshalk, D. R., K. L. Erwin, A. C. Hine, R. B. Morgan and J. C. Nicholas. "Lee County Coastal Study, Appendix V, Support Documentation, Conservation and Coastal Management Element." Godshalk and Associates, Consultants, Chapel Hill, NC, 1988.

Hine, A.C., et. al. *Impact of Florida's Gulf Coast Inlets on the Coastal Sand Budget*. Final Report. University of South Florida, 1986.

Hobson, R.D., "Review of Design Elements for Beach-Fill Evaluation, TP No. 77-6," U.S. Army Corps of Engineers, CERC, Fort Belvoir, VA. 1977.

Hubertz, J. and R. Brooks. *Gulf of Mexico Hindcast Wave Information*, WIS Report 18, U.S. Army Waterways Experiment Station. May 1989.

Keulegan, G.H., "Tidal Flow in Entrances Water Level Fluctuations of Basins in Communications with Seas", Technical Bulletin No. 14 USACE, July 1967.

Leadon, M.E., P.E., Florida Division of Beaches and Shores, Bureau of Coastal Engineering & Regulation. *Assessment of the Terminal Groin Extension at Blind Pass on the Shoreline of North Sanibel Island*. April 8, 1991.

Lee County, Florida. "The Lee Plan," Section A, *Adopted Comprehensive Plan*. January 31, 1989.

LeBuff, Charles R., Jr. "Sea Turtle Conservation - Captiva Style," Caretta Research, Inc. 1990.

Lindblad, E. Sanibel-Captiva Conservation Foundation, personal communication. April 9, 1992.

Lindblad, E. Sanibel-Captiva Conservation Foundation, personal communication. March 13, 1995.

Morrill, S. and J. Harvey. *An Environmental Assessment of North Captiva Island*. New College Environmental Studies Program. Publication No. 23. 91 pp.

Mote Marine Laboratory. *Captiva Nearshore Fisheries Study*, First Progress Report. June 16, 1989.

Missimer, Thomas. *The Depositional History of Sanibel Island*, Thesis. University of Florida, 1973.

Nelson, W. G., "Physical and Biological Guidelines for Beach Restoration Projects. Part I, Biological Guidelines." Report No. 76. Florida Sea Grant College. 1985. 65 pp.

O'Brien, M. P. "Equilibrium Flow Areas of Tidal Inlets on Sandy Coasts," *Proceedings of the 10th Coastal Engineering Conference*, Tokyo, Vol. 1, Ch. 39, ASCE. 1966.

Olsen, E. J. "An Evaluation of Offshore Sand Sources at Captiva Island, Florida." Tetra Tech., Inc., Jacksonville, FL, 34 p. 1980.

Phillips, T.D. and J. M. Sprinkel, Mote Marine Laboratory, 1989.

Purpura, J.A. *Model Studies of Coastal Inlets with Special References to the Bakers Haulover Inlet Model Study*, University of Florida, April 1962.

Robbins, C.S., B. Bruun, and H.S. Zim. Birds of North America: A Guide to Field Identification. Golden Pres, New York, NY. 1983. 360 pg.

Saunders, L. H., "Environmental Impacts of Beach Nourishment in Florida." U.S. Army Corps of Engineers, Jacksonville, Florida. Unpublished.

Tackney & Associates, Inc. "Physical Monitoring Captiva Beach Restoration Project, Final Report (18 Months Monitoring)." August 1983.

Tetra Tech. "Geotechnical Exploration of Offshore Sand Sources at Captiva Island, Florida, Final Report." October 1980.

Tetra Tech. "Wave Refraction Analysis." November 1982.

Tetra Tech. "An Evaluation of Offshore Sand Sources at Captiva Island, Florida, Final Report." March 1980.

Tetra Tech. "Engineering Report for South Seas Plantation Beach Improvement Project," June 1979.

Tetra Tech. "Engineering Report for Captiva Erosion Prevention District Beach Nourishment Project," August 1981.

Turbeville, D. B. and G. A. Marsh, "Benthic Fauna of an Offshore Borrow Area in Broward County, Florida." Miscellaneous Report No. 82-1. U.S. Army Corps of Engineers, Ft. Belvoir, Virginia. January, 1982. 42 pp.

U. S. Army. "Beach Erosion Control Study on Lee County, Fla." U.S. Army, Corps of Engineers District, Jacksonville, FL, 1969.

U.S. Army Corps of Engineers. *Lee County, Florida Charlotte Harbor Section 933 Study*, July 1990 (Revised April 1991).

U.S. Army Corps of Engineers. "Joint Public Hearing on Captiva Erosion Prevention District Groin Construction," Captiva Island, Florida, June 3, 1976.

U.S. Army Corps of Engineers. *Shore Protection Manual*, Coastal Engineering Research Center, 1974.

University of Florida. *Recommended Coastal Setback Line for Lee County, Florida*, UFL/COEL-75/009, May 1975.

University of Florida. *Coastal Engineering Study of Captiva Island*. 1974.

University of Florida. *Coastal Engineering Investigations at Captiva Island*, Report No. 58/003. 1958.

Vincent, C.L. and W.D. Corson, "The Geometry of Selected U.S. Tidal Inlets", GITI Report #20, May 1980.

Walton, T.L. and W.D. Adams. *Capacity of Inlet Outer Bars to Store Sand*, 1976.

Walton, T.L. and R.G. Dean. "Use of Outer Bars of Inlet as Sources of Beach Nourishment Material," *Shore & Beach*. ASBPA. July 1976.

Walton, T. L. "Longshore transport Estimates Along the Coastline of Florida," Florida Sea Grant Report 13. 1976.

Winton, Brooks, Degner & Ruth. *Hydraulics and Geology Related to Beach Restoration in Lee County, Florida*. July 1981.

George F. Young, Inc. "Beach Monitoring Report, St. Petersburg, Florida," 1987.

George F. Young, Inc. *Lee County, Florida Department of Transportation & Engineering, Captiva Road Erosion Protection Report*. January 1988.

Aerial Photographs Reviewed for Redfish Pass Analysis

1. Captiva Island & Northern Sanibel Island (9 vertical views)
   April 9, 1991, Kucera South, Inc.

2. Captiva Island, Redfish Pass to Blind Pass (6 vertical views)
   December 13, 1990, Kucera South, Inc.

3. Blind Pass, Lee County, Florida (vertical)
   February 14, 1970. University of Florida Archives.

4. Blind Pass, Lee County, Florida (vertical)
   November 1, 1978. University of Florida Archives.

5. Redfish Pass, Lee County, Florida (vertical)
   February 17, 1944. University of Florida Archives.

6. Redfish Pass, Lee County, Florida (vertical)
   May 5, 1952. University of Florida Archives.

7. Redfish Pass, Lee County, Florida (vertical)
   October 21, 1958. University of Florida Archives.

8. Redfish Pass, Lee County, Florida (vertical)

November 22, 1960. University of Florida Archives.

9. Redfish Pass, Lee County, Florida (vertical)
May 31, 1969. University of Florida Archives.

10. Redfish Pass, Lee County, Florida (vertical)
February 14, 1970. University of Florida Archives.

11. Redfish Pass - Captiva Pass, Lee County, Florida (vertical)
September 27, 1976. University of Florida Archives

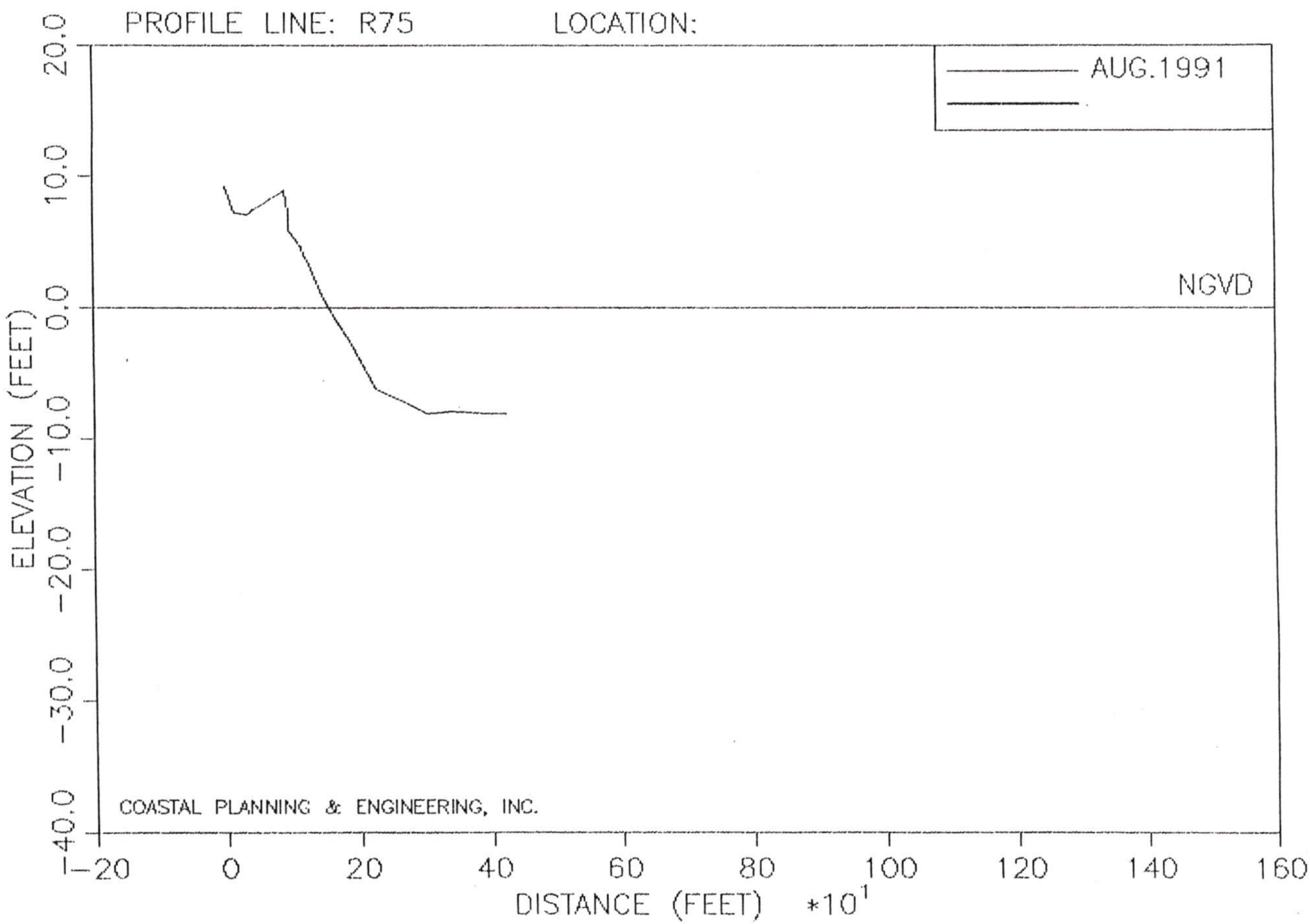
12. Captiva Island and Northern Sanibel Island (6 vertical views)
January 7, 1992. Kucera South, Inc.

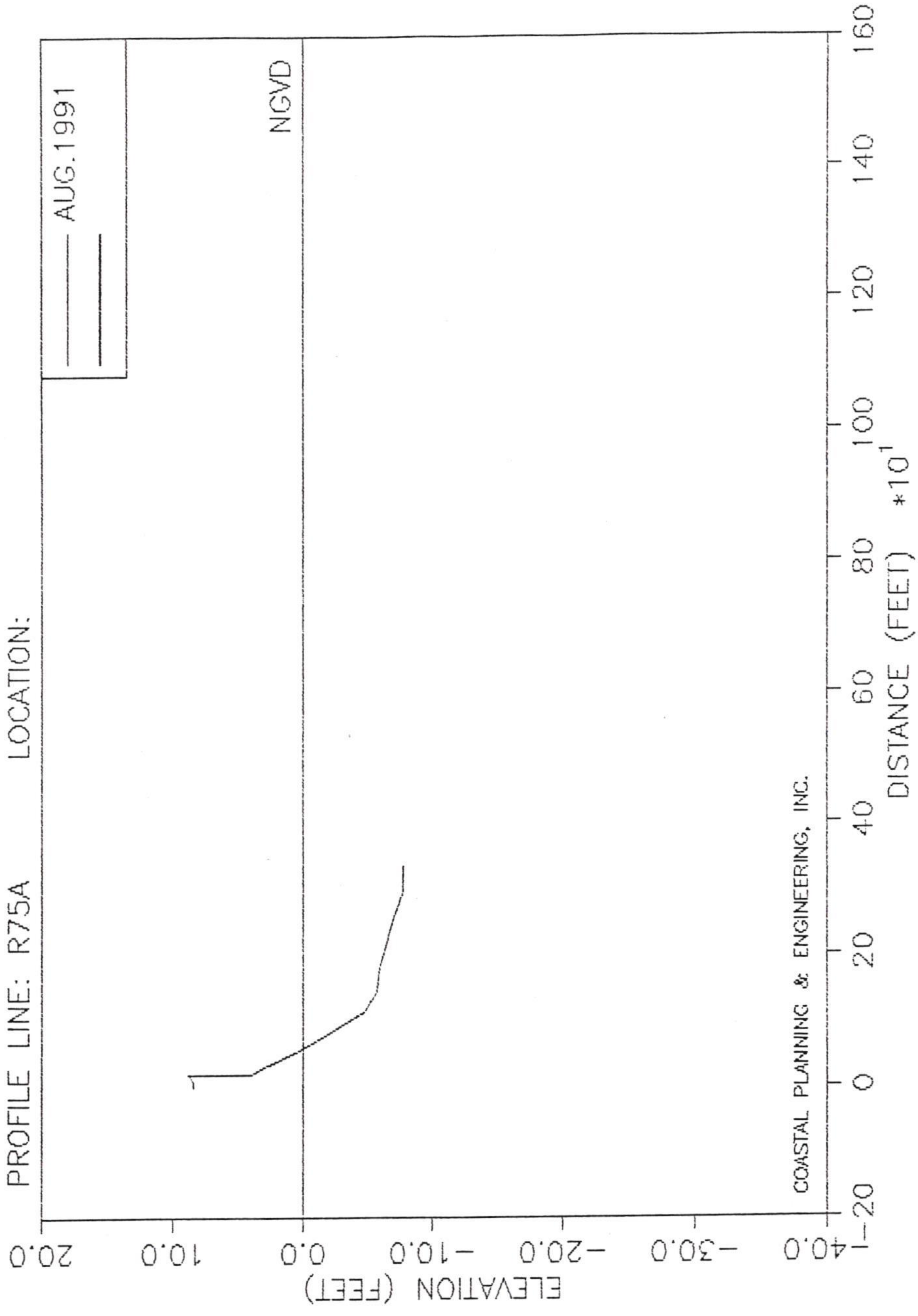
13. Captiva Island and Northern Sanibel Island (13 vertical views)
April 27, 1992. Kucera South, Inc.

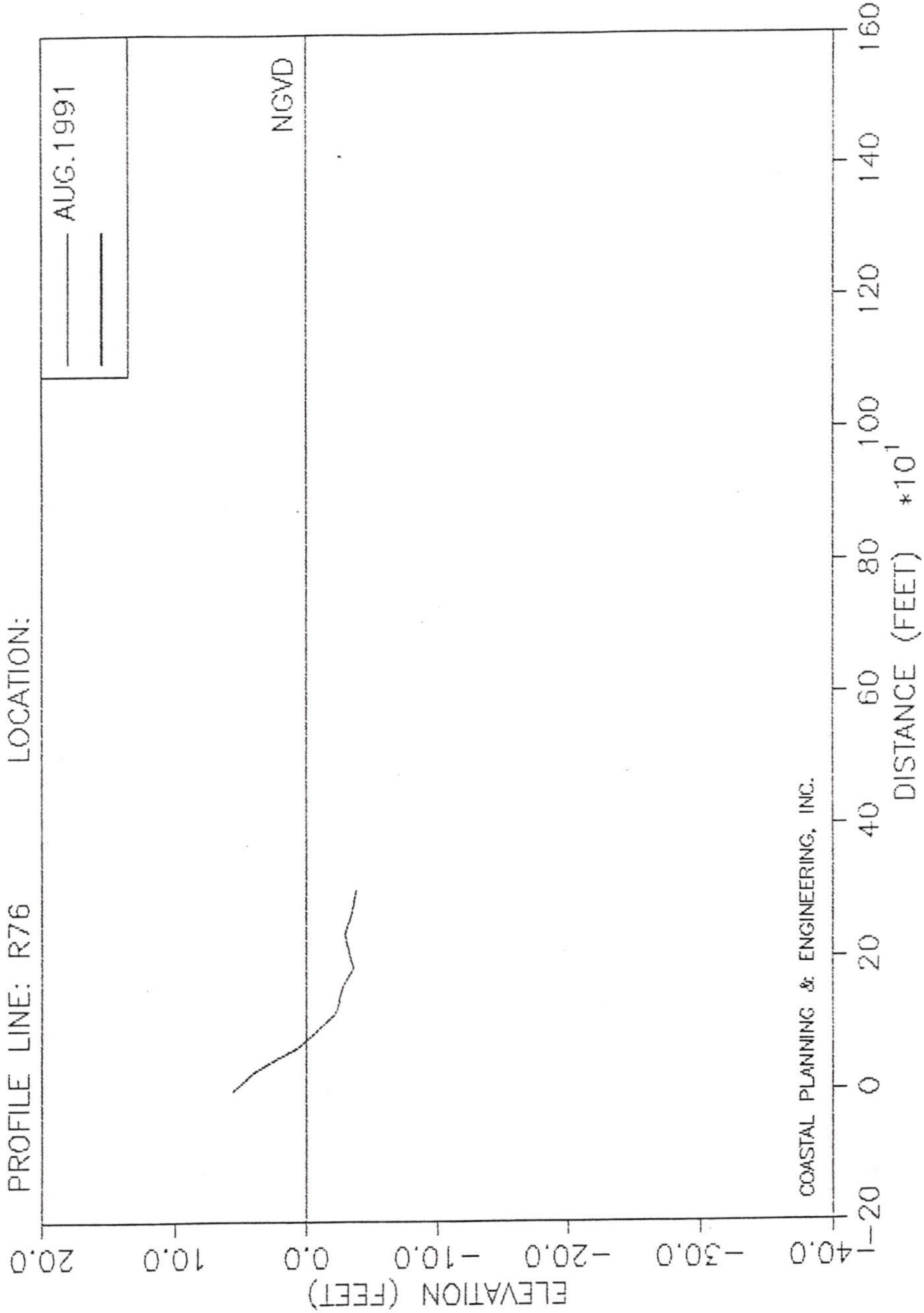
14. Redfish Pass, August 3, 1989 (vertical color).

APPENDIX A

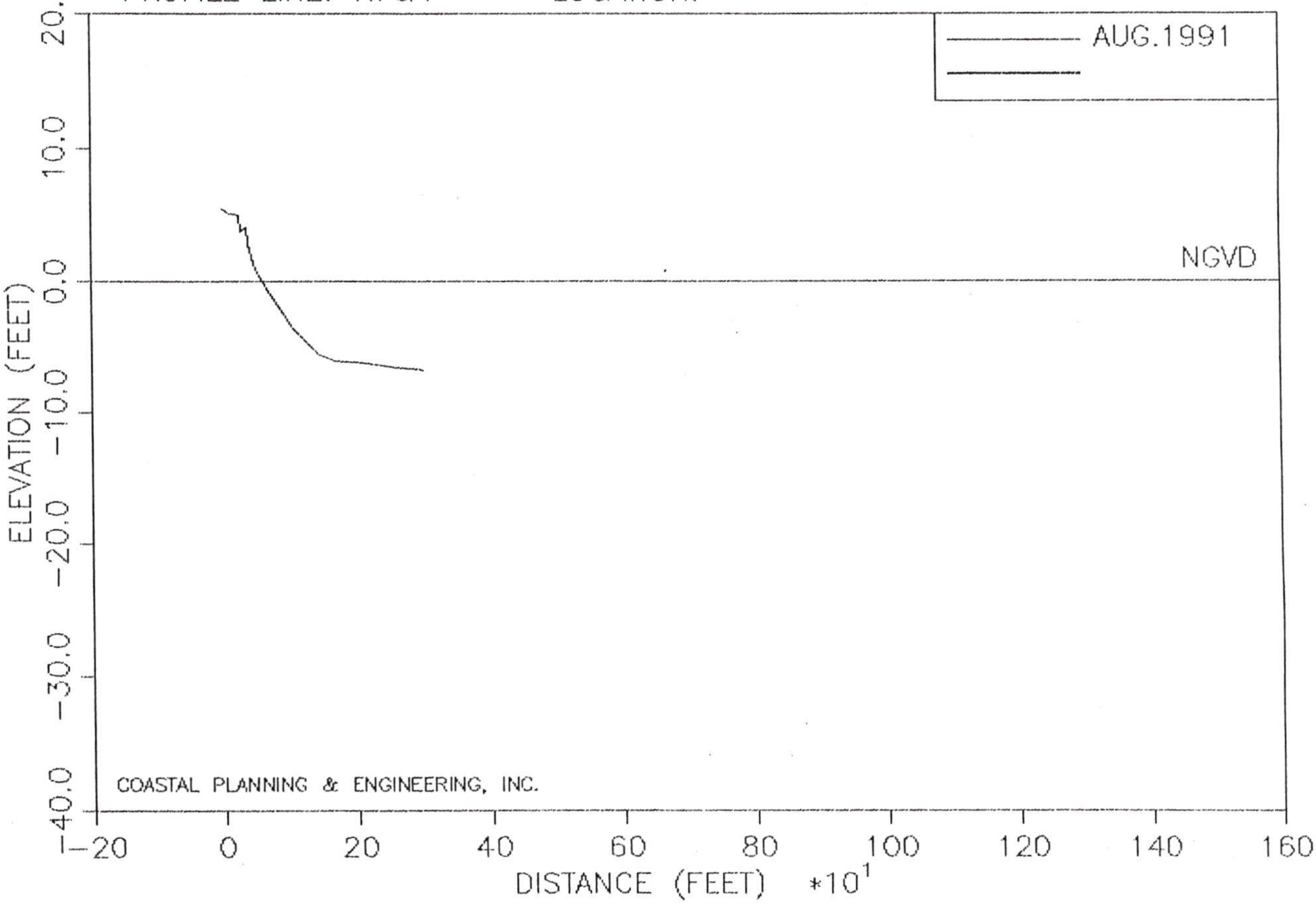
BEACH PROFILES
NORTH AND SOUTH OF REDFISH PASS

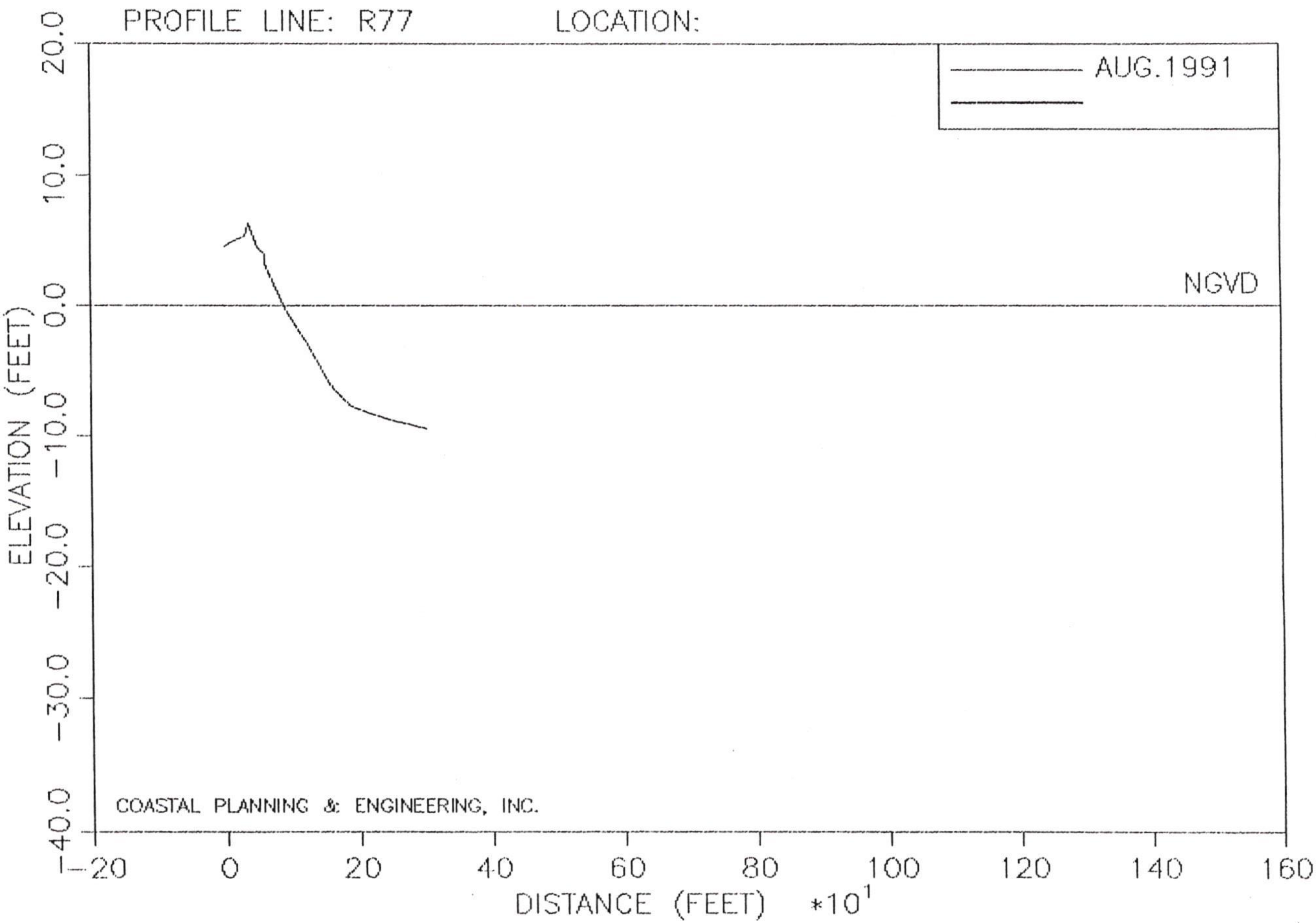

PROFILE LINE: R75
LOCATION:
AUG.1991
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.

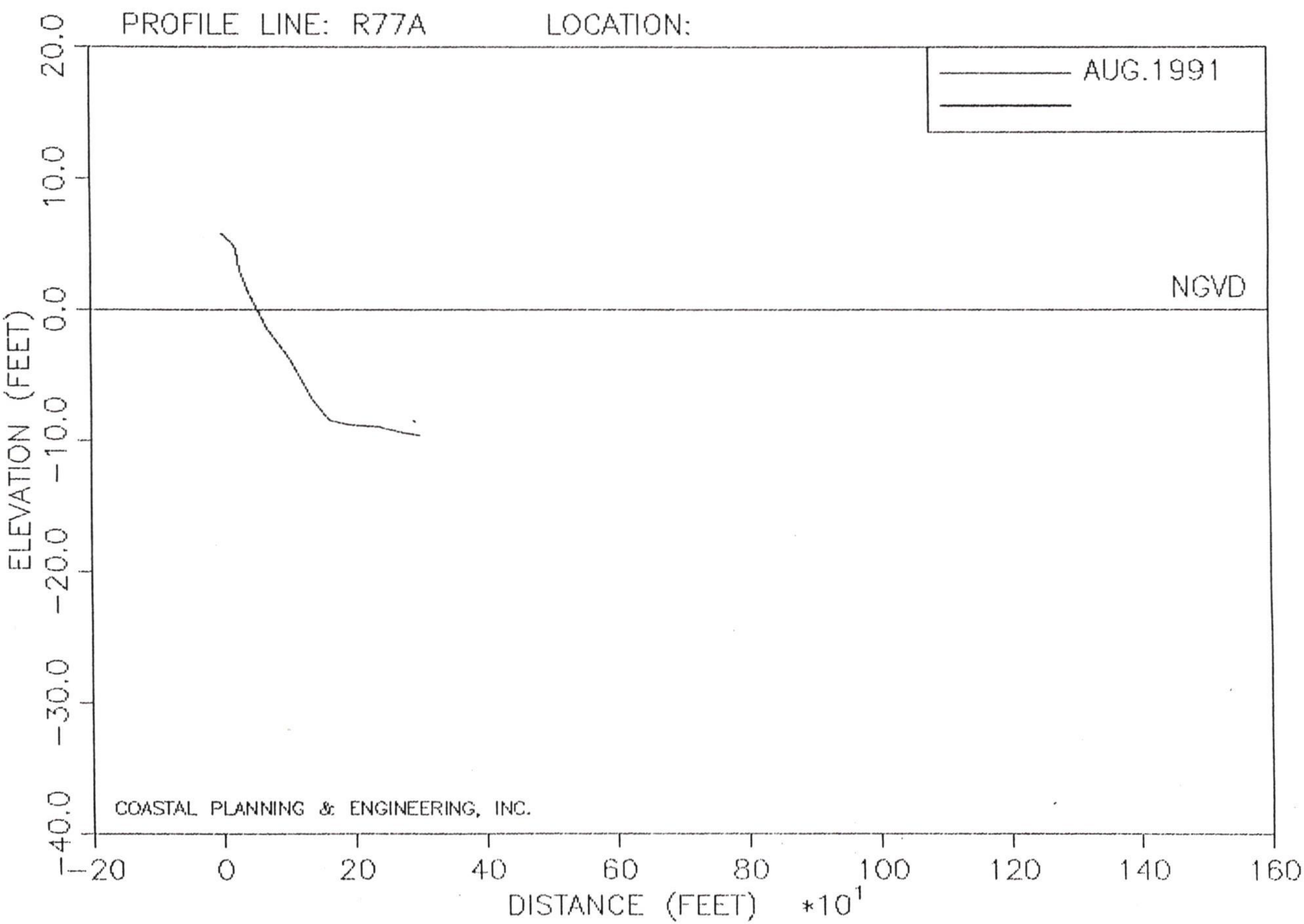

PROFILE LINE: R75A
LOCATION:
AUG.1991
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

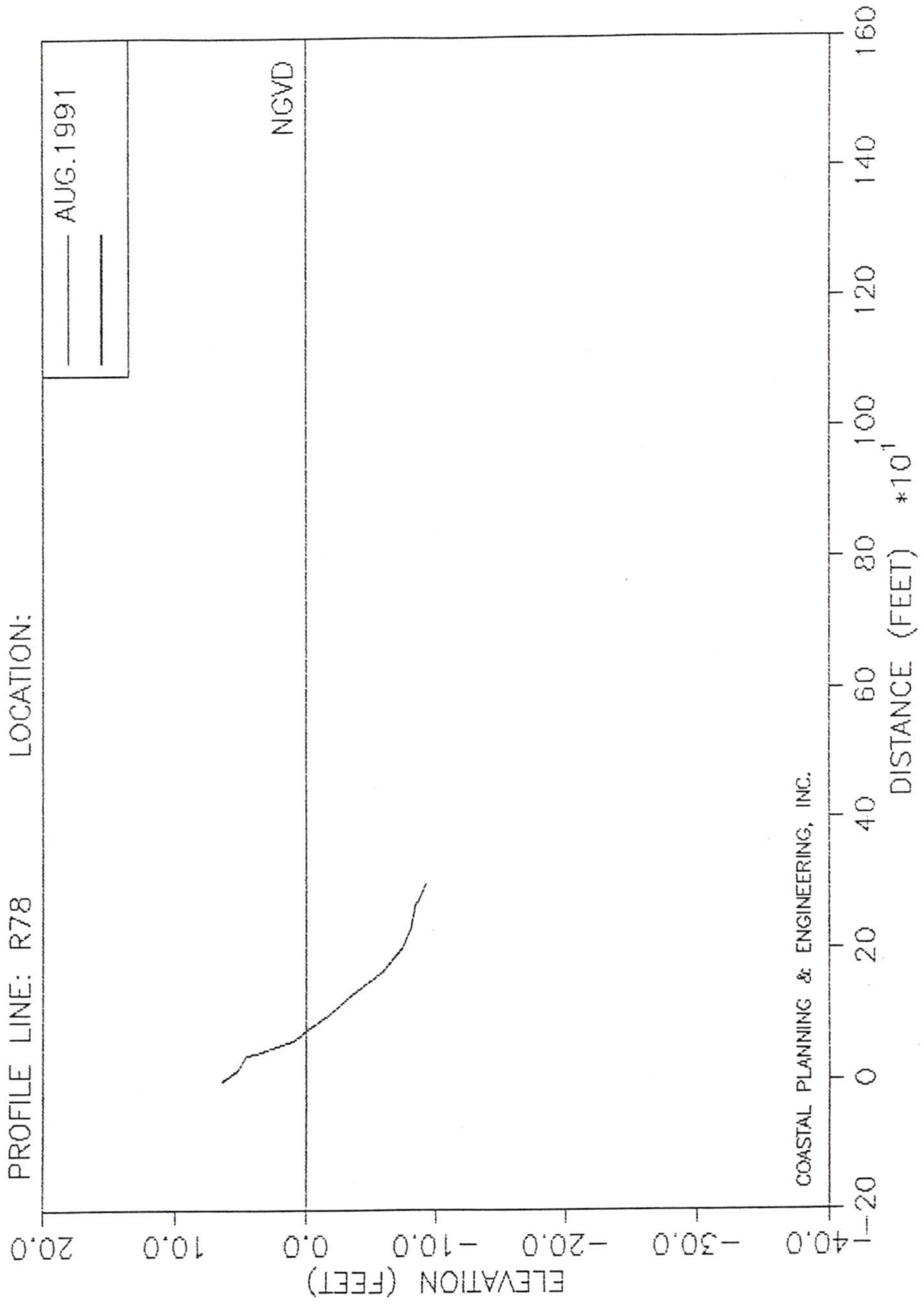

PROFILE LINE: R76
LOCATION:
AUG.1991
NGVD
COASTAL PLANNING & ENGINEERING, INC.
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
DISTANCE (FEET) *10¹
-20
0
20
40
60
80
100
120
140
160

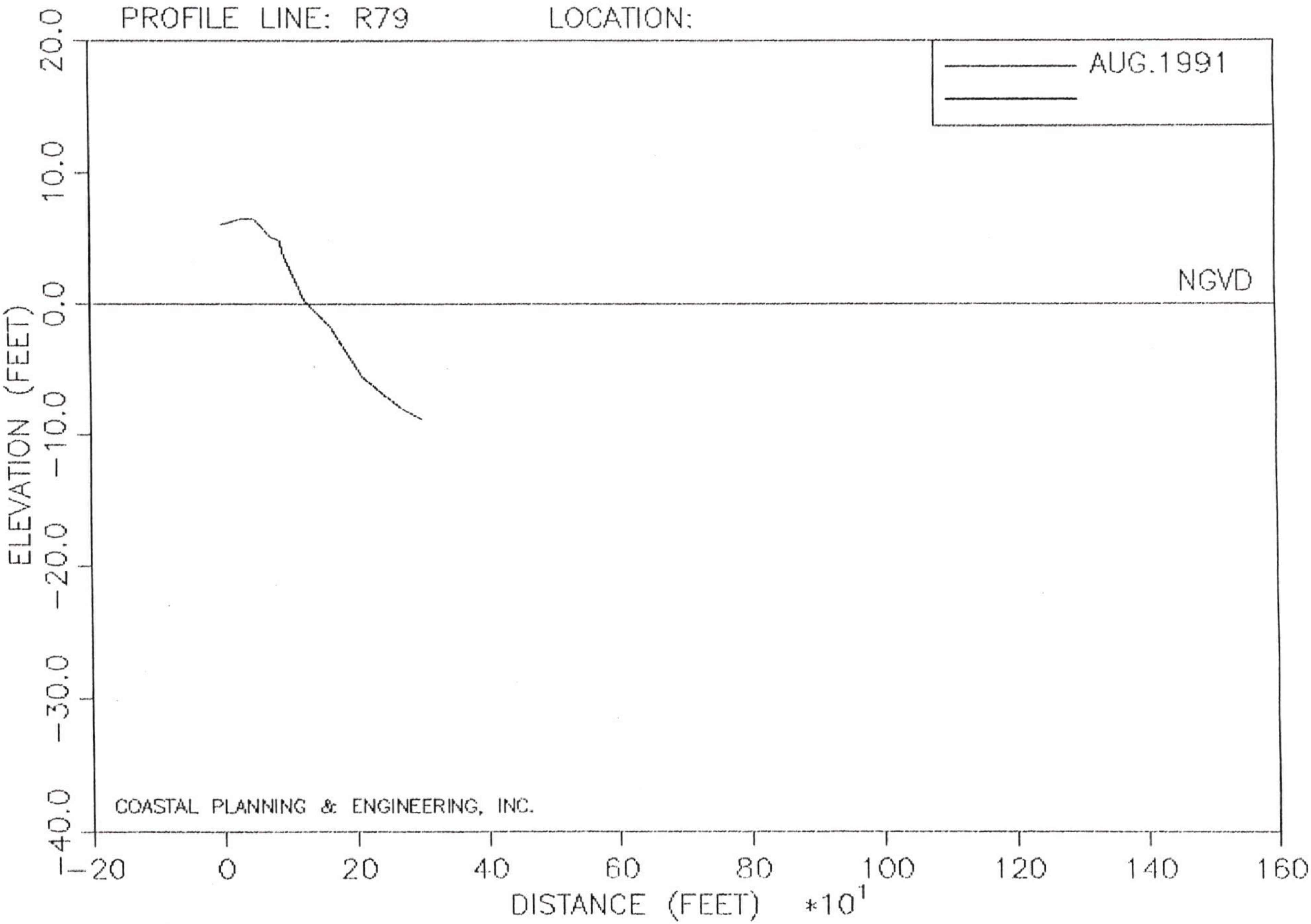
PROFILE LINE: R76A LOCATION:

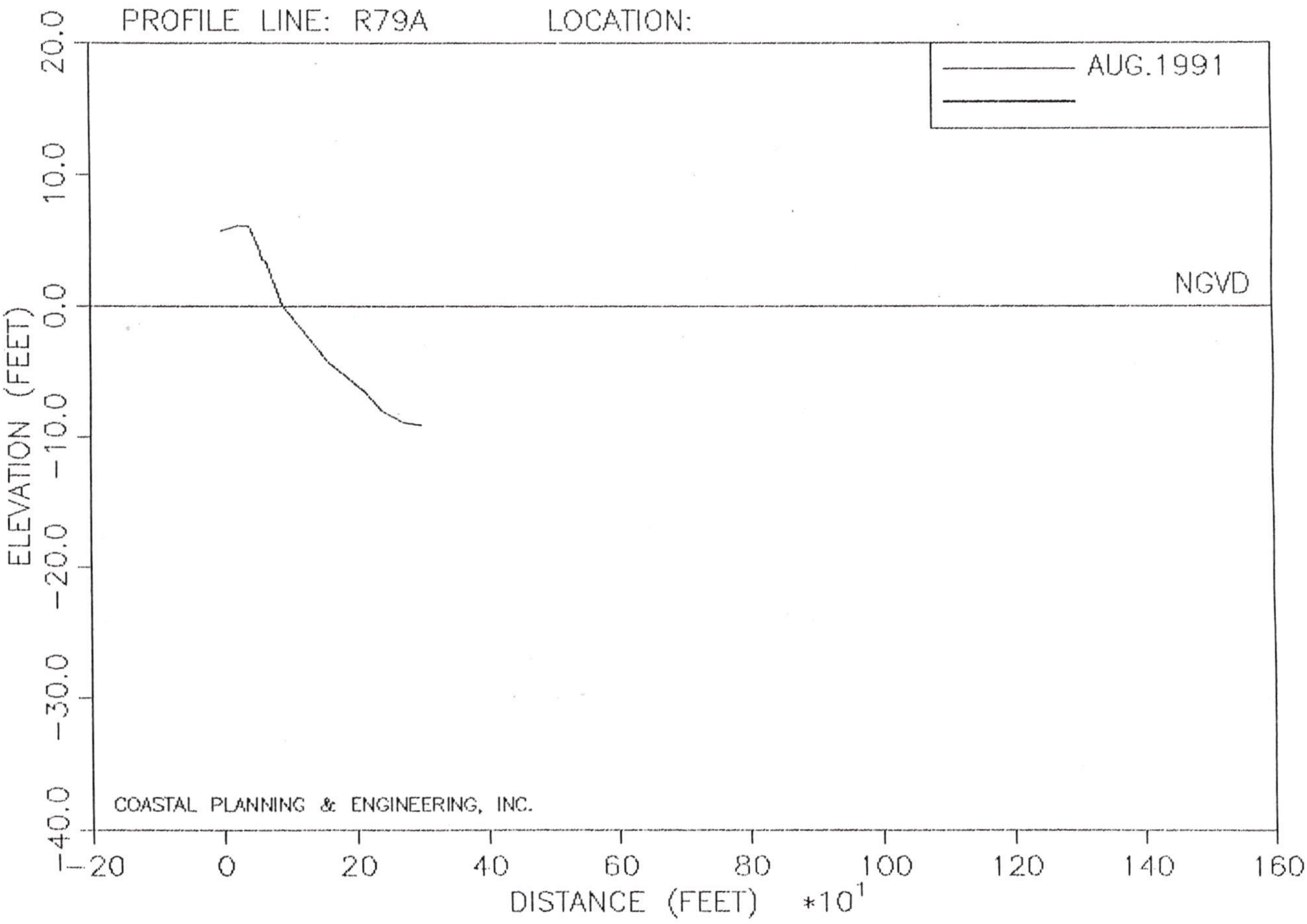


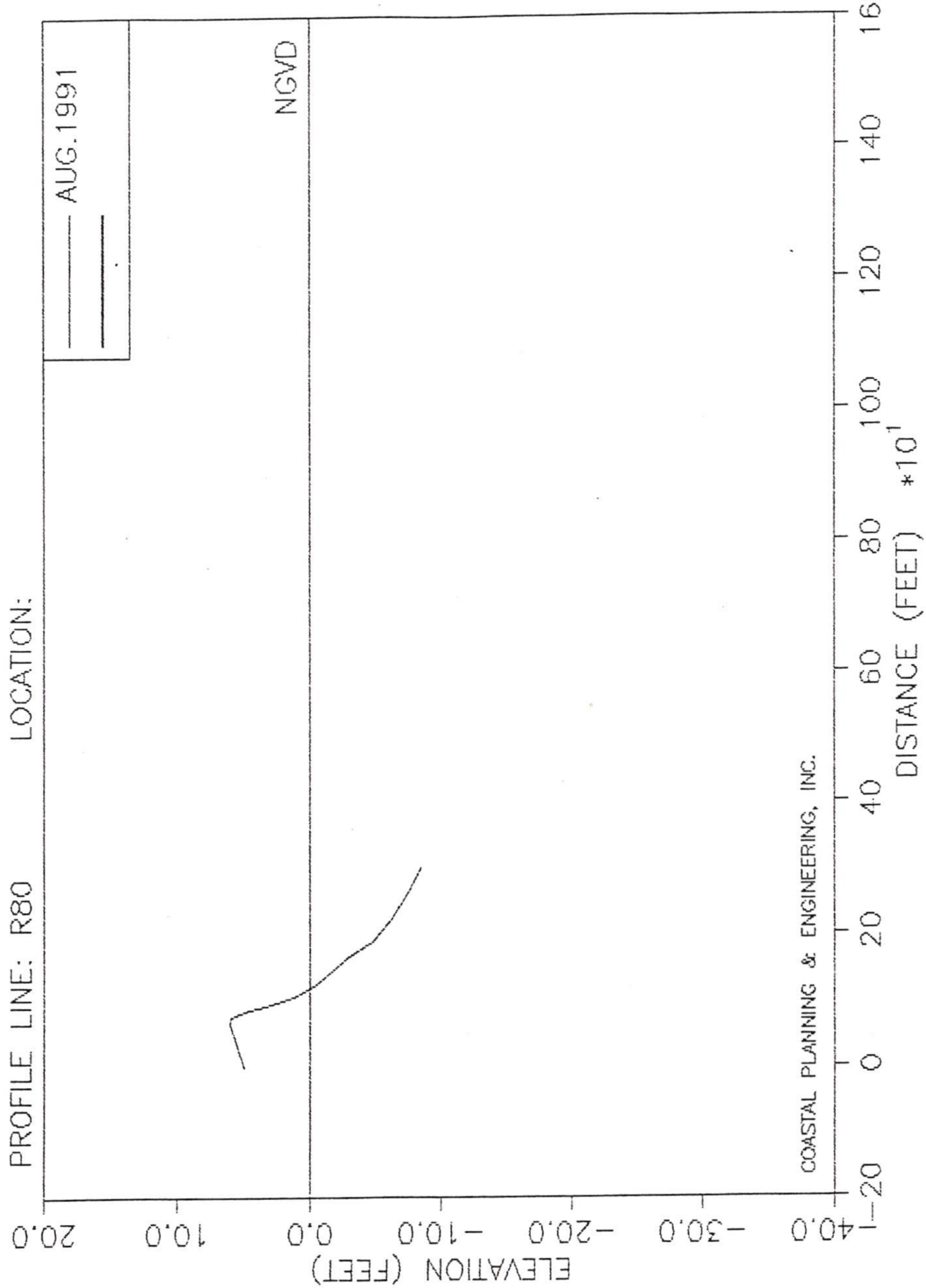

PROFILE LINE: R77
LOCATION:
AUG.1991
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: R77A
LOCATION:
AUG.1991
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.

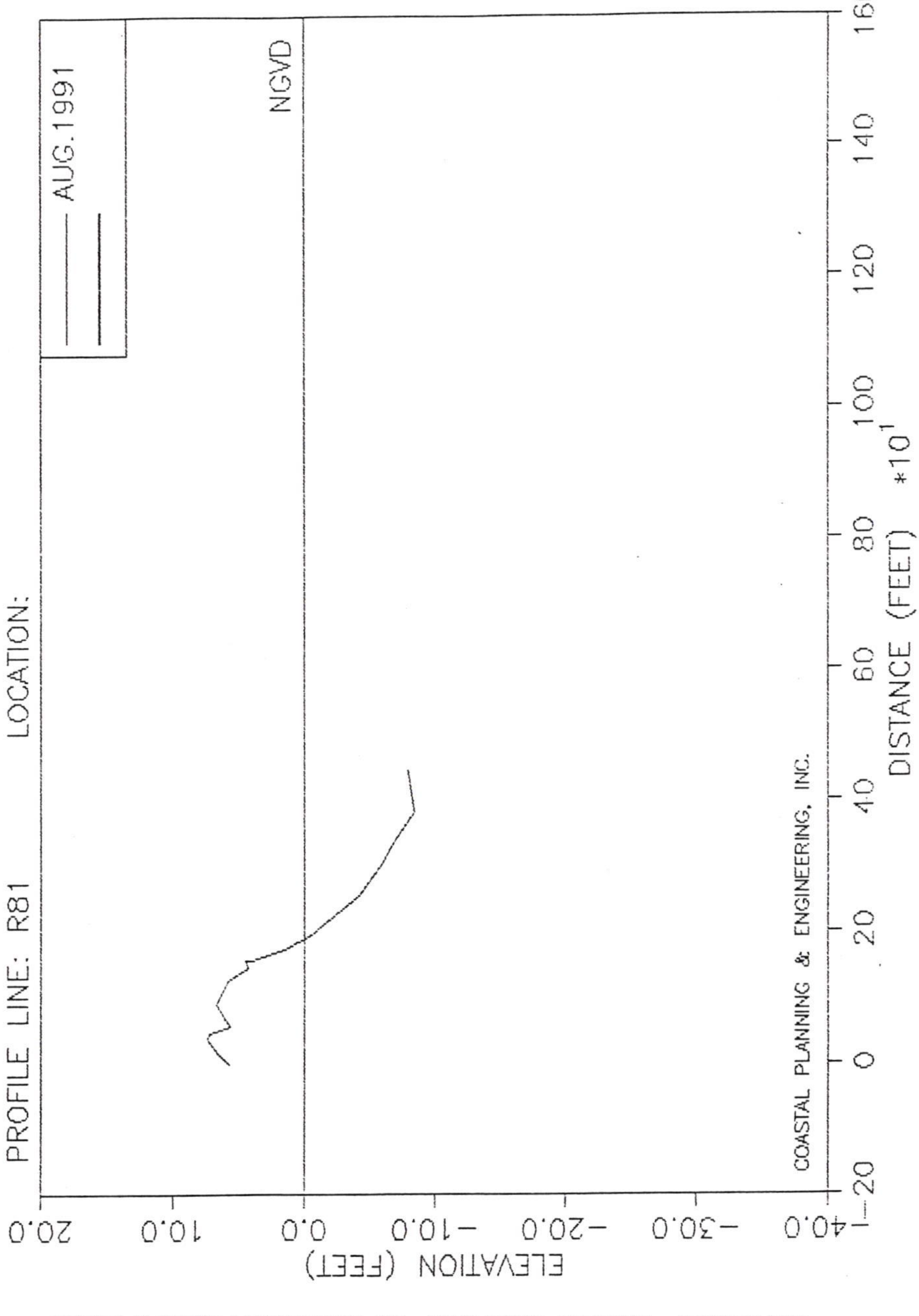

PROFILE LINE: R78
LOCATION:
AUG.1991
NGVD
COASTAL PLANNING & ENGINEERING, INC.
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160

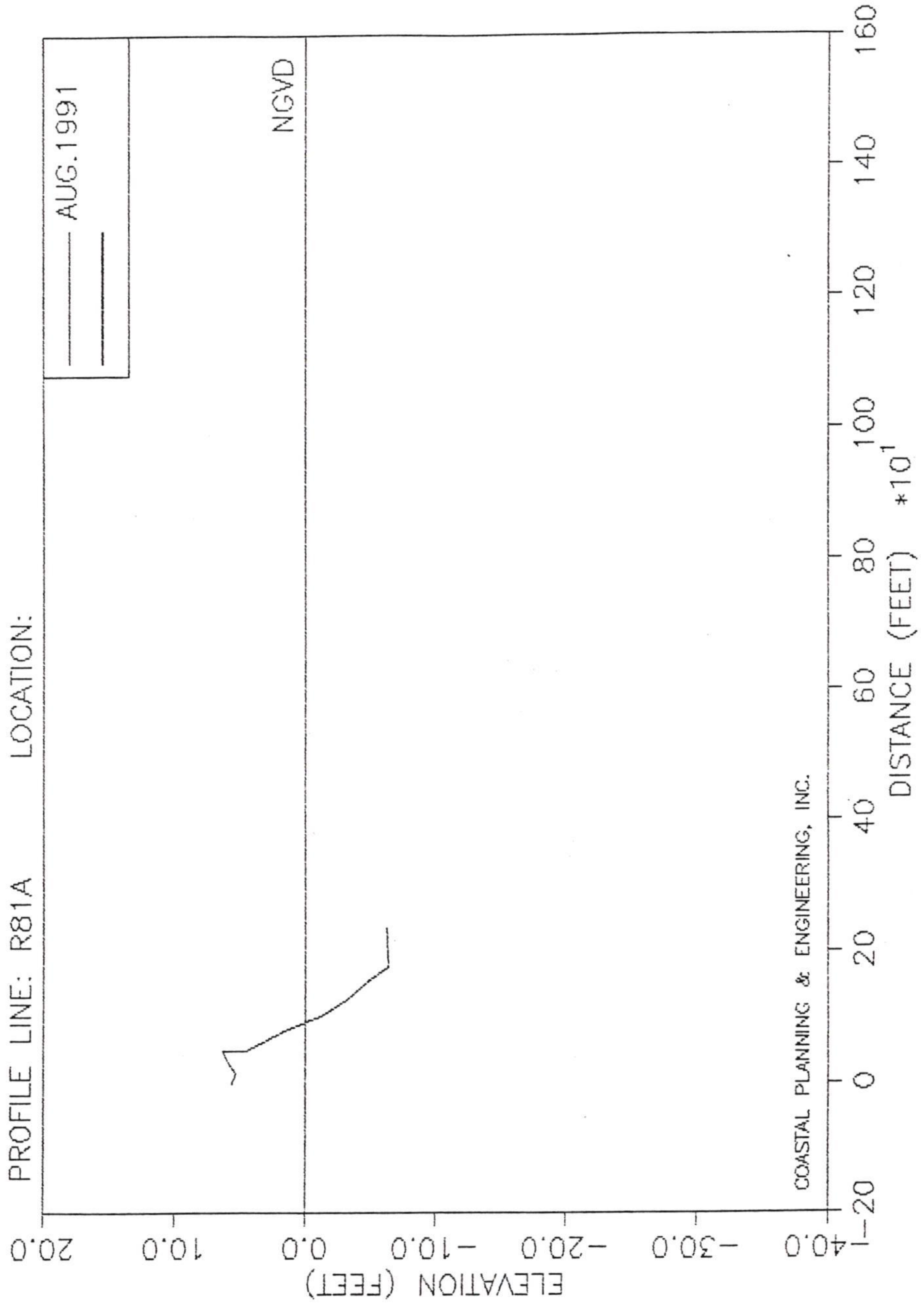

PROFILE LINE: R79
LOCATION:
AUG.1991
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10¹
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: R79A
LOCATION:
AUG.1991
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.

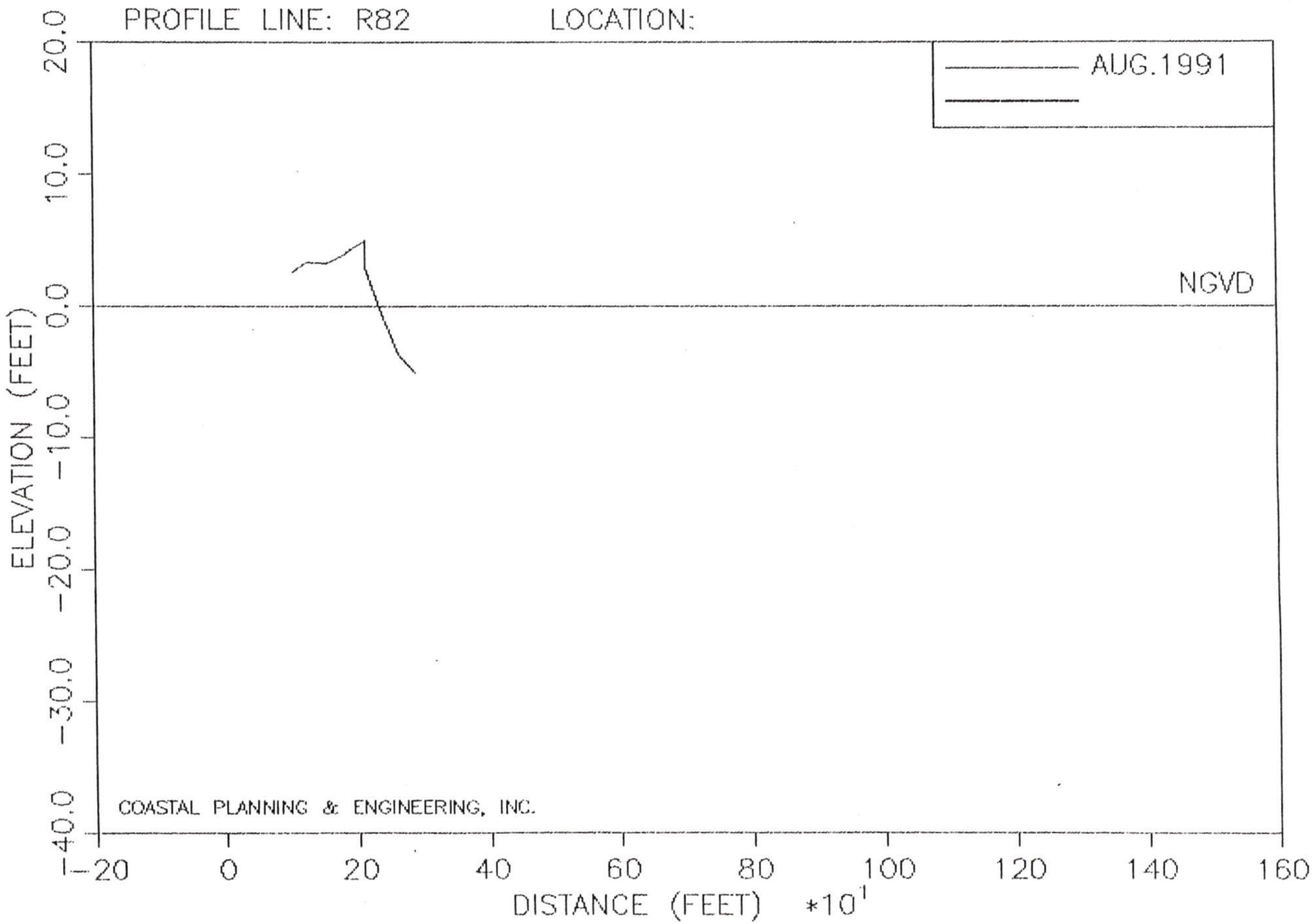


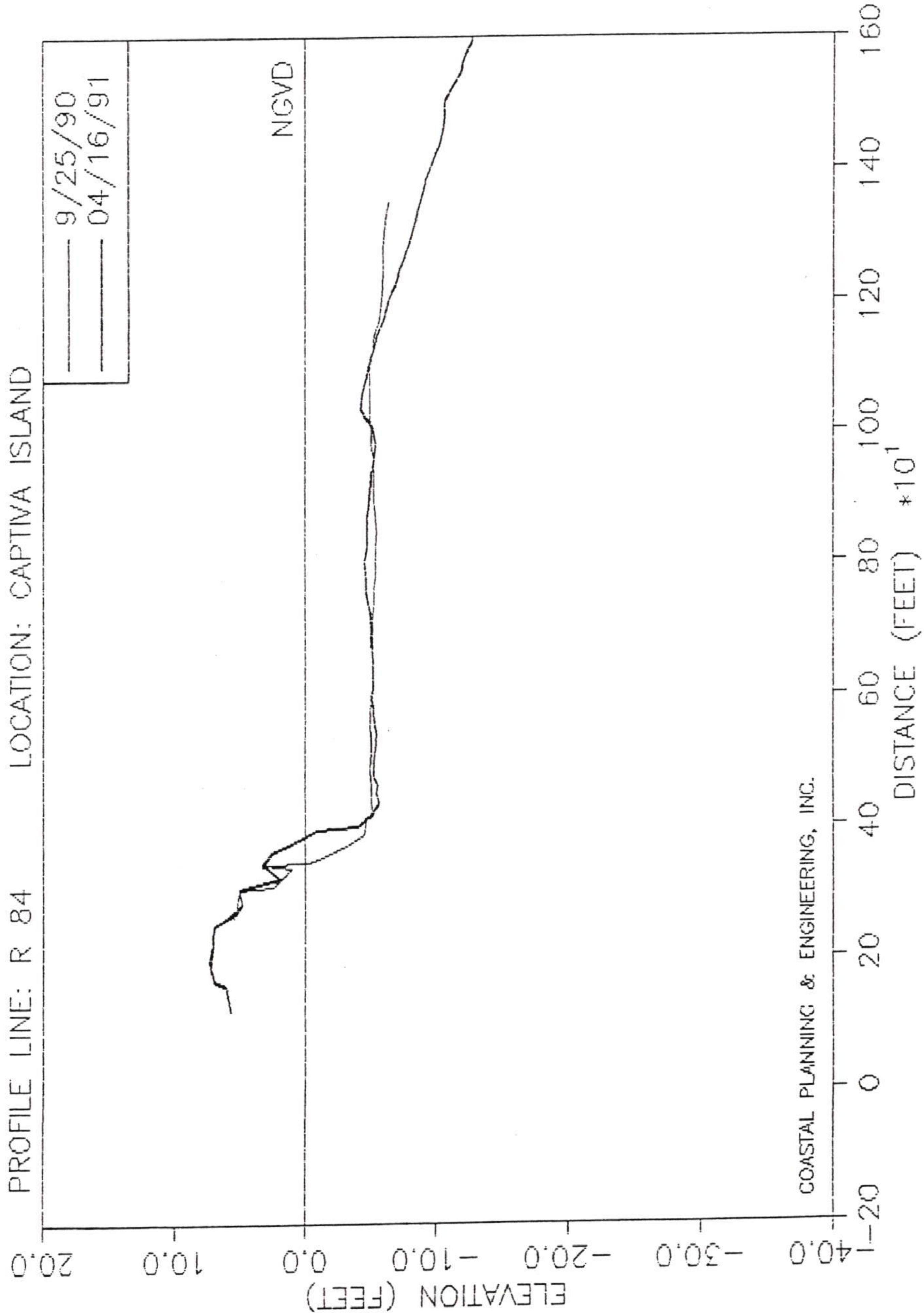
PROFILE LINE: R80
LOCATION:
AUG.1991
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10[1]
ELEVATION (FEET)
-20
0
20
40
60
80
100
120
140
160
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0


PROFILE LINE: R81
LOCATION:
AUG.1991
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

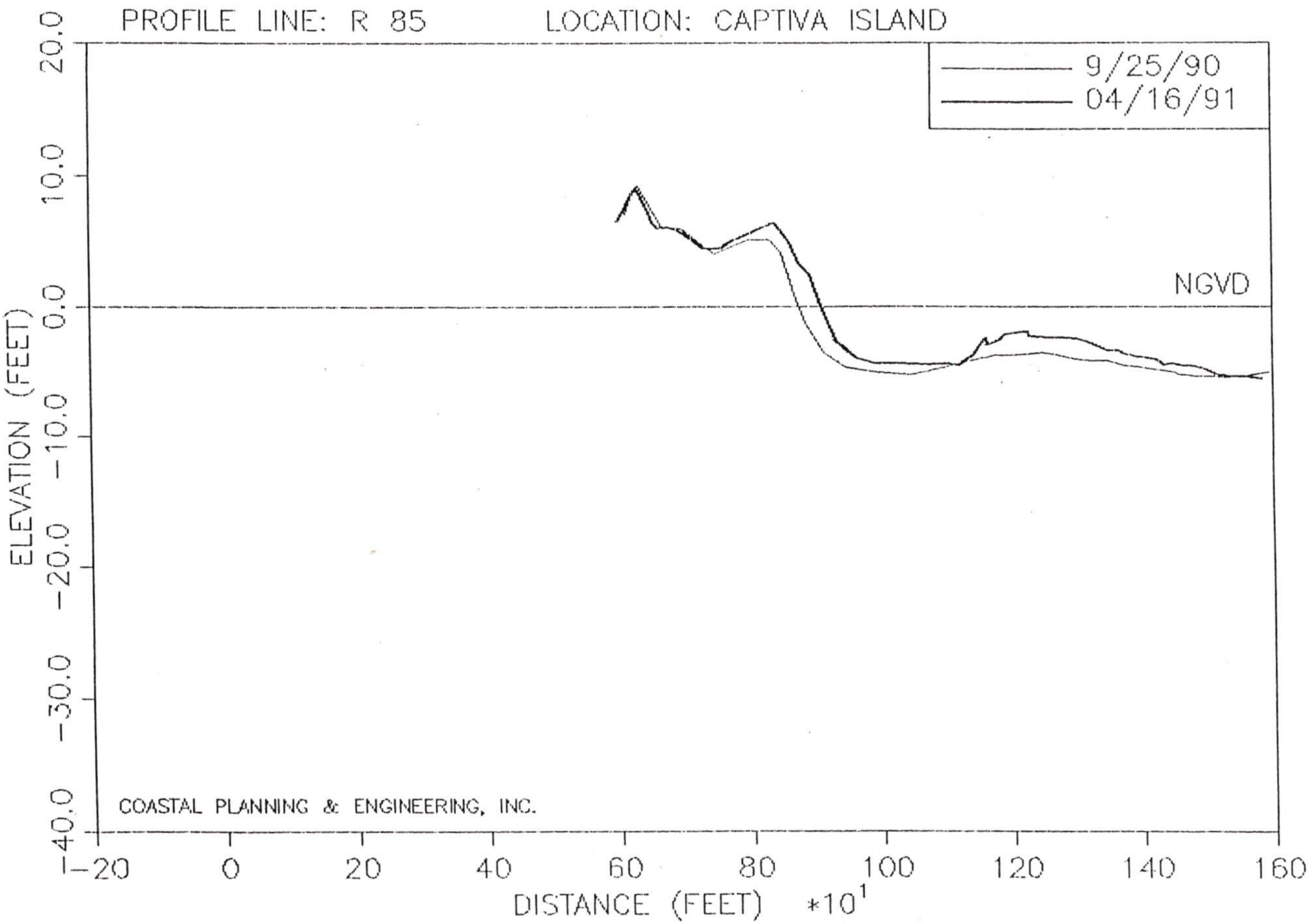


PROFILE LINE: R81A
LOCATION:
AUG.1991
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

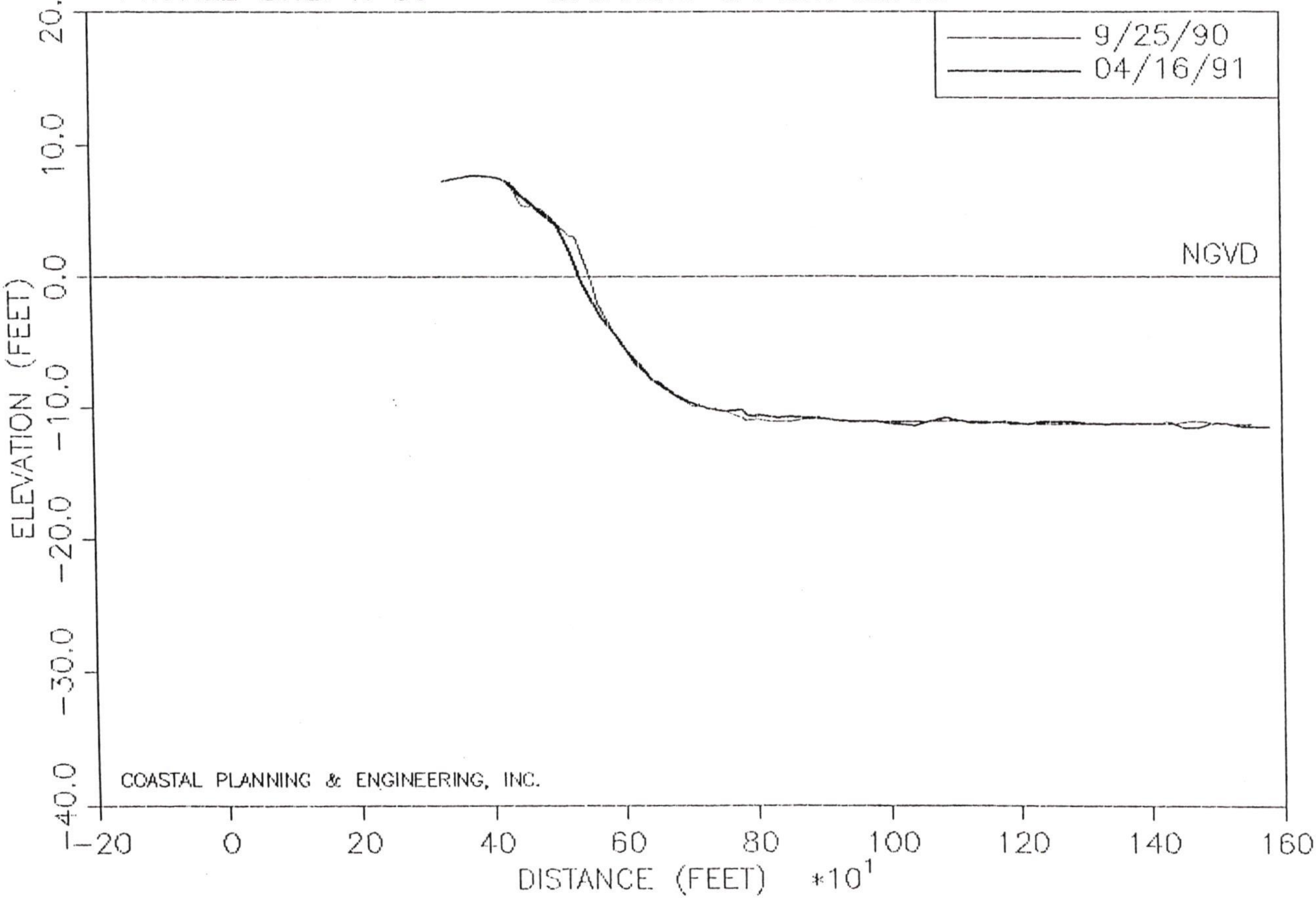

PROFILE LINE: R82
LOCATION:
AUG.1991
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.

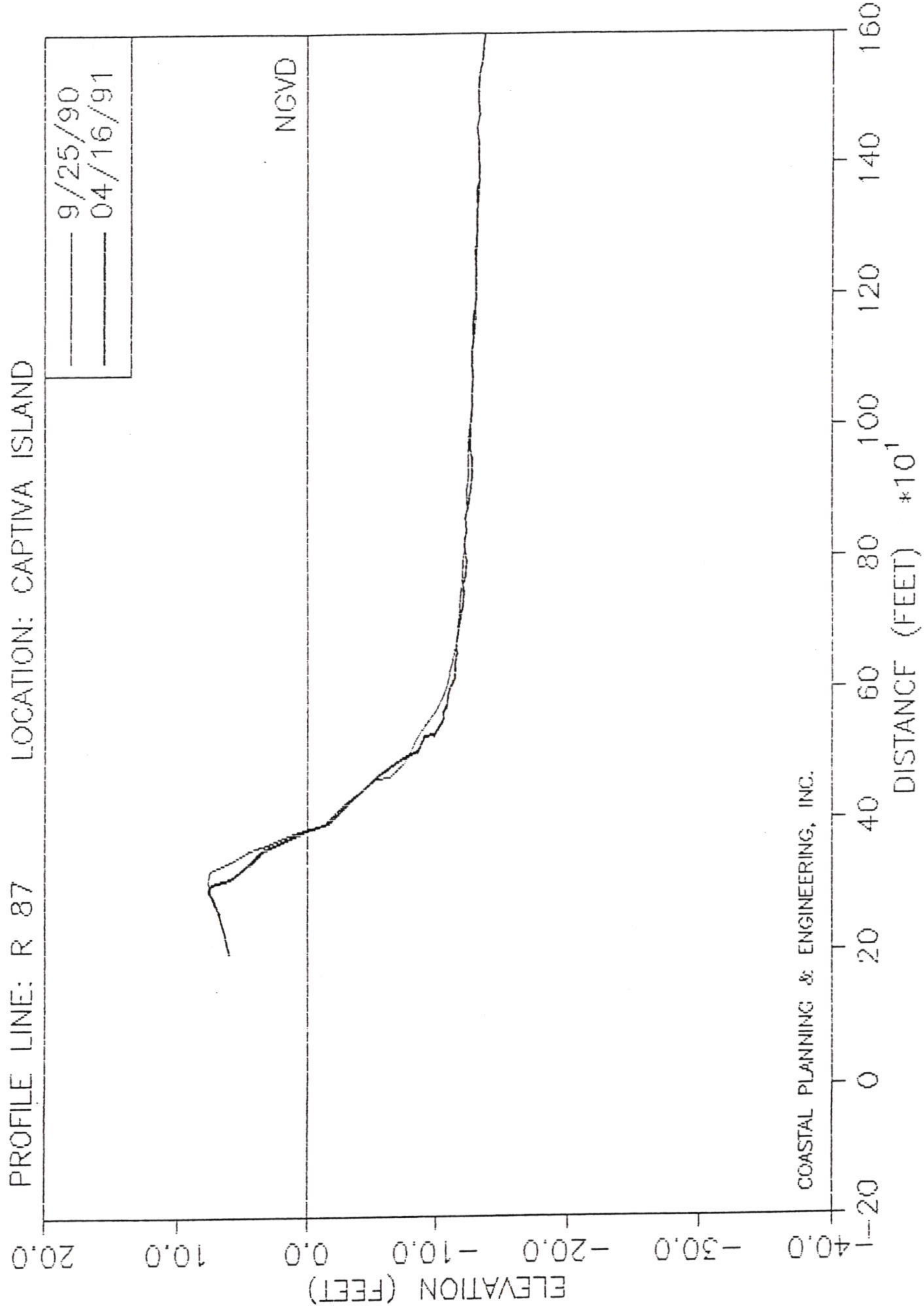


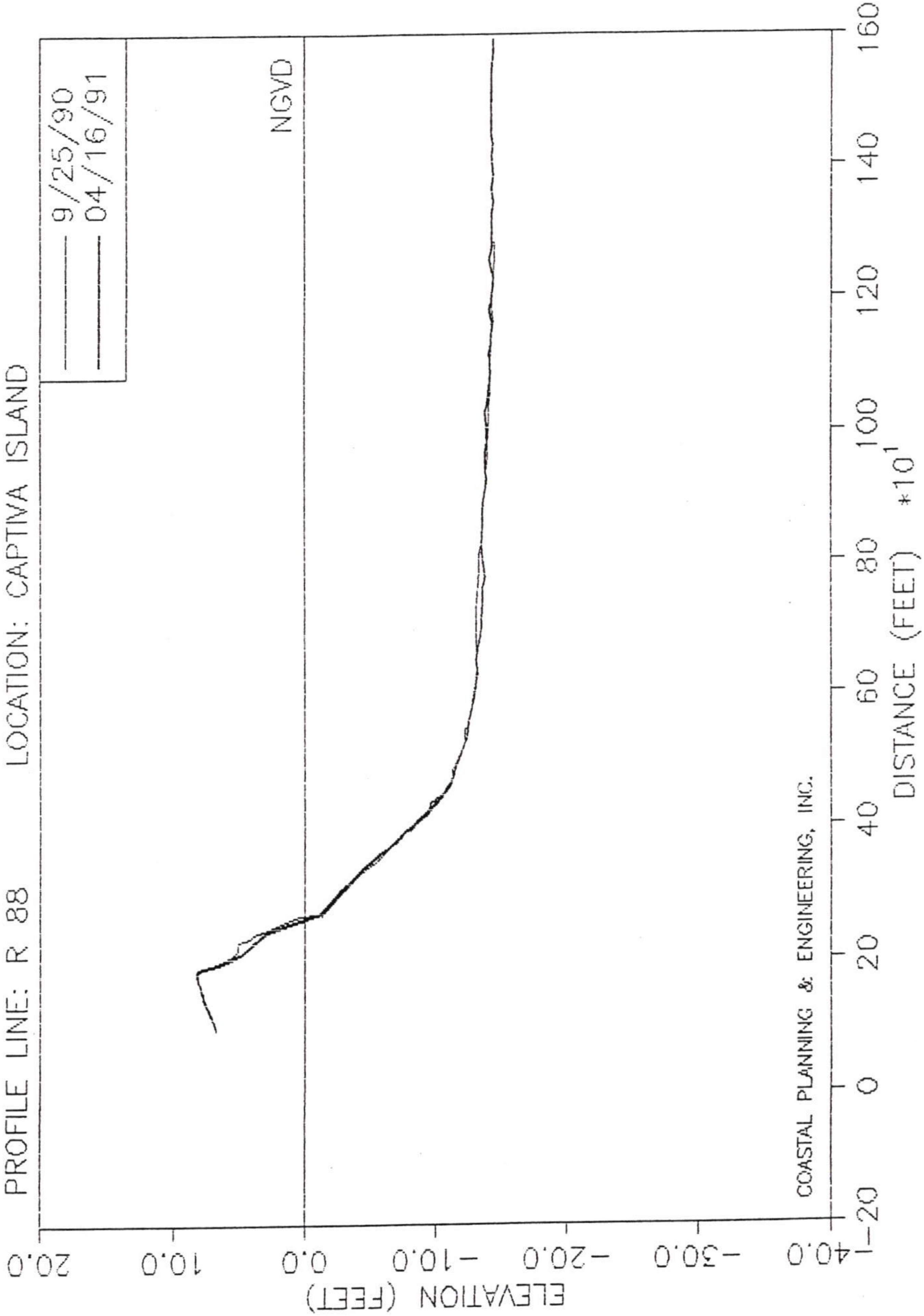
PROFILE LINE: R 84
LOCATION: CAPTIVA ISLAND
9/25/90
04/16/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

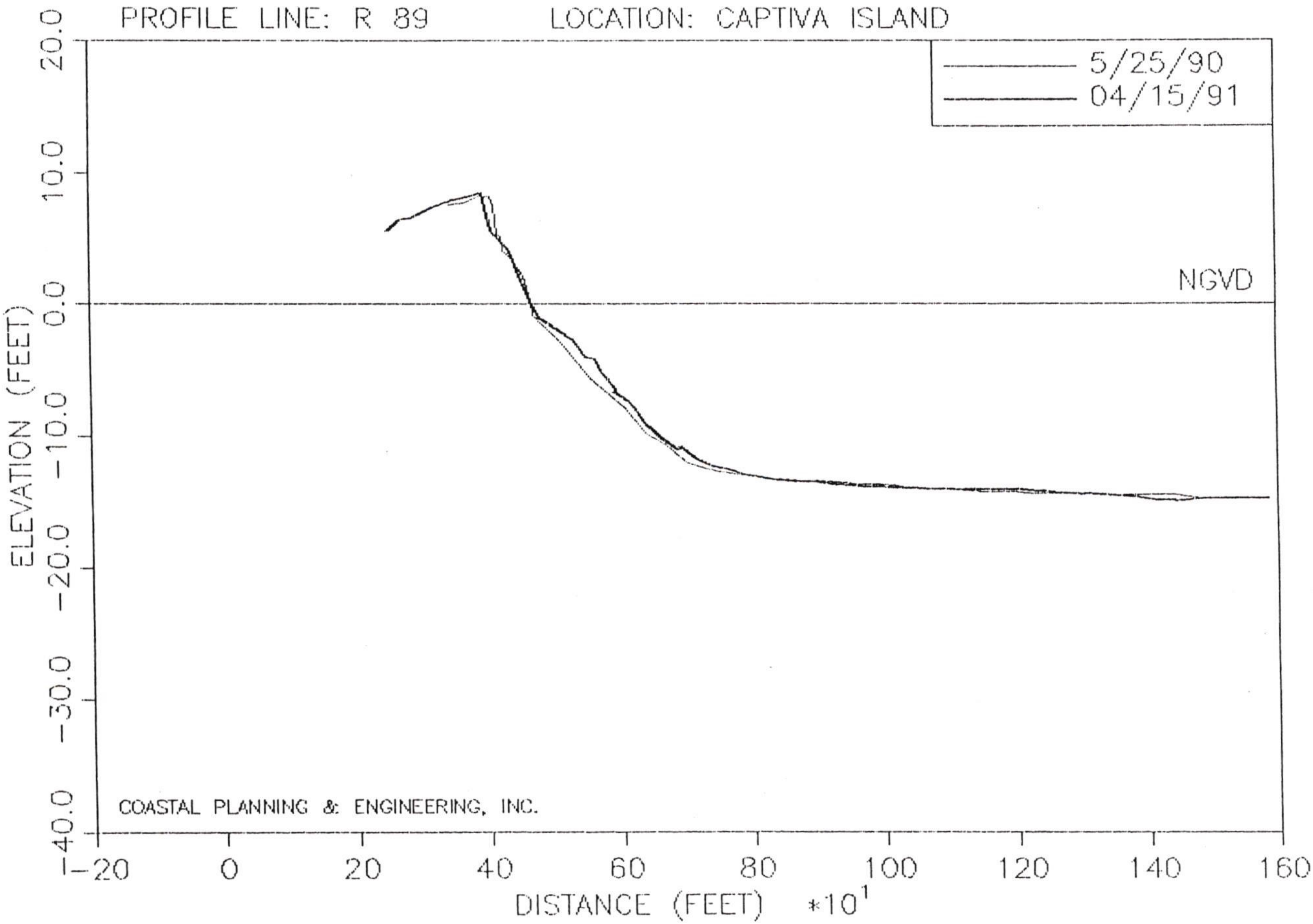

PROFILE LINE: R 85
LOCATION: CAPTIVA ISLAND
9/25/90
04/16/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.

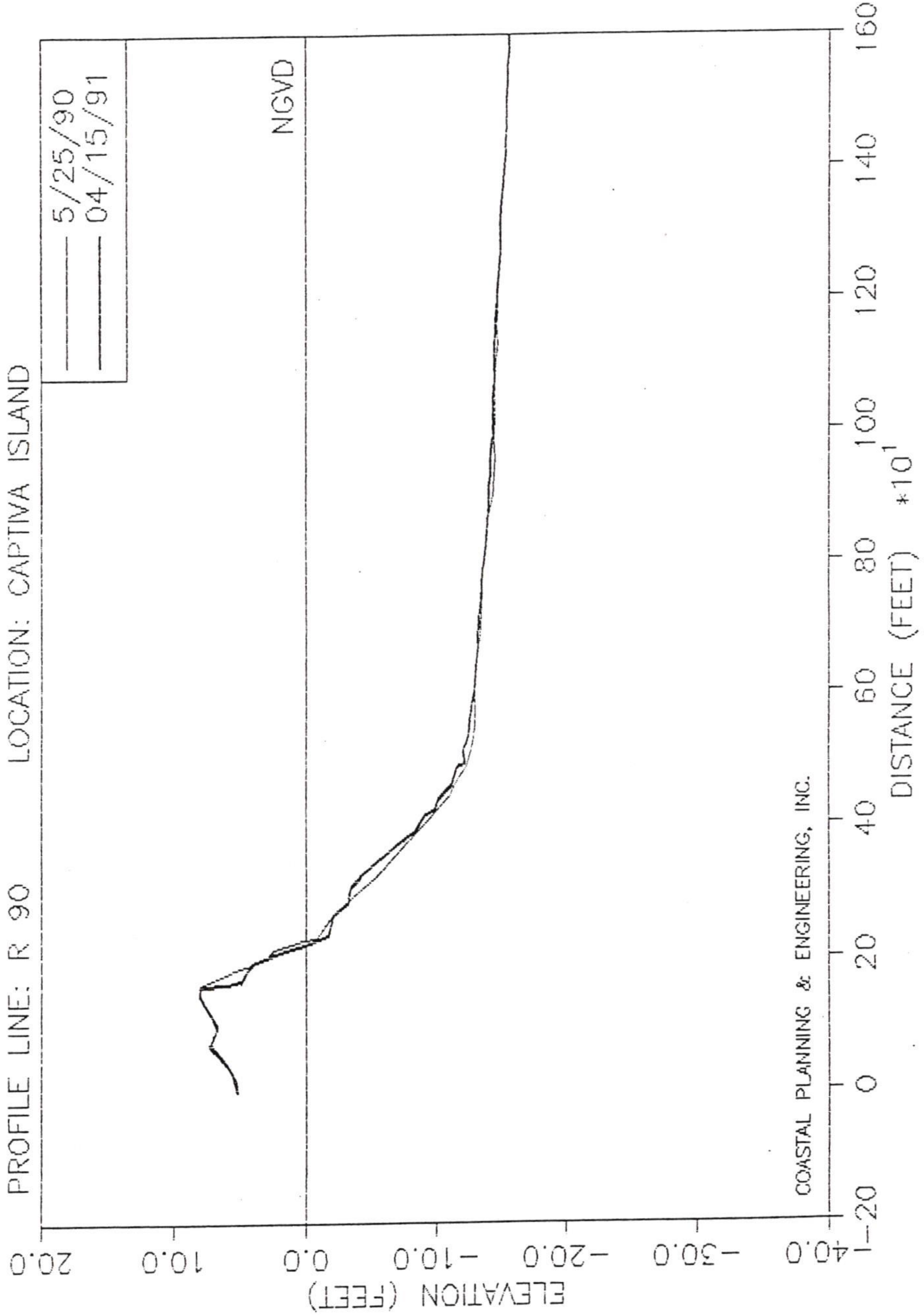
PROFILE LINE: R 86 LOCATION: CAPTIVA ISLAND

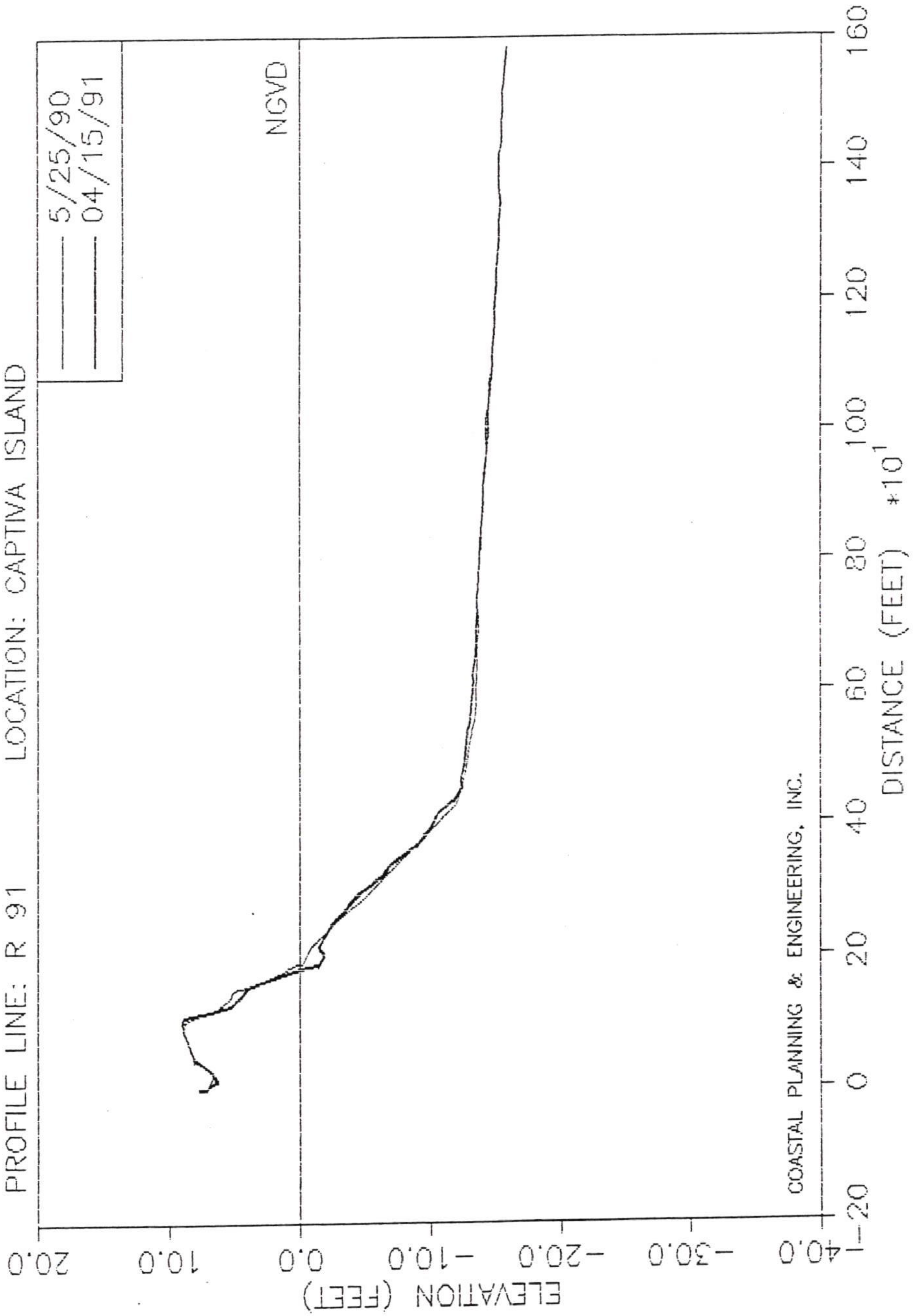


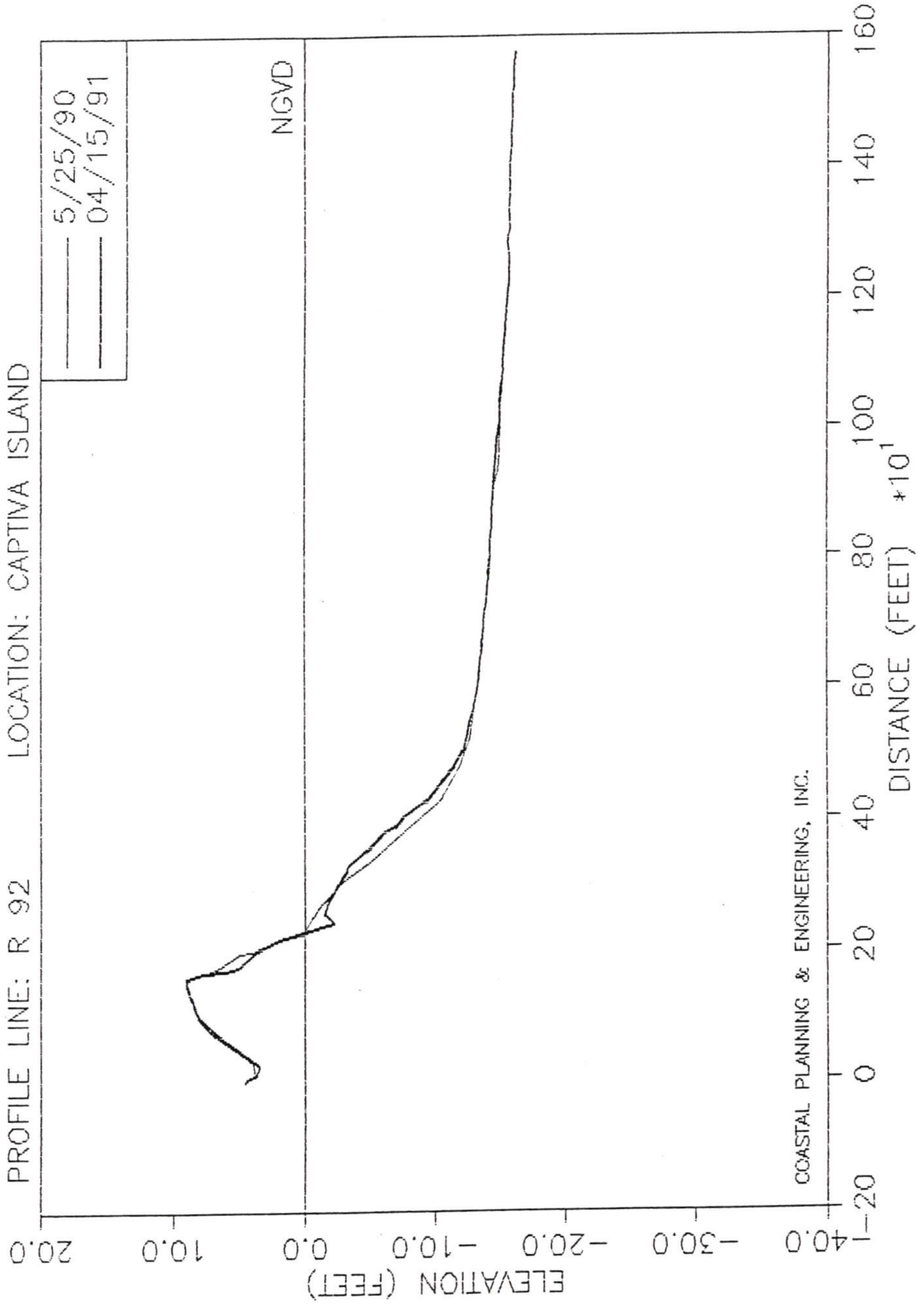

PROFILE LINE: R 87
LOCATION: CAPTIVA ISLAND
9/25/90
04/16/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
ELEVATION (FEET)
20.0
10.0
0.0
−10.0
−20.0
−30.0
−40.0
DISTANCE (FEET) *10^1
−20
0
20
40
60
80
100
120
140
160

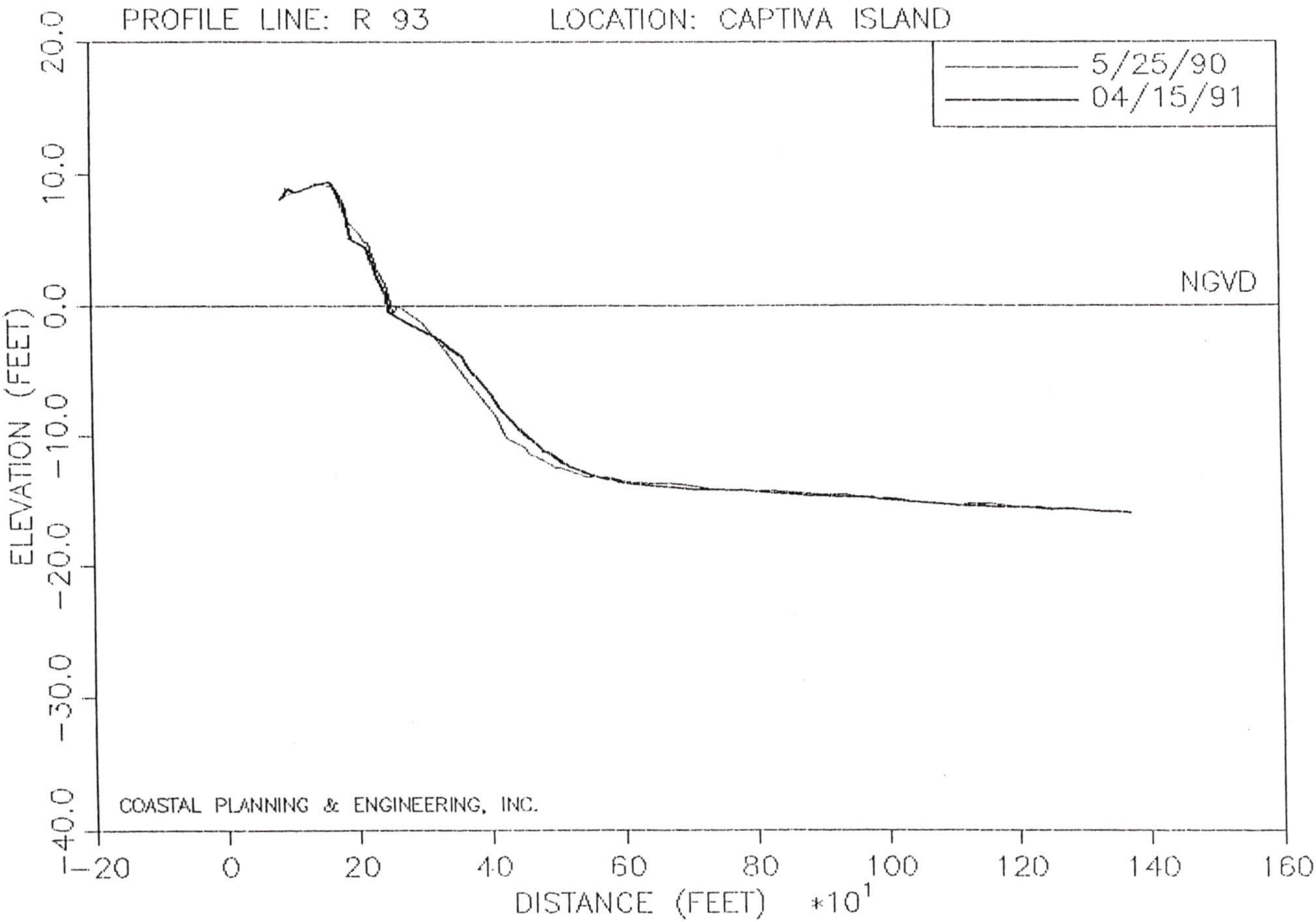

PROFILE LINE: R 88
LOCATION: CAPTIVA ISLAND
9/25/90
04/16/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0


PROFILE LINE: R 89
LOCATION: CAPTIVA ISLAND
5/25/90
04/15/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
−10.0
−20.0
−30.0
−40.0
−20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.

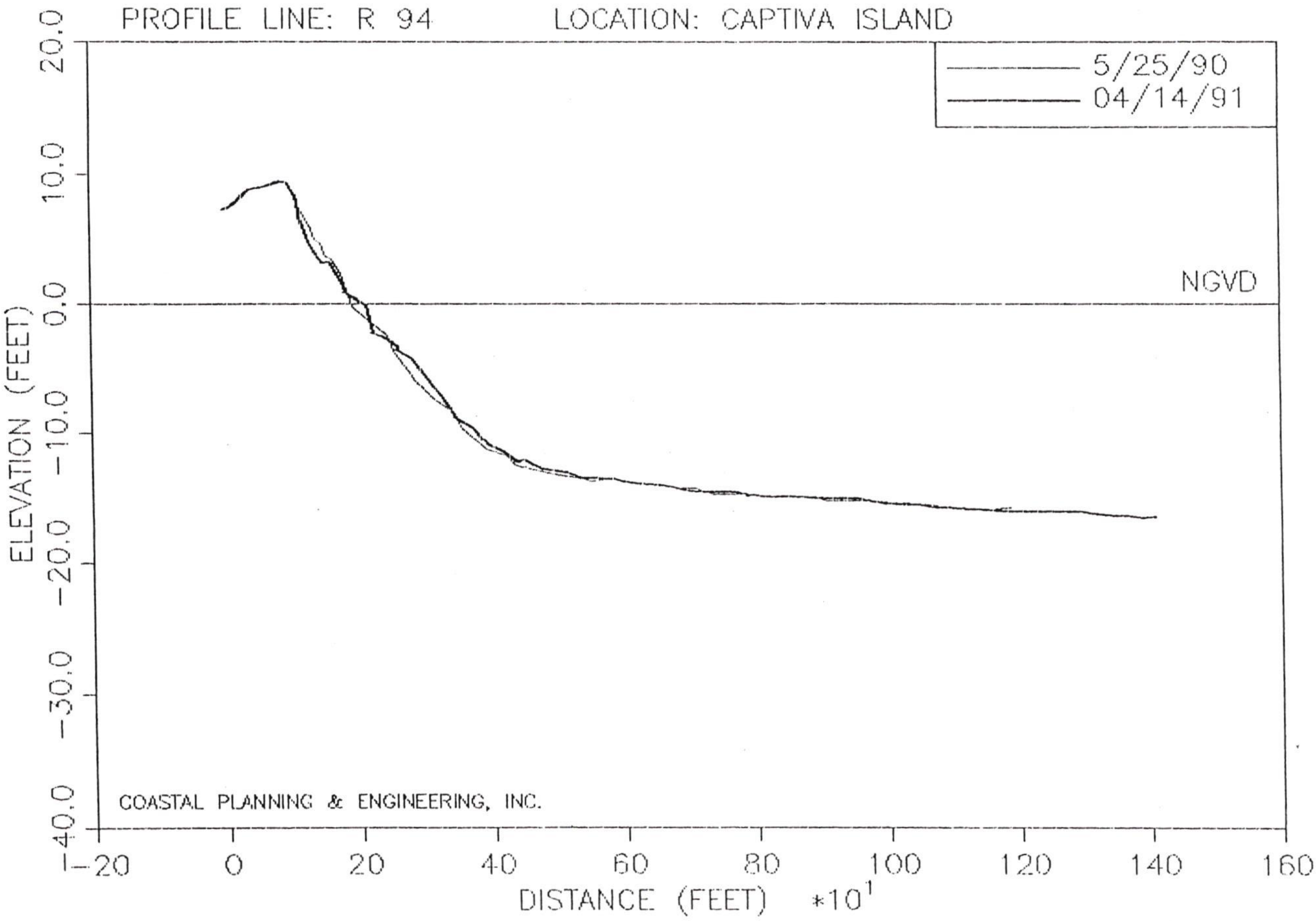

PROFILE LINE: R 90
LOCATION: CAPTIVA ISLAND
5/25/90
04/15/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

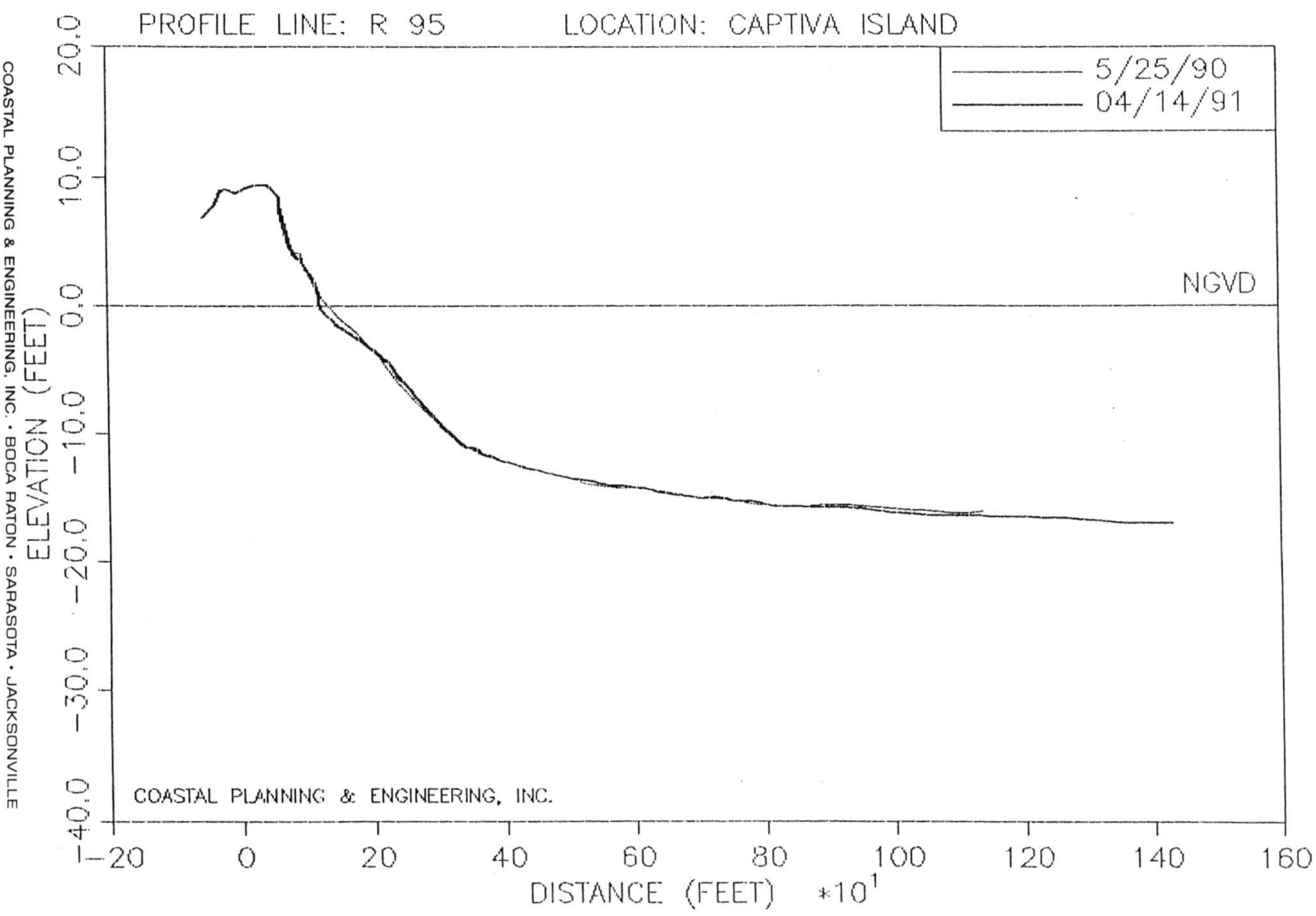

PROFILE LINE: R 91
LOCATION: CAPTIVA ISLAND
5/25/90
04/15/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10[1]
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0


PROFILE LINE: R 92
LOCATION: CAPTIVA ISLAND
5/25/90
04/15/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
ELEVATION (FEET)
-20 0 20 40 60 80 100 120 140 160
20.0 10.0 0.0 -10.0 -20.0 -30.0 -40.0

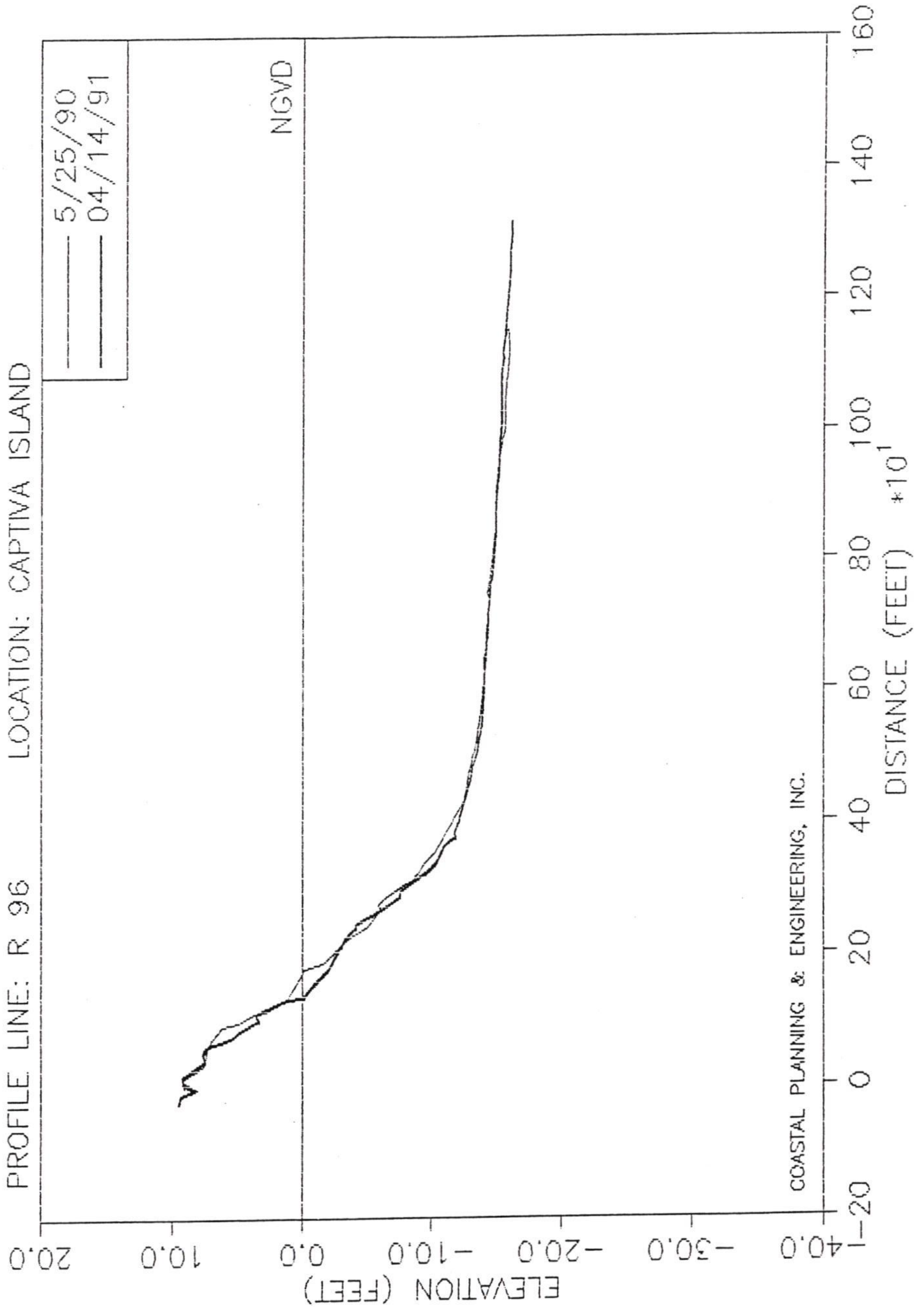


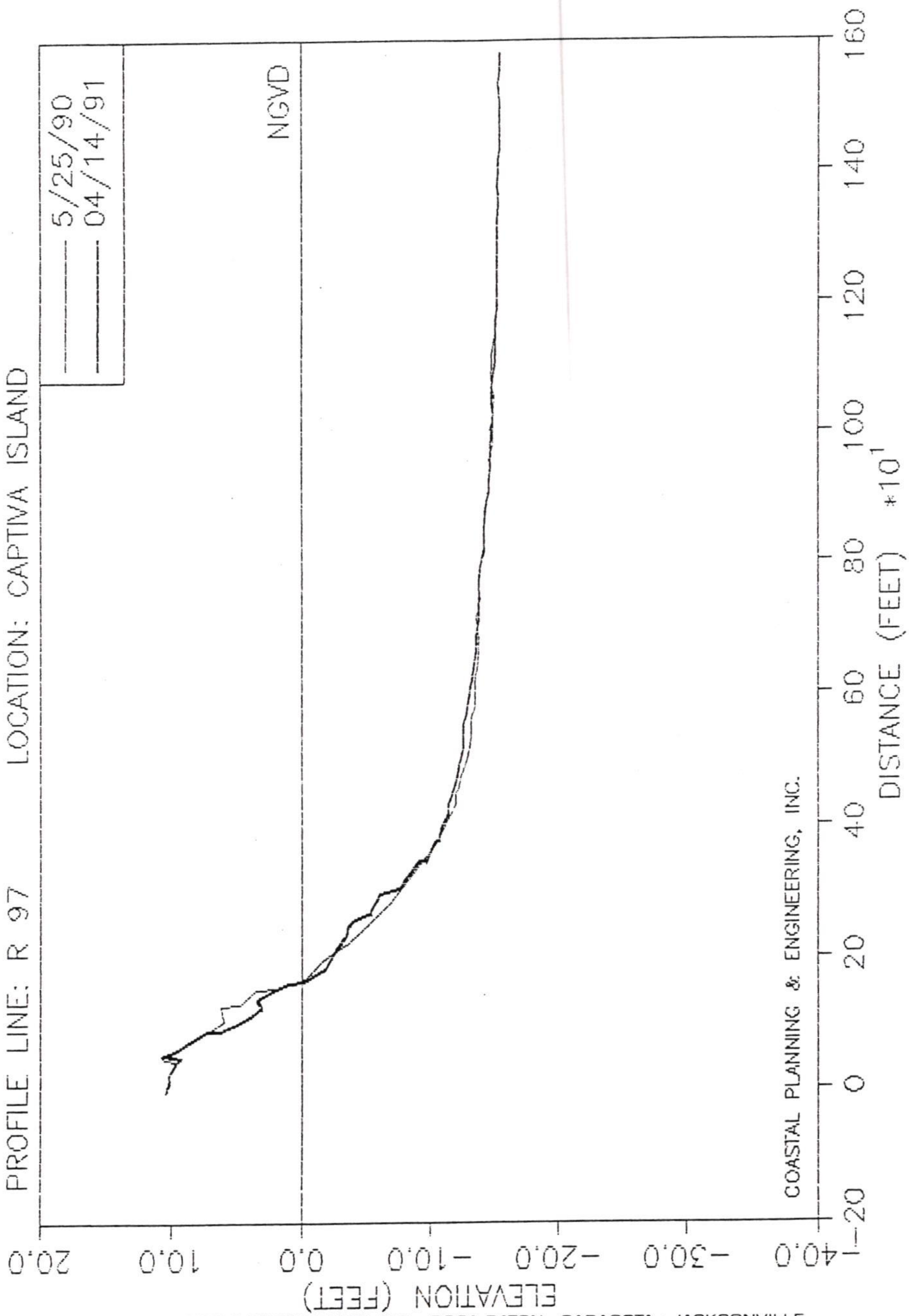
PROFILE LINE: R 93
LOCATION: CAPTIVA ISLAND
5/25/90
04/15/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: R 94
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.

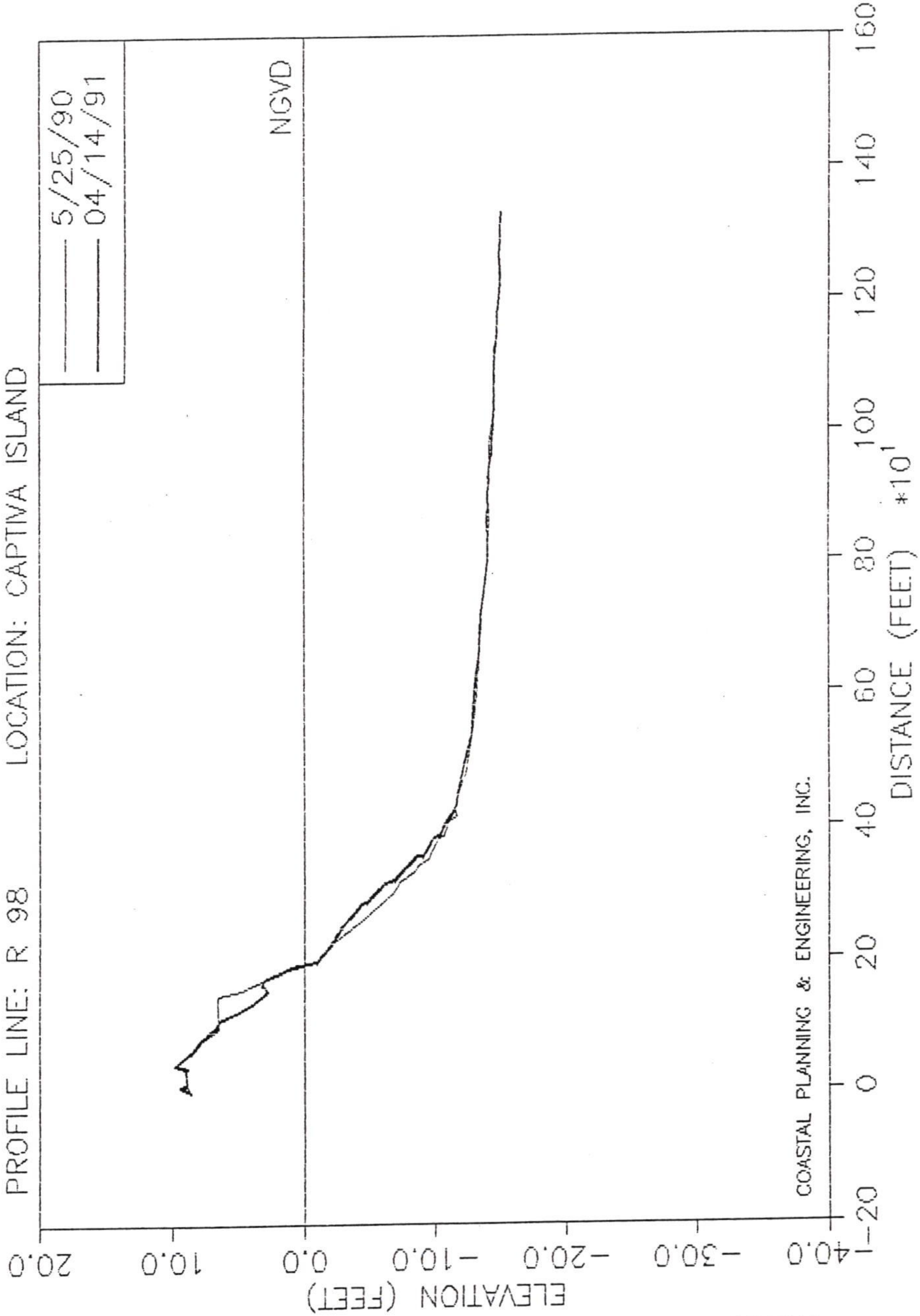


PROFILE LINE: R 95
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.

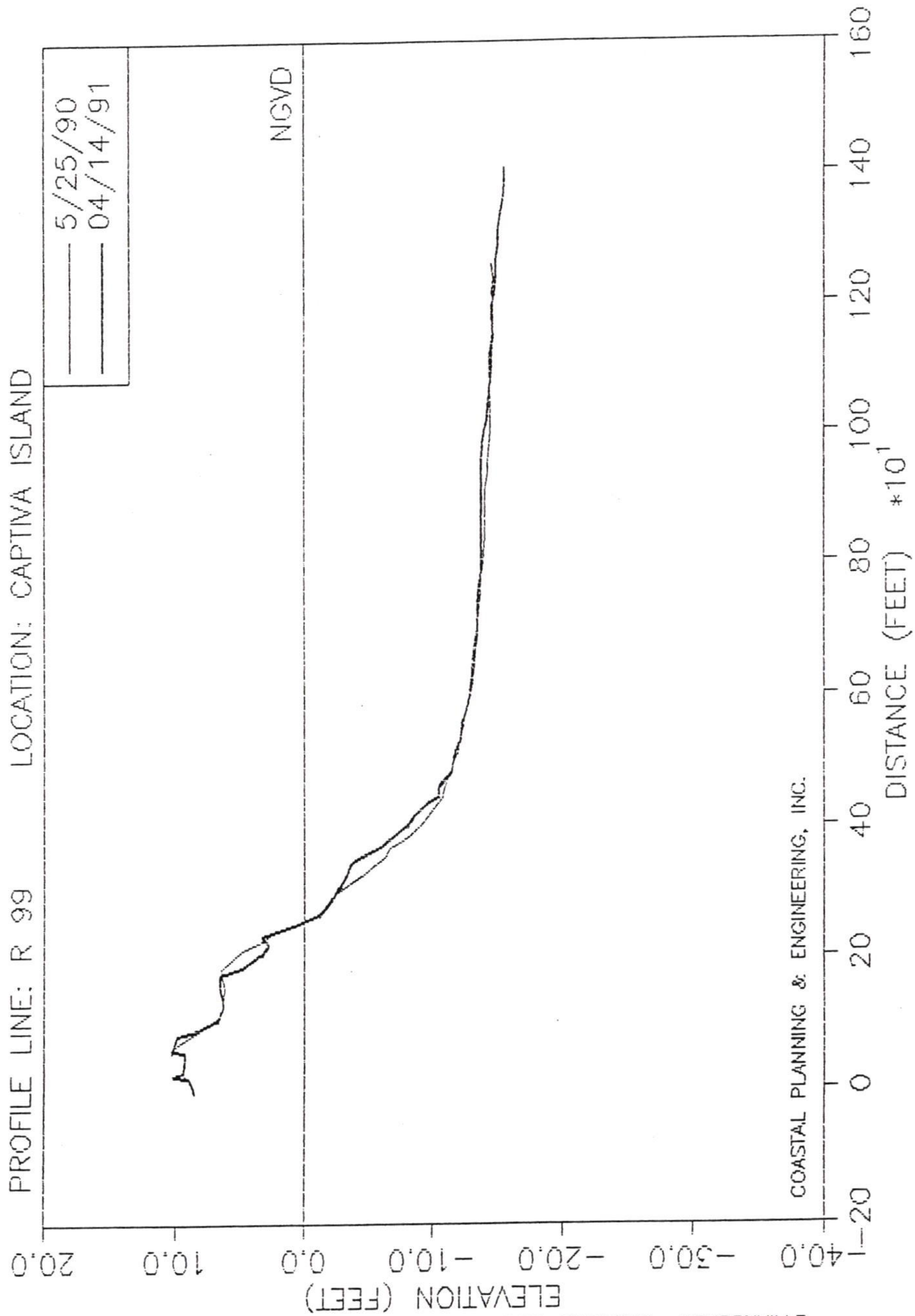

PROFILE LINE: R 96
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

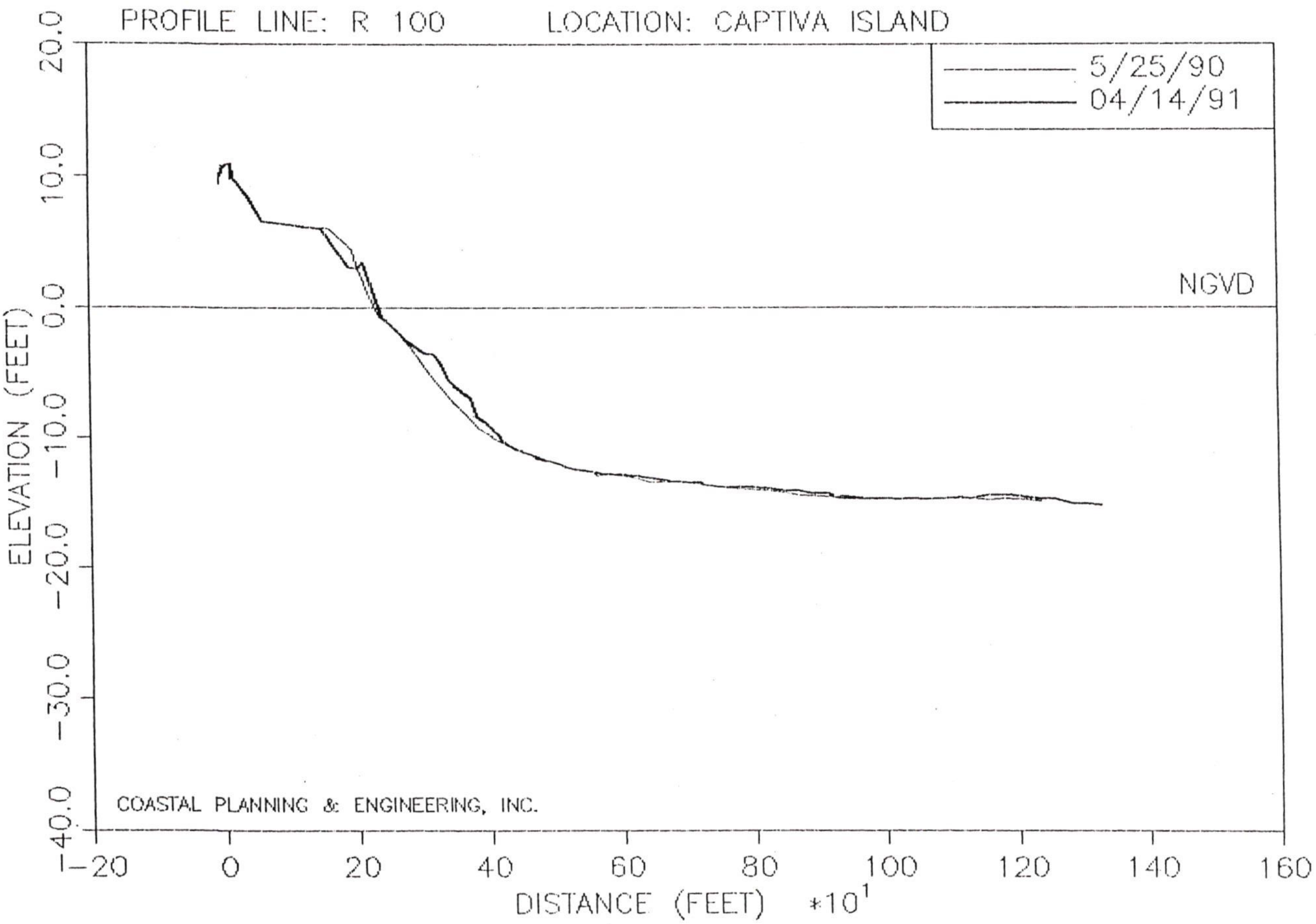


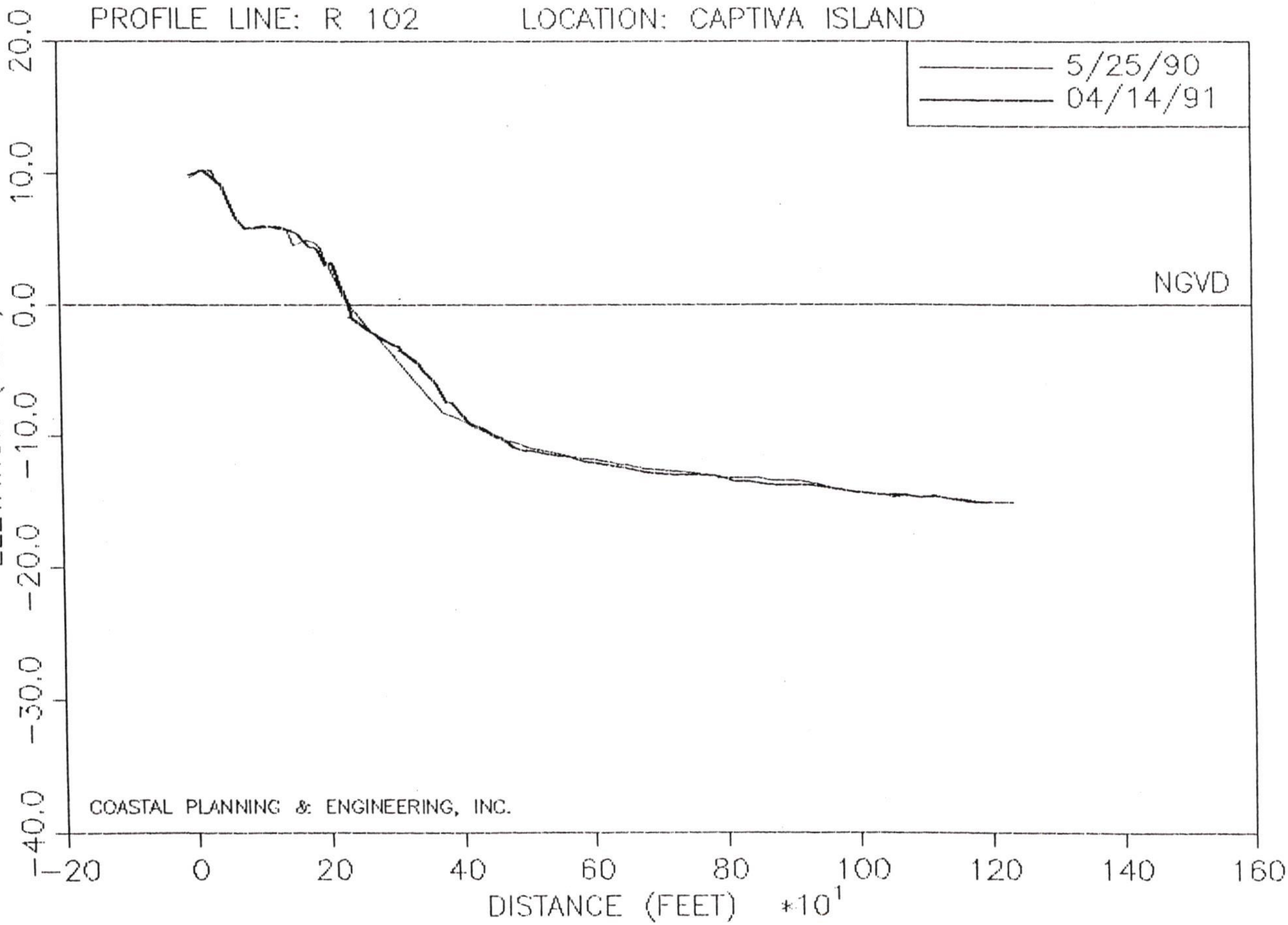
PROFILE LINE: R 97
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

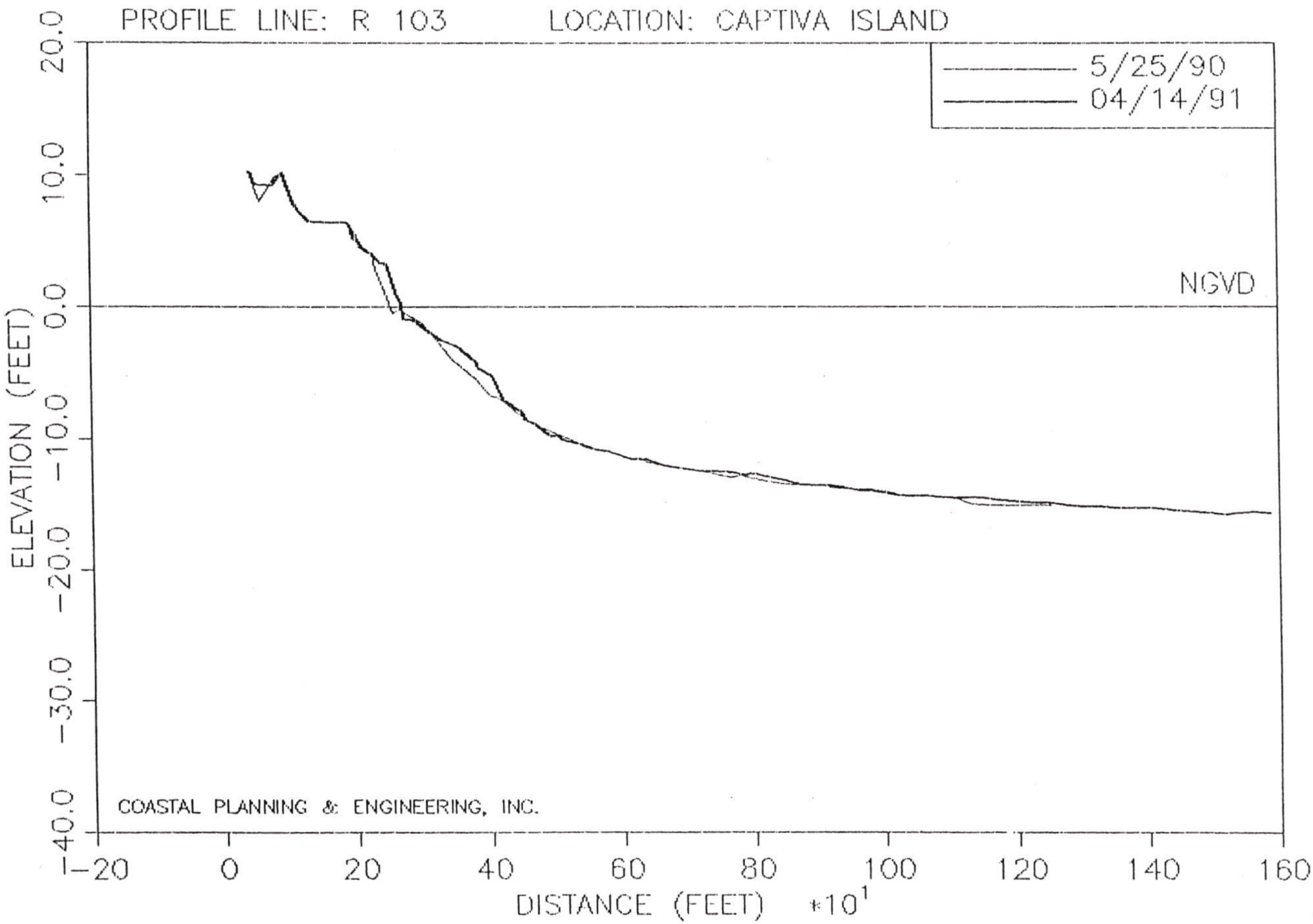


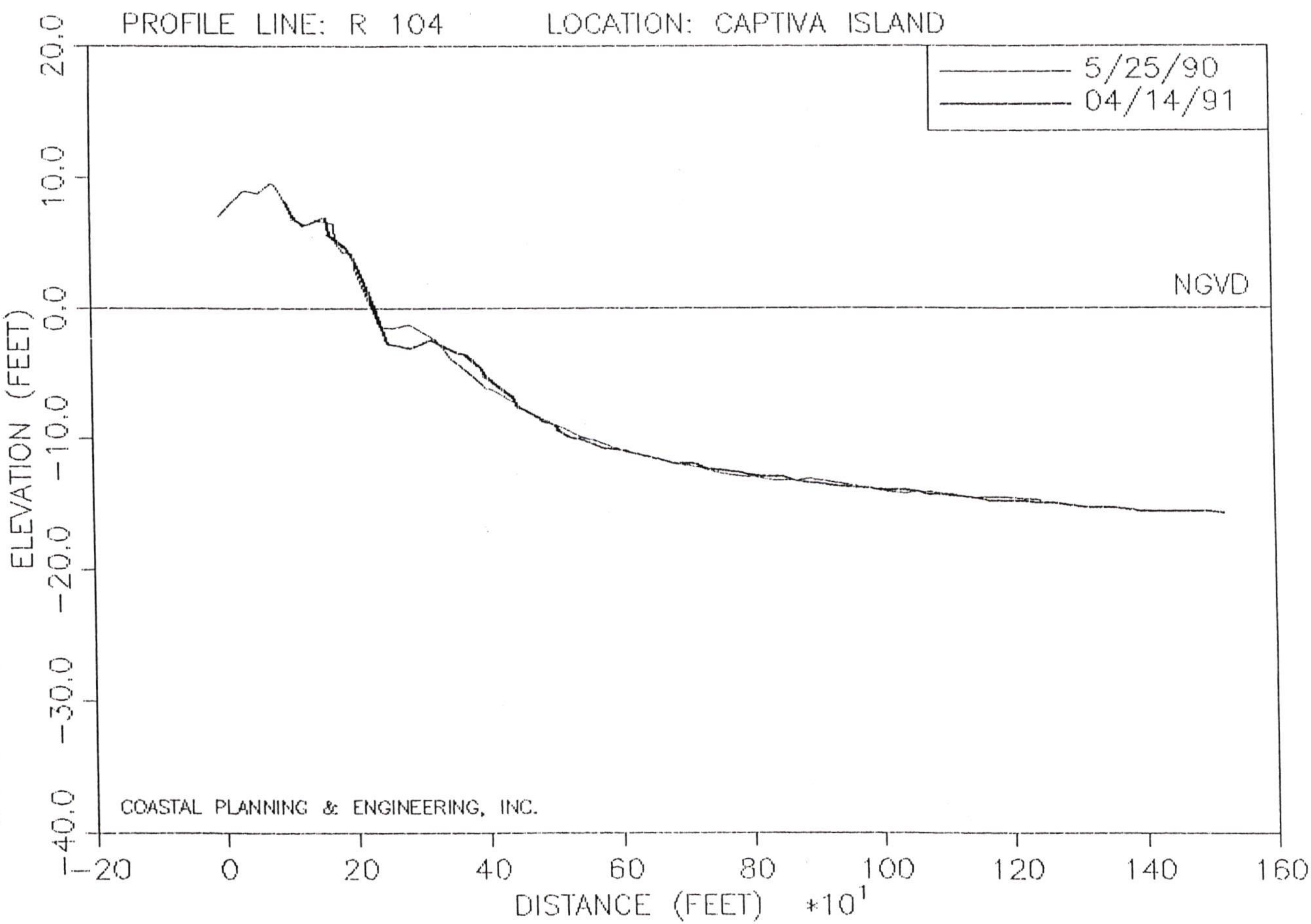
PROFILE LINE: R 98
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

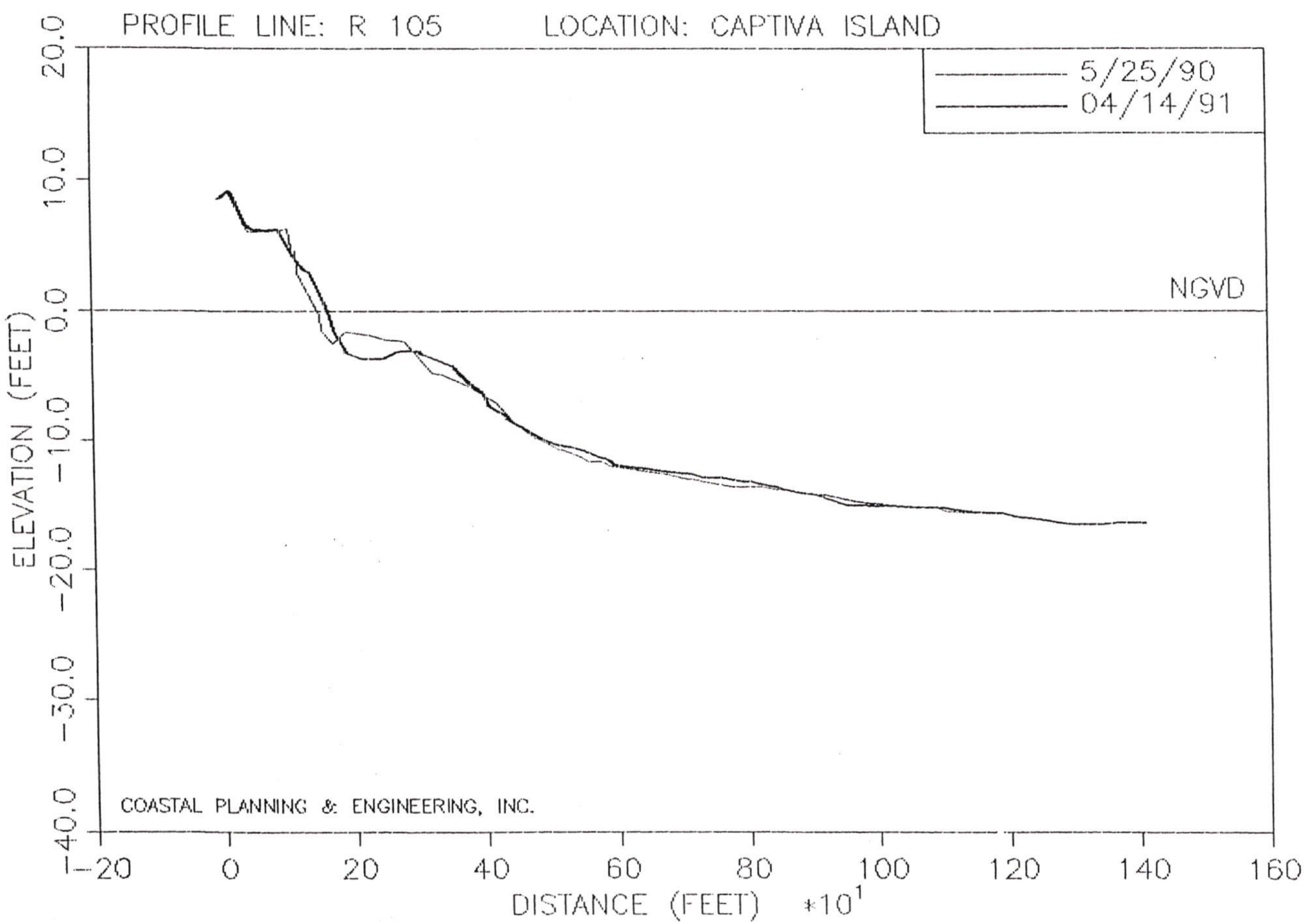

PROFILE LINE: R 99
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10^1
ELEVATION (FEET)
-20
0
20
40
60
80
100
120
140
160
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

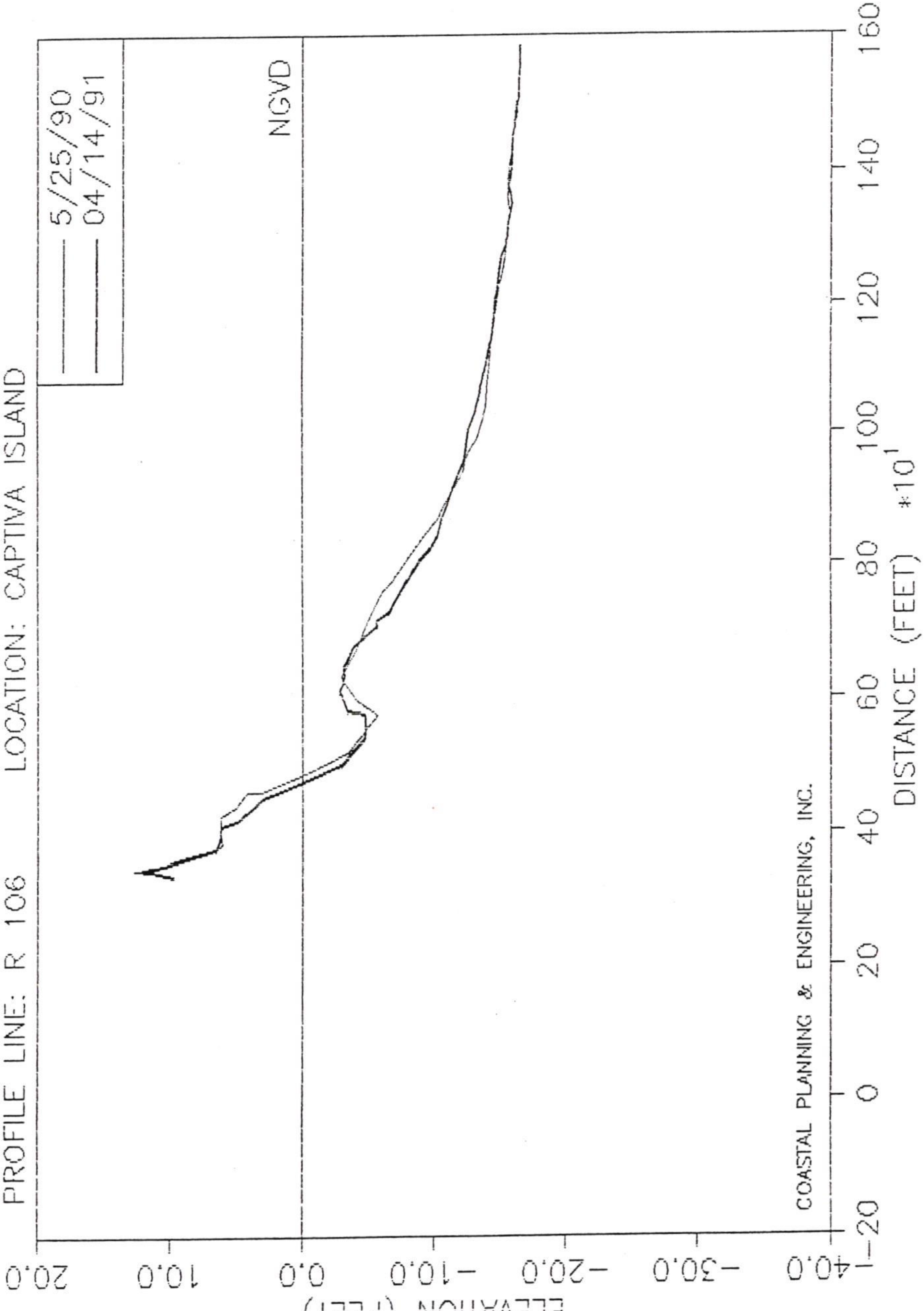

PROFILE LINE: R 100
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.

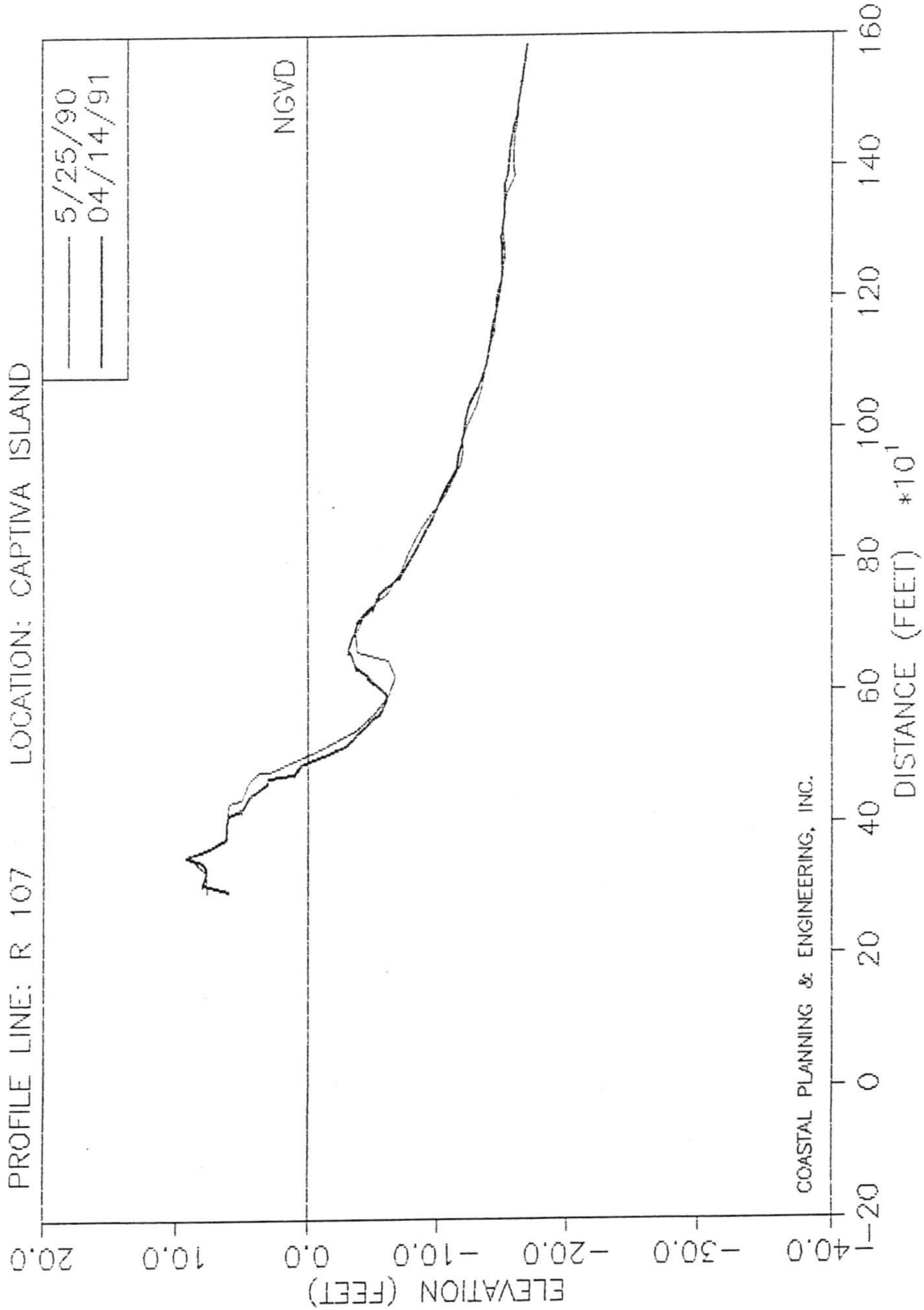

PROFILE LINE: R 102
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.

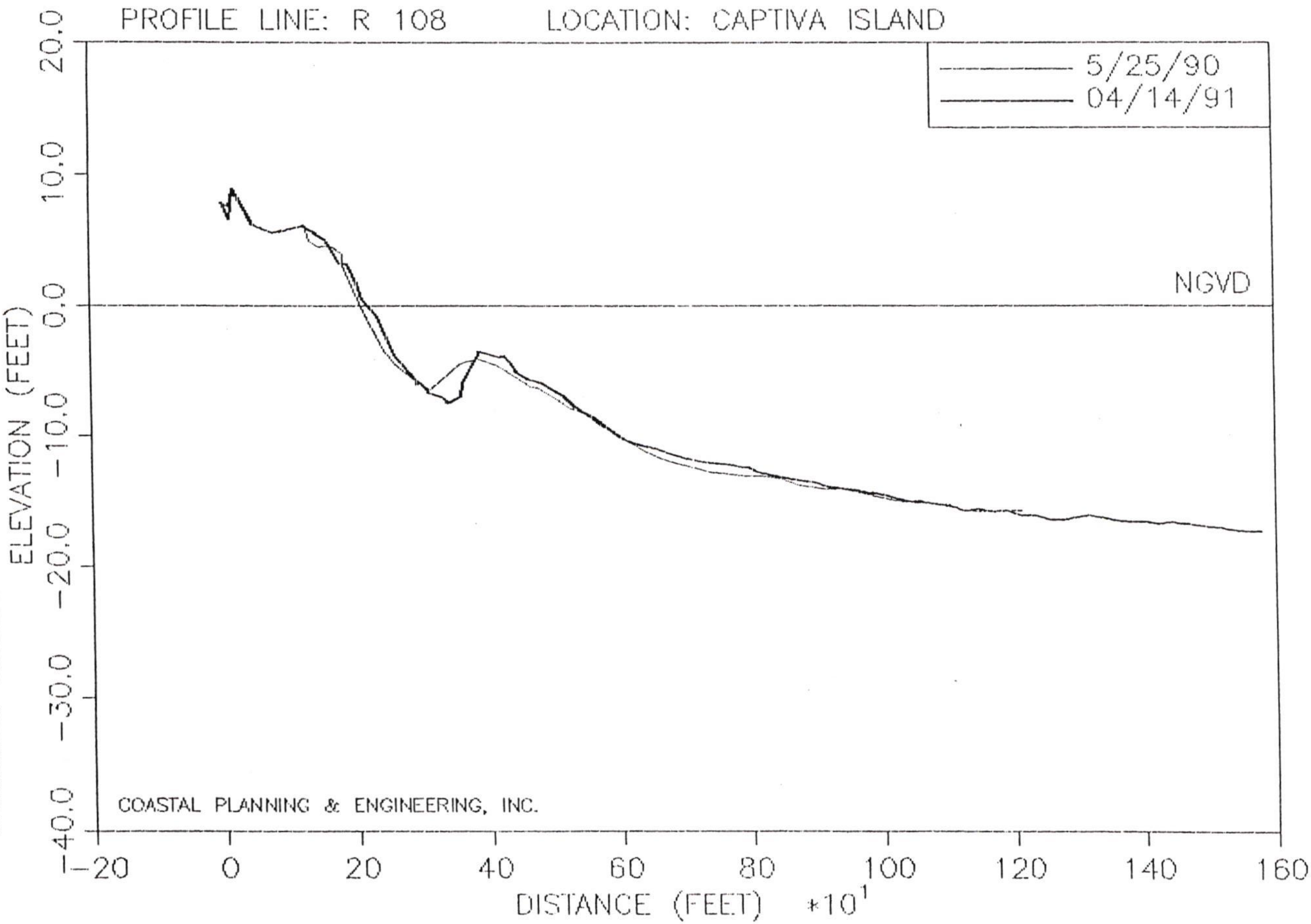

PROFILE LINE: R 103
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
−10.0
−20.0
−30.0
−40.0
−20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: R 104
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: R 105
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
ELEVATION (FEET)
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.

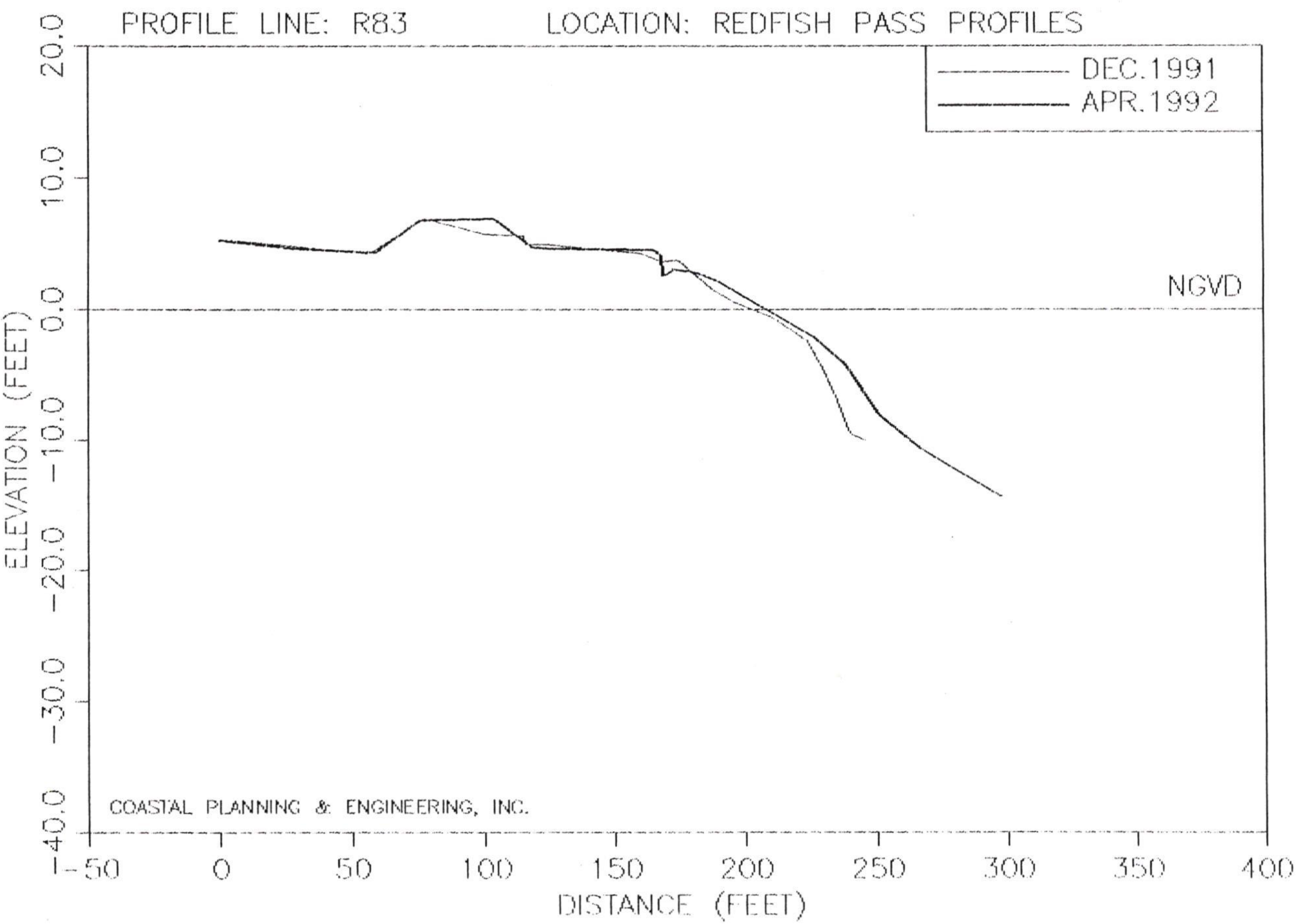

PROFILE LINE: R 106
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10¹
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

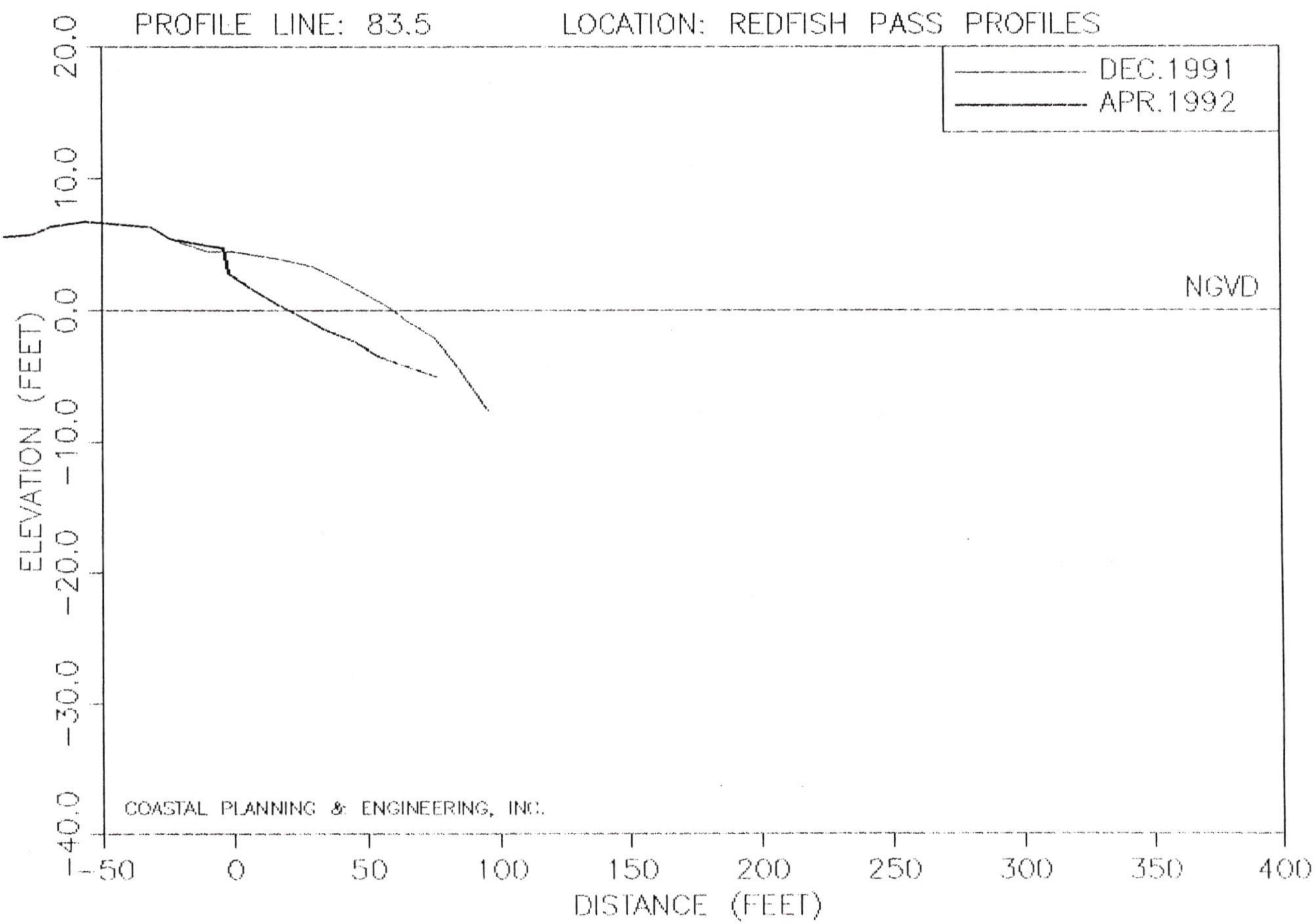

PROFILE LINE: R 107
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
COASTAL PLANNING & ENGINEERING, INC.
DISTANCE (FEET) *10[1]
-20
0
20
40
60
80
100
120
140
160
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0

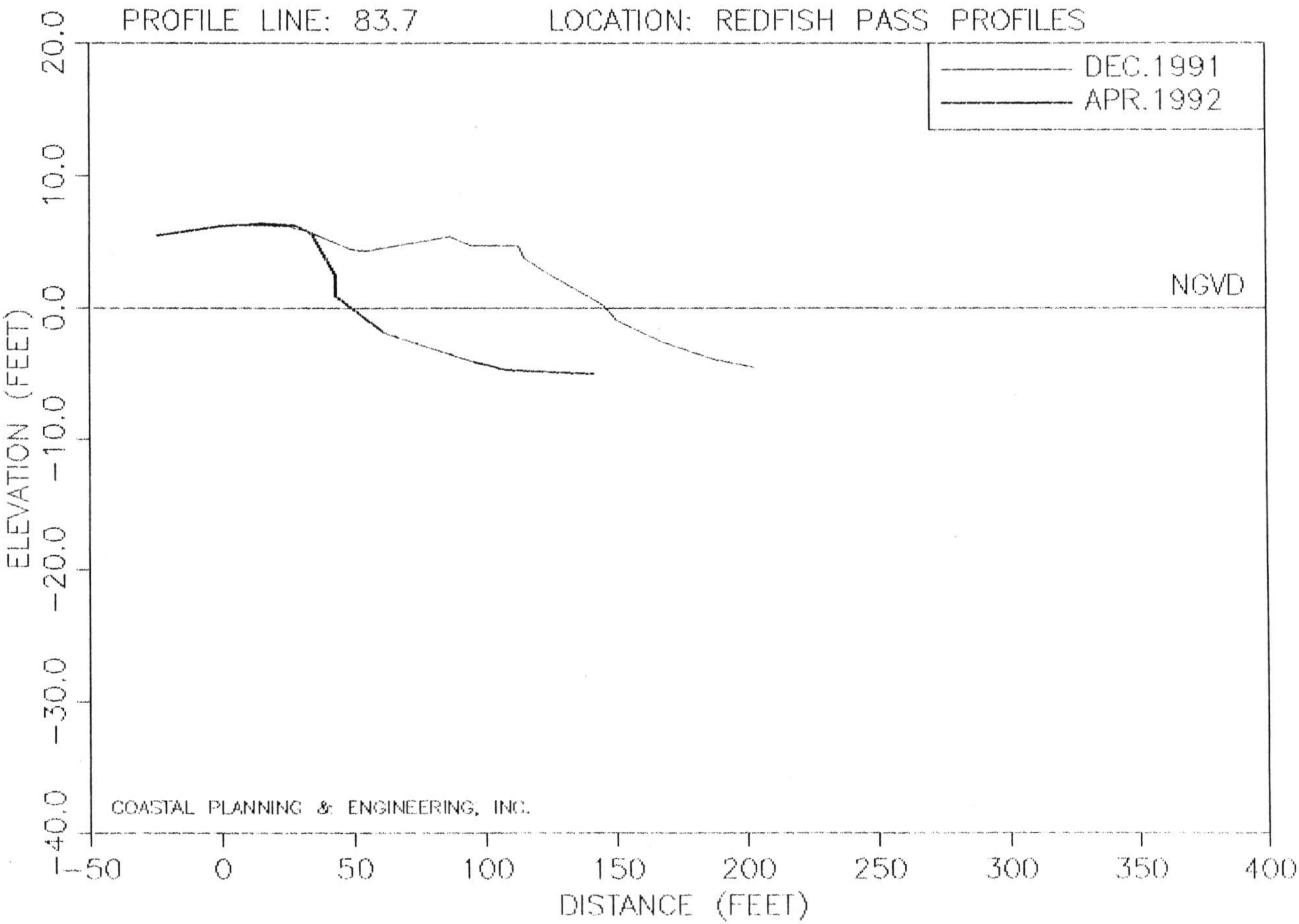

PROFILE LINE: R 108
LOCATION: CAPTIVA ISLAND
5/25/90
04/14/91
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.

APPENDIX B

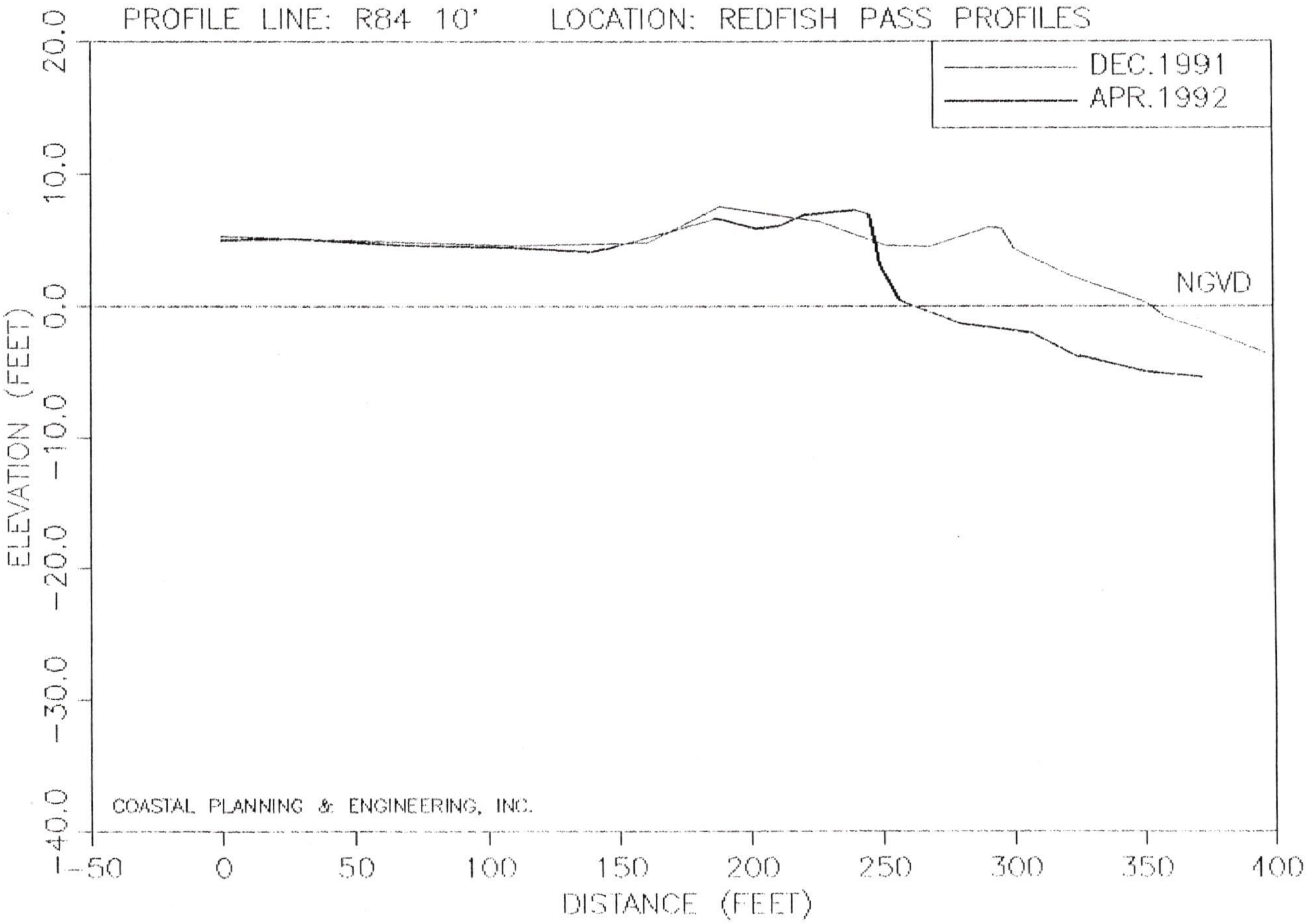
BEACH AND CROSS-SECTION PROFILES
REDFISH PASS INTERIOR SHORELINE

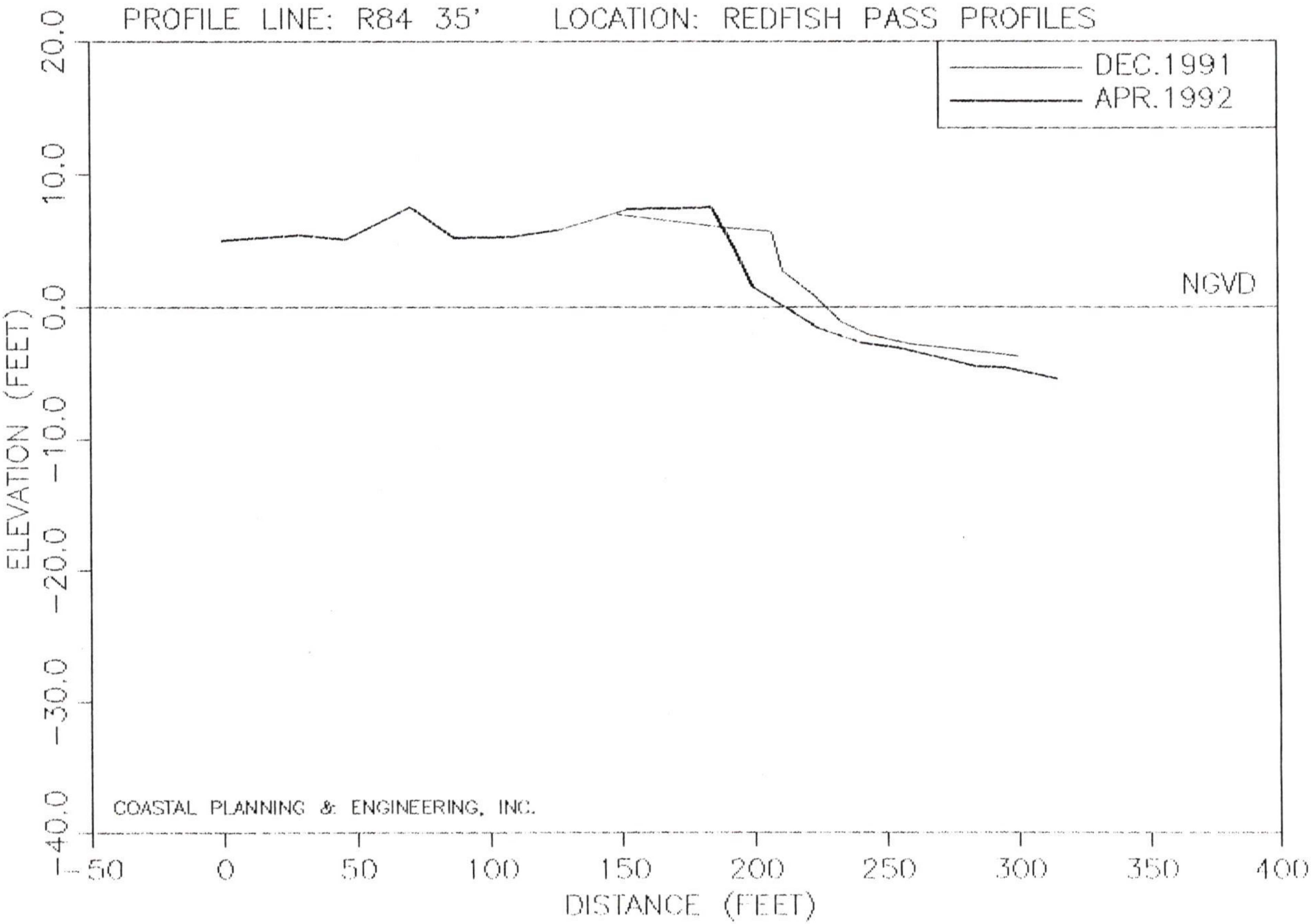

PROFILE LINE: R83
LOCATION: REDFISH PASS PROFILES
DEC.1991
APR.1992
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50
0
50
100
150
200
250
300
350
400
DISTANCE (FEET)
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: 83.5
LOCATION: REDFISH PASS PROFILES
DEC.1991
APR.1992
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50
0
50
100
150
200
250
300
350
400
DISTANCE (FEET)
COASTAL PLANNING & ENGINEERING, INC.

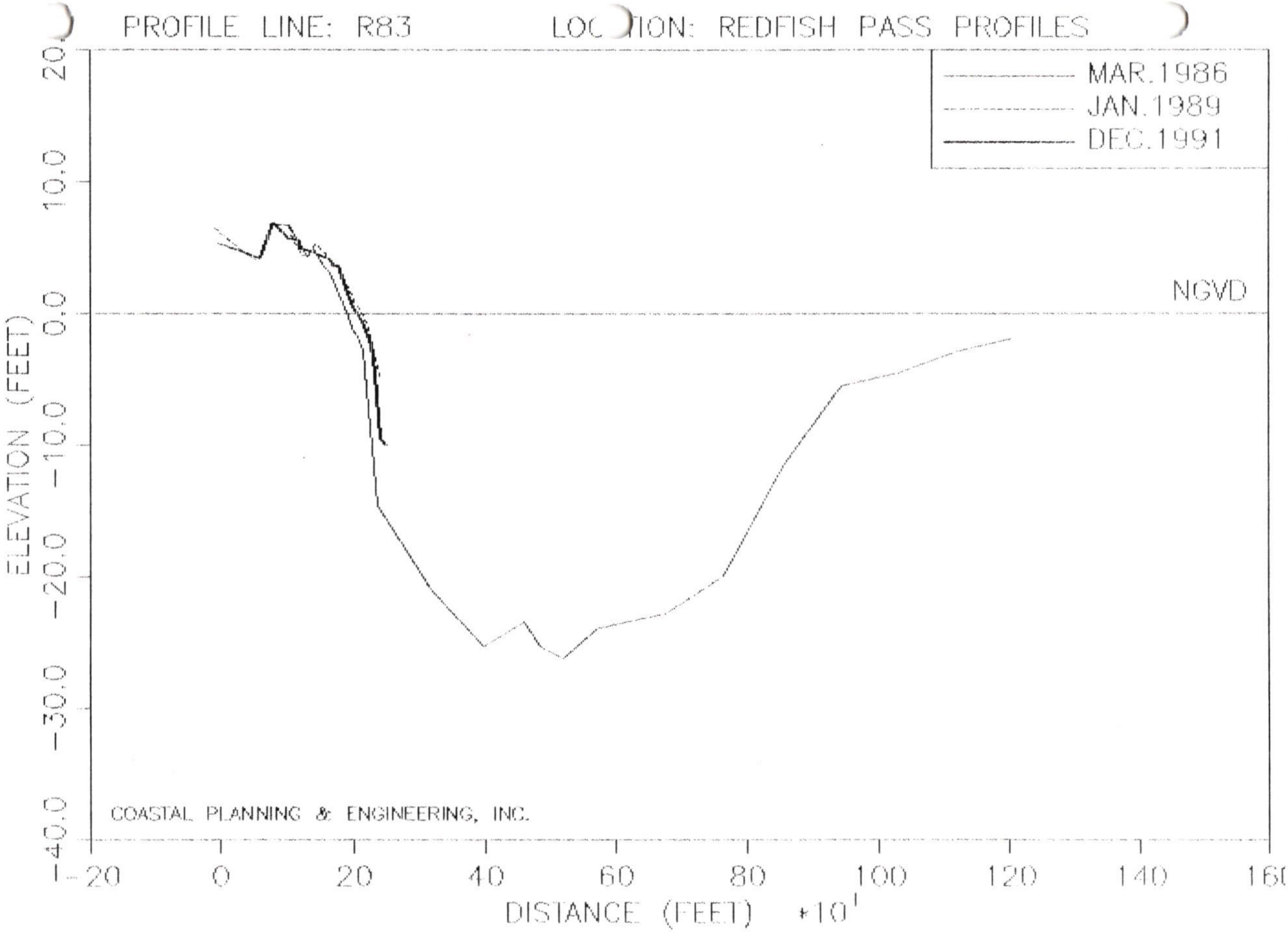


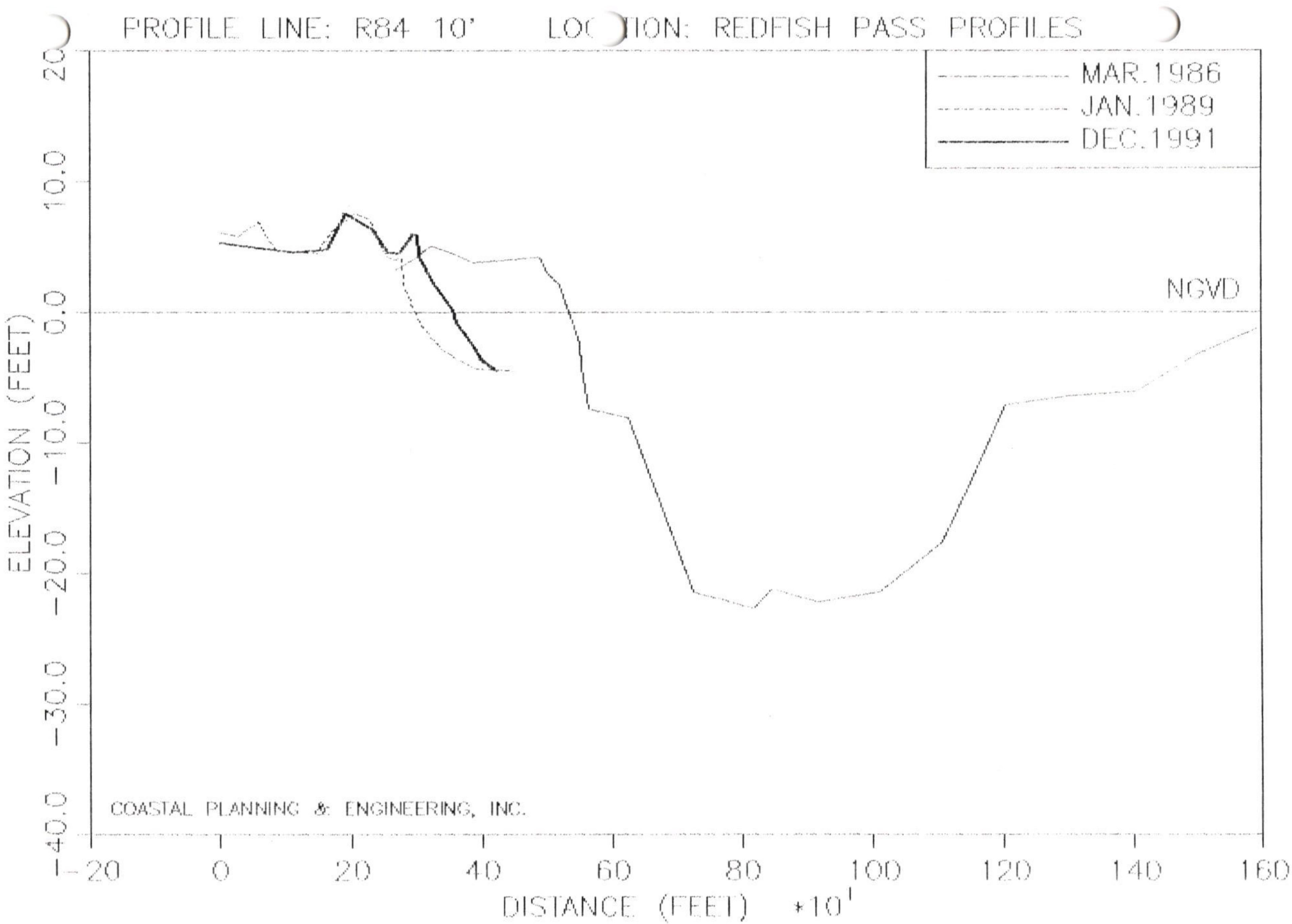
PROFILE LINE: 83.7
LOCATION: REDFISH PASS PROFILES
DEC.1991
APR.1992
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
COASTAL PLANNING & ENGINEERING, INC.
-50
0
50
100
150
200
250
300
350
400
DISTANCE (FEET)

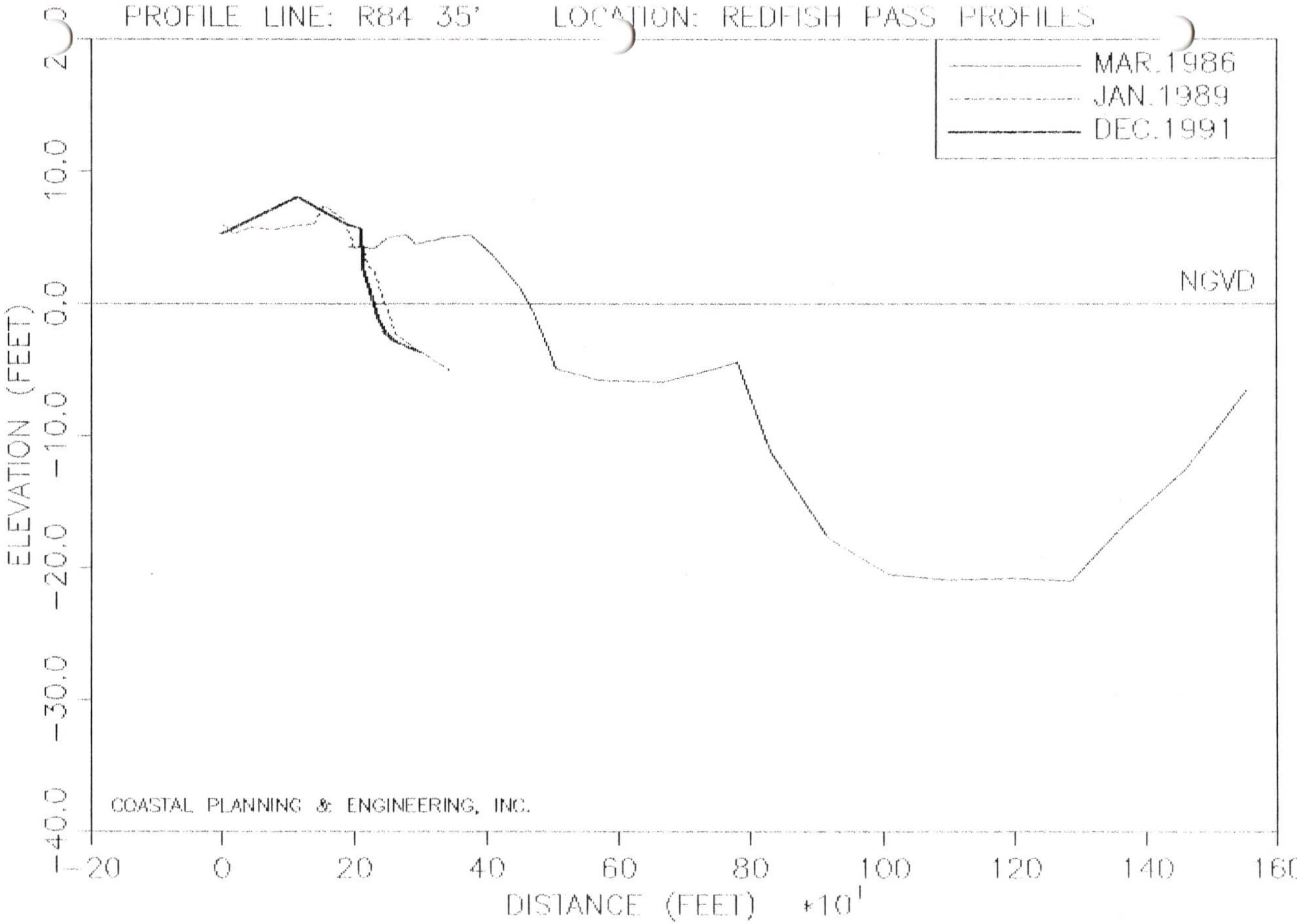

PROFILE LINE: R84 10'
LOCATION: REDFISH PASS PROFILES
DEC.1991
APR.1992
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50
0
50
100
150
200
250
300
350
400
DISTANCE (FEET)
COASTAL PLANNING & ENGINEERING, INC.



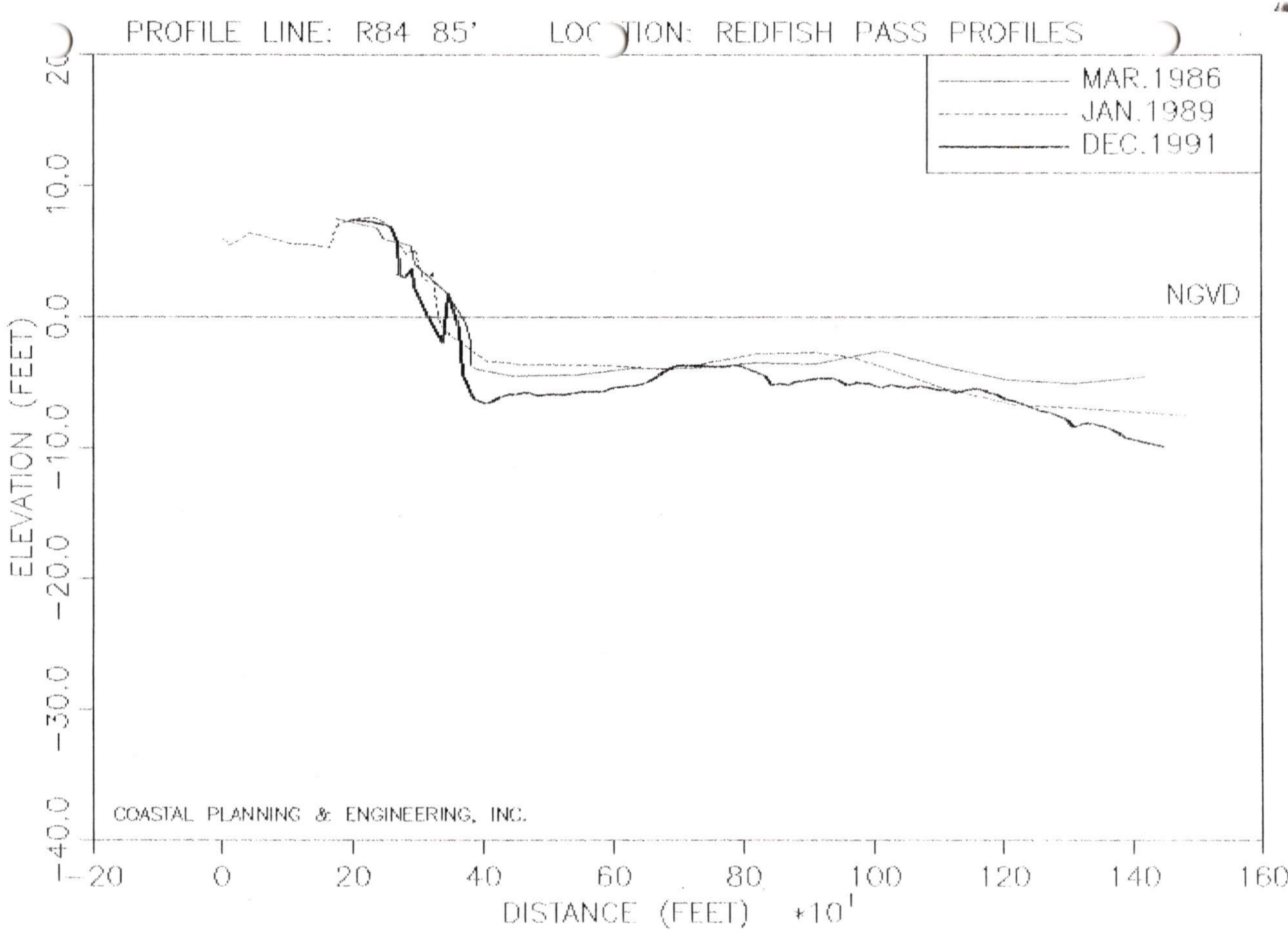
PROFILE LINE: R84 35'
LOCATION: REDFISH PASS PROFILES
DEC.1991
APR.1992
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
COASTAL PLANNING & ENGINEERING, INC.
-50
0
50
100
150
200
250
300
350
400
DISTANCE (FEET)

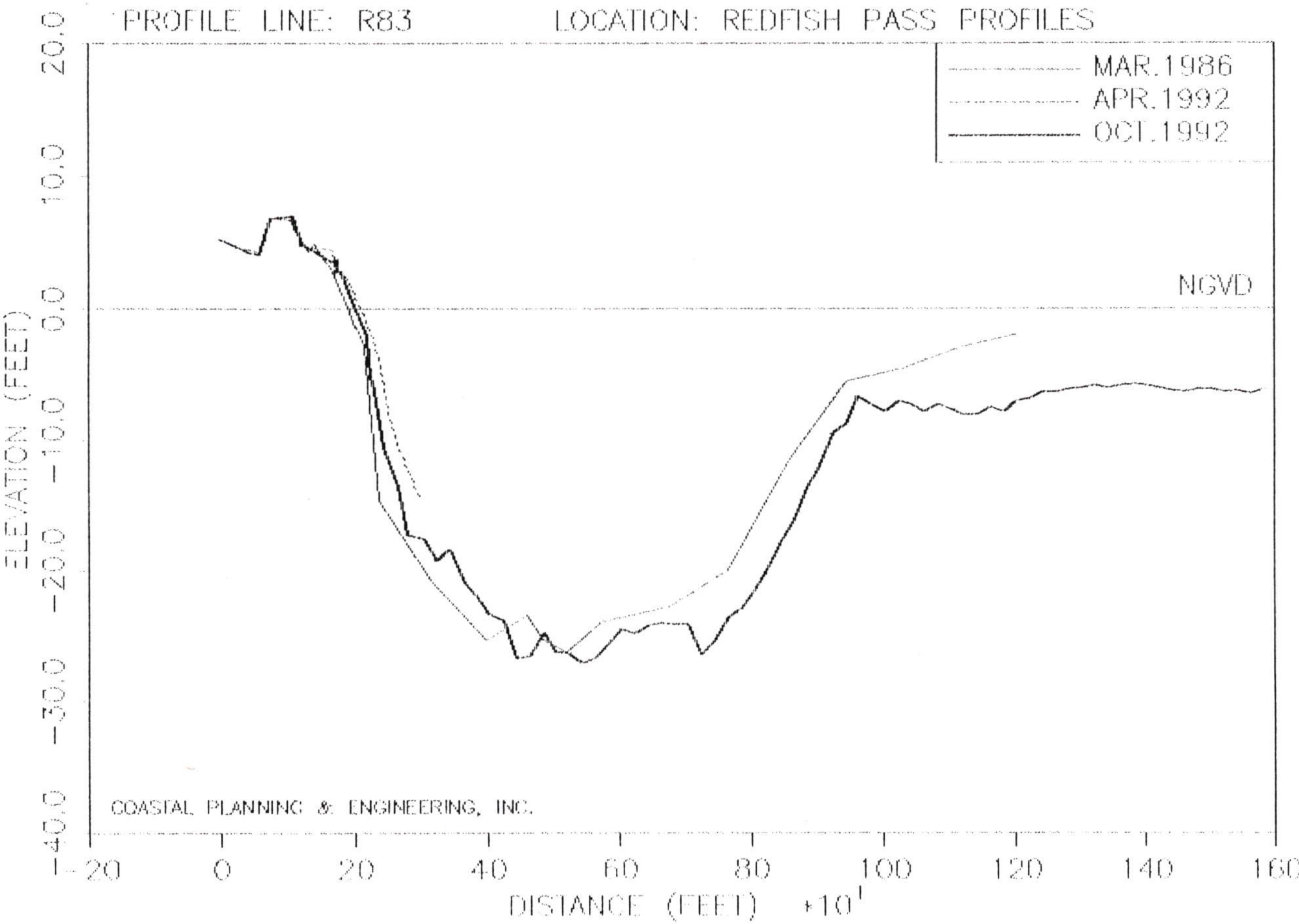

PROFILE LINE: R83
LOCATION: REDFISH PASS PROFILES
MAR.1986
JAN.1989
DEC.1991
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.

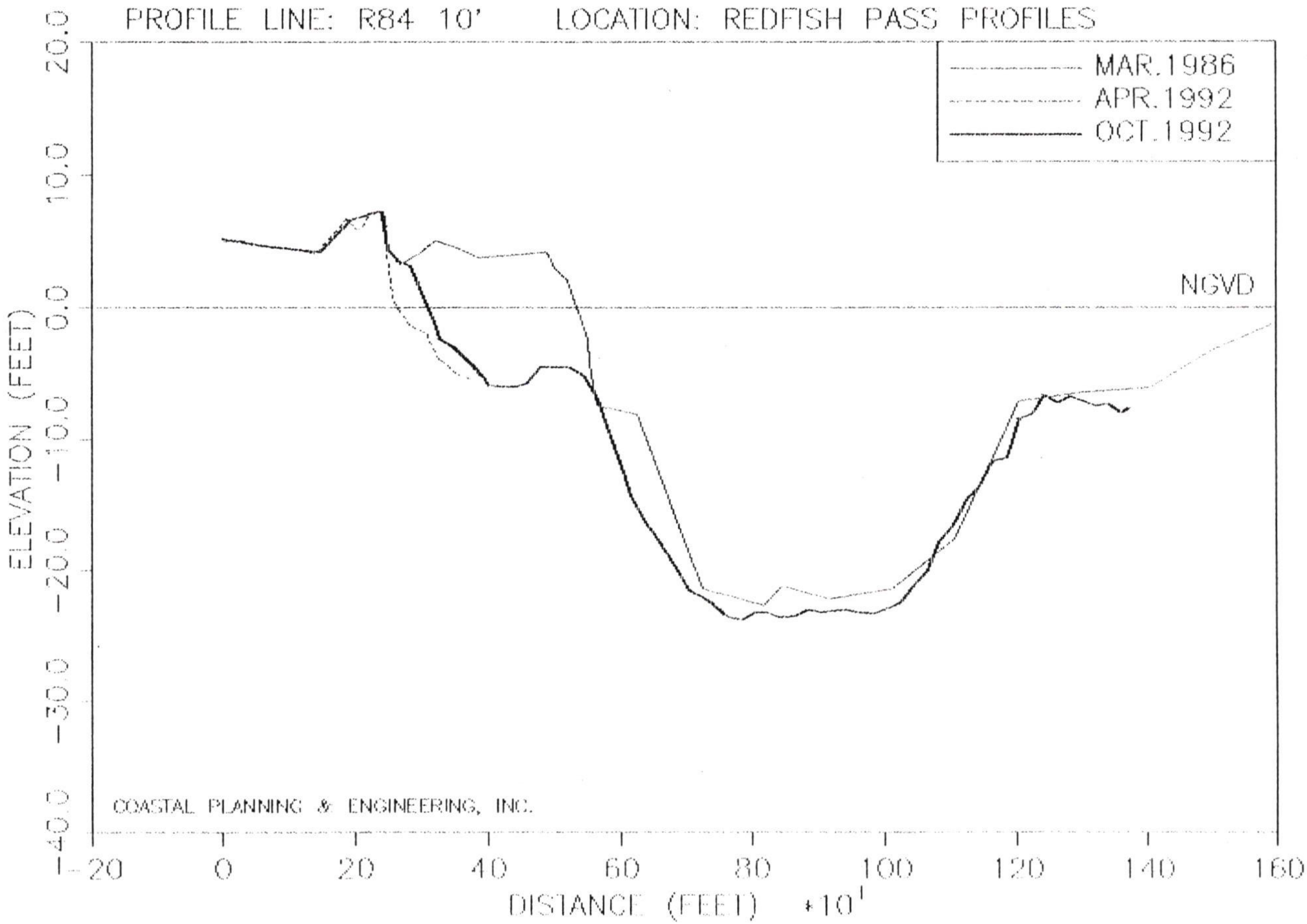

PROFILE LINE: R84 10' LOC TION: REDFISH PASS PROFILES
MAR.1986
JAN.1989
DEC.1991
NGVD
ELEVATION (FEET)
20
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.



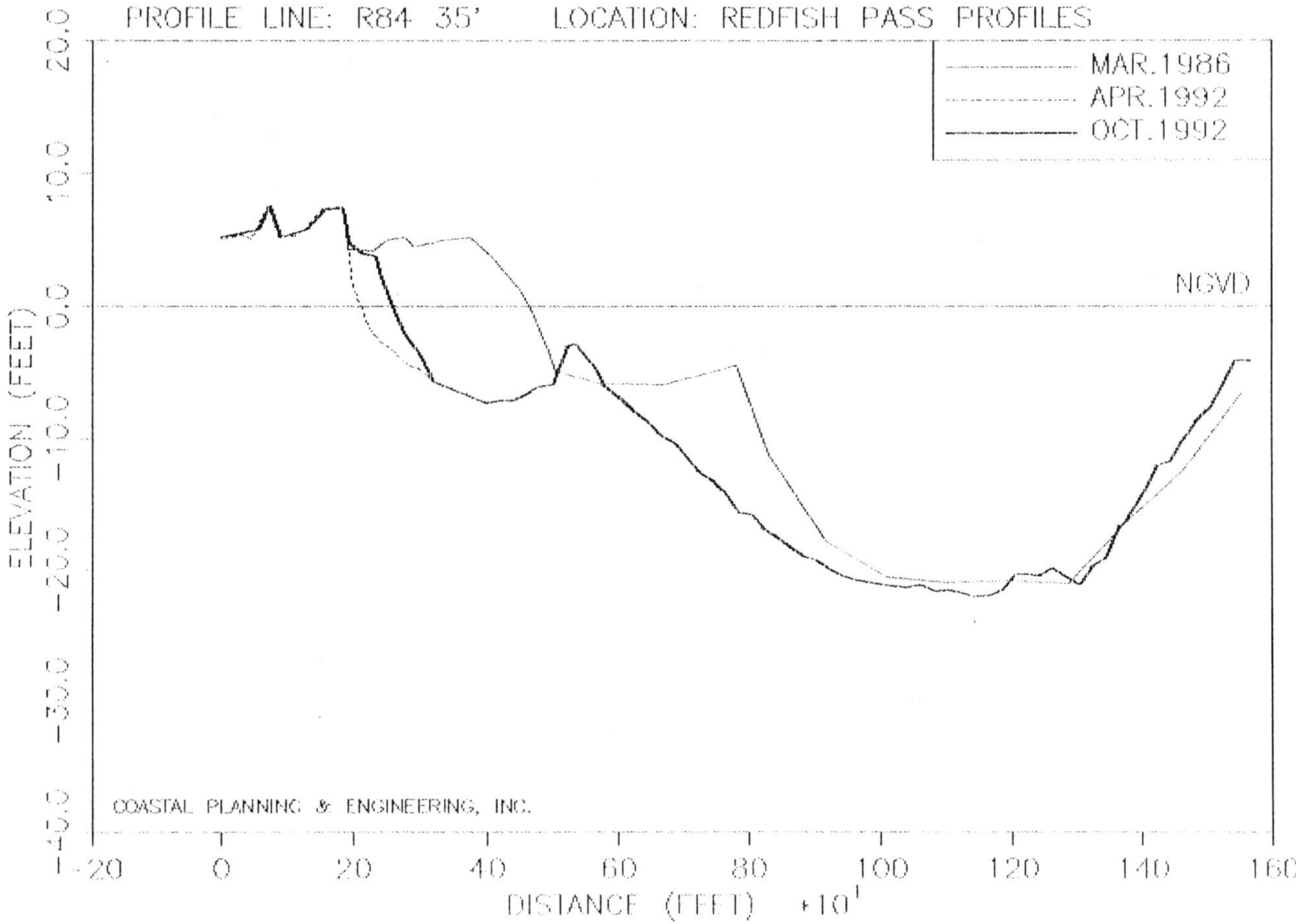
PROFILE LINE: R84 35'
LOCATION: REDFISH PASS PROFILES
MAR.1986
JAN.1989
DEC.1991
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: R84 85'
LOC TION: REDFISH PASS PROFILES
MAR.1986
JAN.1989
DEC.1991
NGVD
ELEVATION (FEET)
20
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: R83
LOCATION: REDFISH PASS PROFILES
MAR.1986
APR.1992
OCT.1992
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
COASTAL PLANNING & ENGINEERING, INC.
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]



PROFILE LINE: R84 10'
LOCATION: REDFISH PASS PROFILES
MAR.1986
APR.1992
OCT.1992
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10[1]
COASTAL PLANNING & ENGINEERING, INC.


PROFILE LINE: R84 35'
LOCATION: REDFISH PASS PROFILES
MAR.1986
APR.1992
OCT.1992
NGVD
ELEVATION (FEET)
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
COASTAL PLANNING & ENGINEERING, INC.
-20
0
20
40
60
80
100
120
140
160
DISTANCE (FEET) *10^1

APPENDIX C

ENGINEERING ALTERNATIVES - COST ESTIMATES

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: A. CLOSE THE INLET AND REMOVE THE TERMINAL GROIN

		GROIN REMOVAL	
CONTINGENCY	15%	MOB COST	$50,000
E&D&S&A	10%	3,106 TONS @ $30	$93,180
		FILL COST	
		MOB COST W/ DREDGE	$525,000
		SHEET PILES INSTAL	$242,796
		FILL @ $5/CY	$500,000

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH	SAND VOLUME (CY)
1993	$1,784,000	1.00000	$1,784,000	100,000
1994	$0	0.97087	$0	0
1995	$0	0.94260	$0	0
1996	$0	0.91514	$0	0
1997	$0	0.88849	$0	0
1998	$0	0.86261	$0	0
1999	$0	0.83748	$0	0
2000	$0	0.81309	$0	0
2001	$0	0.78941	$0	0
2002	$0	0.76642	$0	0
2003	$0	0.74409	$0	0
2004	$0	0.72242	$0	0
2005	$0	0.70138	$0	0
2006	$0	0.68095	$0	0
2007	$0	0.66112	$0	0
2008	$0	0.64186	$0	0
2009	$0	0.62317	$0	0
2010	$0	0.60502	$0	0
2011	$0	0.58739	$0	0
2012	$0	0.57029	$0	0
2013	$0	0.55368	$0	0
2014	$0	0.53755	$0	0
2015	$0	0.52189	$0	0
2016	$0	0.50669	$0	0
2017	$0	0.49193	$0	0
2018	$0	0.47761	$0	0
2019	$0	0.46369	$0	0
2020	$0	0.45019	$0	0
2021	$0	0.43708	$0	0
2022	$0	0.42435	$0	0
2023	$0	0.41199	$0	0
2024	$0	0.39999	$0	0
2025	$0	0.38834	$0	0
2026	$0	0.37703	$0	0
2027	$0	0.36604	$0	0
2028	$0	0.35538	$0	0
2029	$0	0.34503	$0	0
2030	$0	0.33498	$0	0
2031	$0	0.32523	$0	0
2032	$0	0.31575	$0	0
2033	$0	0.30656	$0	0
2034	$0	0.29763	$0	0
2035	$0	0.28896	$0	0
2036	$0	0.28054	$0	0
2037	$0	0.27237	$0	0
2038	$0	0.26444	$0	0
2039	$0	0.25674	$0	0
2040	$0	0.24926	$0	0
2041	$0	0.24200	$0	0
2042	$0	0.23495	$0	0
2043	$0	0.22811	$0	0

SUM OF PRESENT WORTHS	$1,784,000
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$69,336

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.1. STATUS QUO (CONTINUE BEACH MAINTENANCE NOURISHMENT PROGRAM AND LEAVE GROIN IN PLACE))

CONTINGENCY 15%
E&D&S&A 10%

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH
1993	$0	1.00000	$0
1994	$0	0.97087	$0
1995	$0	0.94260	$0
1996	$0	0.91514	$0
1997	$0	0.88849	$0
1998	$0	0.86261	$0
1999	$0	0.83748	$0
2000	$0	0.81309	$0
2001	$0	0.78941	$0
2002	$0	0.76642	$0
2003	$0	0.74409	$0
2004	$0	0.72242	$0
2005	$0	0.70138	$0
2006	$0	0.68095	$0
2007	$0	0.66112	$0
2008	$0	0.64186	$0
2009	$0	0.62317	$0
2010	$0	0.60502	$0
2011	$0	0.58739	$0
2012	$0	0.57029	$0
2013	$0	0.55368	$0
2014	$0	0.53755	$0
2015	$0	0.52189	$0
2016	$0	0.50669	$0
2017	$0	0.49193	$0
2018	$0	0.47761	$0
2019	$0	0.46369	$0
2020	$0	0.45019	$0
2021	$0	0.43708	$0
2022	$0	0.42435	$0
2023	$0	0.41199	$0
2024	$0	0.39999	$0
2025	$0	0.38834	$0
2026	$0	0.37703	$0
2027	$0	0.36604	$0
2028	$0	0.35538	$0
2029	$0	0.34503	$0
2030	$0	0.33498	$0
2031	$0	0.32523	$0
2032	$0	0.31575	$0
2033	$0	0.30656	$0
2034	$0	0.29763	$0
2035	$0	0.28896	$0
2036	$0	0.28054	$0
2037	$0	0.27237	$0
2038	$0	0.26444	$0
2039	$0	0.25674	$0
2040	$0	0.24926	$0
2041	$0	0.24200	$0
2042	$0	0.23495	$0
2043	$0	0.22811	$0

SUM OF PRESENT WORTHS	$0
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$0

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.2. NO ACTION (STOP BEACH MAINTENANCE NOURISHMENT)

CONTINGENCY 15% NO COST
E&D&S&A 10%

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH
1993	$0	1.00000	$0
1994	$0	0.97087	$0
1995	$0	0.94260	$0
1996	$0	0.91514	$0
1997	$0	0.88849	$0
1998	$0	0.86261	$0
1999	$0	0.83748	$0
2000	$0	0.81309	$0
2001	$0	0.78941	$0
2002	$0	0.76642	$0
2003	$0	0.74409	$0
2004	$0	0.72242	$0
2005	$0	0.70138	$0
2006	$0	0.68095	$0
2007	$0	0.66112	$0
2008	$0	0.64186	$0
2009	$0	0.62317	$0
2010	$0	0.60502	$0
2011	$0	0.58739	$0
2012	$0	0.57029	$0
2013	$0	0.55368	$0
2014	$0	0.53755	$0
2015	$0	0.52189	$0
2016	$0	0.50669	$0
2017	$0	0.49193	$0
2018	$0	0.47761	$0
2019	$0	0.46369	$0
2020	$0	0.45019	$0
2021	$0	0.43708	$0
2022	$0	0.42435	$0
2023	$0	0.41199	$0
2024	$0	0.39999	$0
2025	$0	0.38834	$0
2026	$0	0.37703	$0
2027	$0	0.36604	$0
2028	$0	0.35538	$0
2029	$0	0.34503	$0
2030	$0	0.33498	$0
2031	$0	0.32523	$0
2032	$0	0.31575	$0
2033	$0	0.30656	$0
2034	$0	0.29763	$0
2035	$0	0.28896	$0
2036	$0	0.28054	$0
2037	$0	0.27237	$0
2038	$0	0.26444	$0
2039	$0	0.25674	$0
2040	$0	0.24926	$0
2041	$0	0.24200	$0
2042	$0	0.23495	$0
2043	$0	0.22811	$0

SUM OF PRESENT WORTHS	$0
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$0

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.3. REMOVE THE TERMINAL GROIN

		REMOVAL COSTS	
CONTINGENCY	15%	MOB COST	$50,000
E&D&S&A	10%	3,106 TONS @ $30	$93,180

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH
1993	$181,123	1.00000	$181,123
1994	$0	0.97087	$0
1995	$0	0.94260	$0
1996	$0	0.91514	$0
1997	$0	0.88849	$0
1998	$0	0.86261	$0
1999	$0	0.83748	$0
2000	$0	0.81309	$0
2001	$0	0.78941	$0
2002	$0	0.76642	$0
2003	$0	0.74409	$0
2004	$0	0.72242	$0
2005	$0	0.70138	$0
2006	$0	0.68095	$0
2007	$0	0.66112	$0
2008	$0	0.64186	$0
2009	$0	0.62317	$0
2010	$0	0.60502	$0
2011	$0	0.58739	$0
2012	$0	0.57029	$0
2013	$0	0.55368	$0
2014	$0	0.53755	$0
2015	$0	0.52189	$0
2016	$0	0.50669	$0
2017	$0	0.49193	$0
2018	$0	0.47761	$0
2019	$0	0.46369	$0
2020	$0	0.45019	$0
2021	$0	0.43708	$0
2022	$0	0.42435	$0
2023	$0	0.41199	$0
2024	$0	0.39999	$0
2025	$0	0.38834	$0
2026	$0	0.37703	$0
2027	$0	0.36604	$0
2028	$0	0.35538	$0
2029	$0	0.34503	$0
2030	$0	0.33498	$0
2031	$0	0.32523	$0
2032	$0	0.31575	$0
2033	$0	0.30656	$0
2034	$0	0.29763	$0
2035	$0	0.28896	$0
2036	$0	0.28054	$0
2037	$0	0.27237	$0
2038	$0	0.26444	$0
2039	$0	0.25674	$0
2040	$0	0.24926	$0
2041	$0	0.24200	$0
2042	$0	0.23495	$0
2043	$0	0.22811	$0

SUM OF PRESENT WORTHS	$181,123
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$7,039

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLA
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.4. CHANGE THE BORROW AREA

CONTINGENCY	15%	COST DIFFERENCE	$2,260,000
E&D&S&A	10%	SITE IV AND III	

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH
1993	$0	1.00000	$0
1994	$0	0.97087	$0
1995	$0	0.94260	$0
1996	$0	0.91514	$0
1997	$0	0.88849	$0
1998	$0	0.86261	$0
1999	$0	0.83748	$0
2000	$0	0.81309	$0
2001	$0	0.78941	$0
2002	$0	0.76642	$0
2003	$0	0.74409	$0
2004	$0	0.72242	$0
2005	$0	0.70138	$0
2006	$0	0.68095	$0
2007	$2,260,000	0.66112	$1,494,126
2008	$0	0.64186	$0
2009	$0	0.62317	$0
2010	$0	0.60502	$0
2011	$0	0.58739	$0
2012	$0	0.57029	$0
2013	$0	0.55368	$0
2014	$0	0.53755	$0
2015	$0	0.52189	$0
2016	$0	0.50669	$0
2017	$0	0.49193	$0
2018	$0	0.47761	$0
2019	$0	0.46369	$0
2020	$0	0.45019	$0
2021	$0	0.43708	$0
2022	$0	0.42435	$0
2023	$0	0.41199	$0
2024	$0	0.39999	$0
2025	$2,260,000	0.38834	$877,642
2026	$0	0.37703	$0
2027	$0	0.36604	$0
2028	$0	0.35538	$0
2029	$0	0.34503	$0
2030	$0	0.33498	$0
2031	$0	0.32523	$0
2032	$0	0.31575	$0
2033	$0	0.30656	$0
2034	$0	0.29763	$0
2035	$0	0.28896	$0
2036	$0	0.28054	$0
2037	$0	0.27237	$0
2038	$0	0.26444	$0
2039	$0	0.25674	$0
2040	$0	0.24926	$0
2041	$0	0.24200	$0
2042	$0	0.23495	$0
2043	$2,260,000	0.22811	$515,522
SUM OF PRESENT WORTHS			$2,887,290
CAPITAL RECOVERY FACTOR			0.03887
AVERAGE ANNUAL VALUE			$112,216

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.5. ADD FEEDER BEACH TO BEACH MAINTENANCE NOURISHME PROGRAM

		MARGINAL COST	
CONTINGENCY	15%	32% OF IN CYCLE	$2,528,088
E&D&S&A	10%	COST ($7,900,276)	

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH	SAND VOLUME (CY)
1993	$0	1.00000	$0	0
1994	$0	0.97087	$0	0
1995	$2,528,088	0.94260	$2,382,965	192,000
1996	$0	0.91514	$0	0
1997	$0	0.88849	$0	0
1998	$0	0.86261	$0	0
1999	$0	0.83748	$0	0
2000	$0	0.81309	$0	0
2001	$2,528,088	0.78941	$1,995,696	192,000
2002	$0	0.76642	$0	0
2003	$0	0.74409	$0	0
2004	$0	0.72242	$0	0
2005	$0	0.70138	$0	0
2006	$0	0.68095	$0	0
2007	$2,528,088	0.66112	$1,671,364	192,000
2008	$0	0.64186	$0	0
2009	$0	0.62317	$0	0
2010	$0	0.60502	$0	0
2011	$0	0.58739	$0	0
2012	$0	0.57029	$0	0
2013	$2,528,088	0.55368	$1,399,741	192,000
2014	$0	0.53755	$0	0
2015	$0	0.52189	$0	0
2016	$0	0.50669	$0	0
2017	$0	0.49193	$0	0
2018	$0	0.47761	$0	0
2019	$2,528,088	0.46369	$1,172,261	192,000
2020	$0	0.45019	$0	0
2021	$0	0.43708	$0	0
2022	$0	0.42435	$0	0
2023	$0	0.41199	$0	0
2024	$0	0.39999	$0	0
2025	$2,528,088	0.38834	$981,750	192,000
2026	$0	0.37703	$0	0
2027	$0	0.36604	$0	0
2028	$0	0.35538	$0	0
2029	$0	0.34503	$0	0
2030	$0	0.33498	$0	0
2031	$2,528,088	0.32523	$822,200	192,000
2032	$0	0.31575	$0	0
2033	$0	0.30656	$0	0
2034	$0	0.29763	$0	0
2035	$0	0.28896	$0	0
2036	$0	0.28054	$0	0
2037	$2,528,088	0.27237	$688,580	192,000
2038	$0	0.26444	$0	0
2039	$0	0.25674	$0	0
2040	$0	0.24926	$0	0
2041	$0	0.24200	$0	0
2042	$0	0.23495	$0	0
2043	$2,528,088	0.22811	$576,675	192,000

SUM OF PRESENT WORTHS	$11,691,233
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$454,386

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.6. CONSTRUCT DEPOSTIONAL BASIN WITH FEEDER BEACH

		IN CYCLE COST	
CONTINGENCY	15%	96,000 CY @ $7.44	$714,240
E&D&S&A	10%	OUT CYCLE COST	
		MOBILIZATION	$750,000
		96,000 CY SAND @ $5/	$480,000

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH	SAND VOLUME (CY)
1993	$0	1.00000	$0	0
1994	$0	0.97087	$0	0
1995	$903,514	0.94260	$851,649	96,000
1996	$0	0.91514	$0	0
1997	$0	0.88849	$0	0
1998	$1,555,950	0.86261	$1,342,176	96,000
1999	$0	0.83748	$0	0
2000	$0	0.81309	$0	0
2001	$903,514	0.78941	$713,242	96,000
2002	$0	0.76642	$0	0
2003	$0	0.74409	$0	0
2004	$1,555,950	0.72242	$1,124,051	96,000
2005	$0	0.70138	$0	0
2006	$0	0.68095	$0	0
2007	$903,514	0.66112	$597,329	96,000
2008	$0	0.64186	$0	0
2009	$0	0.62317	$0	0
2010	$1,555,950	0.60502	$941,375	96,000
2011	$0	0.58739	$0	0
2012	$0	0.57029	$0	0
2013	$903,514	0.55368	$500,254	96,000
2014	$0	0.53755	$0	0
2015	$0	0.52189	$0	0
2016	$1,555,950	0.50669	$788,387	96,000
2017	$0	0.49193	$0	0
2018	$0	0.47761	$0	0
2019	$903,514	0.46369	$418,955	96,000
2020	$0	0.45019	$0	0
2021	$0	0.43708	$0	0
2022	$1,555,950	0.42435	$660,262	96,000
2023	$0	0.41199	$0	0
2024	$0	0.39999	$0	0
2025	$903,514	0.38834	$350,868	96,000
2026	$0	0.37703	$0	0
2027	$0	0.36604	$0	0
2028	$1,555,950	0.35538	$552,959	96,000
2029	$0	0.34503	$0	0
2030	$0	0.33498	$0	0
2031	$903,514	0.32523	$293,846	96,000
2032	$0	0.31575	$0	0
2033	$0	0.30656	$0	0
2034	$1,555,950	0.29763	$463,094	96,000
2035	$0	0.28896	$0	0
2036	$0	0.28054	$0	0
2037	$903,514	0.27237	$246,092	96,000
2038	$0	0.26444	$0	0
2039	$0	0.25674	$0	0
2040	$1,555,950	0.24926	$387,834	96,000
2041	$0	0.24200	$0	0
2042	$0	0.23495	$0	0
2043	$903,514	0.22811	$206,098	96,000

SUM OF PRESENT WORTHS	$10,438,471
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$405,696

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.7. BEACH NORISHMENT SOUTH INTERIOR SHORELINE

		IN CYCLE COST	
CONTINGENCY	15%	34,000 CY @ 7.44	$253,046
E&D&S&A	10%	OUT CYCLE COST	
		MOBILIZATION	$150,000
		24,000 CY @ $2.50	$60,000

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH	SAND VOLUME (CY)
1994	$265,650	1.00000	$265,650	24,000
1995	$0	0.97087	$0	0
1996	$319,994	0.94260	$301,625	34,000
1997	$0	0.91514	$0	0
1998	$0	0.88849	$0	0
1999	$0	0.86261	$0	0
2000	$265,650	0.83748	$222,478	24,000
2001	$0	0.81309	$0	0
2002	$225,878	0.78941	$178,310	24,000
2003	$0	0.76642	$0	0
2004	$0	0.74409	$0	0
2005	$0	0.72242	$0	0
2006	$265,650	0.70138	$186,322	24,000
2007	$0	0.68095	$0	0
2008	$225,878	0.66112	$149,332	24,000
2009	$0	0.64186	$0	0
2010	$0	0.62317	$0	0
2011	$0	0.60502	$0	0
2012	$265,650	0.58739	$156,041	24,000
2013	$0	0.57029	$0	0
2014	$225,878	0.55368	$125,063	24,000
2015	$0	0.53755	$0	0
2016	$0	0.52189	$0	0
2017	$0	0.50669	$0	0
2018	$265,650	0.49193	$130,682	24,000
2019	$0	0.47761	$0	0
2020	$225,878	0.46369	$104,739	24,000
2021	$0	0.45019	$0	0
2022	$0	0.43708	$0	0
2023	$0	0.42435	$0	0
2024	$265,650	0.41199	$109,444	24,000
2025	$0	0.39999	$0	0
2026	$225,878	0.38834	$87,717	24,000
2027	$0	0.37703	$0	0
2028	$0	0.36604	$0	0
2029	$0	0.35538	$0	0
2030	$265,650	0.34503	$91,658	24,000
2031	$0	0.33498	$0	0
2032	$225,878	0.32523	$73,462	24,000
2033	$0	0.31575	$0	0
2034	$0	0.30656	$0	0
2035	$0	0.29763	$0	0
2036	$265,650	0.28896	$76,762	24,000
2037	$0	0.28054	$0	0
2038	$225,878	0.27237	$61,523	24,000
2039	$0	0.26444	$0	0
2040	$0	0.25674	$0	0
2041	$0	0.24926	$0	0
2042	$265,650	0.24200	$64,287	24,000
2043	$0	0.23495	$0	0
2044	$225,878	0.22811	$51,524	24,000

SUM OF PRESENT WORTHS	$2,436,620
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$94,700

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.8 REVET SOUTH INTERIOR SHORELINE

		CONSTRUCTION	
CONTINGENCY	15%	MOB COST	$50,000
E&D&S&A	10%	REVET 1050 LF	$1,047,900
		10000 CY @ $8.75/CY	$87,500
		FABRIC @ $7.20/CY	$28,195
		MAINTENANCE EA 20 YR	$259,630

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH	SAND VOLUME (CY)
1993	$1,535,198	1.00000	$1,535,198	10,000
1994	$0	0.97087	$0	0
1995	$0	0.94260	$0	0
1996	$0	0.91514	$0	0
1997	$0	0.88849	$0	0
1998	$0	0.86261	$0	0
1999	$0	0.83748	$0	0
2000	$0	0.81309	$0	0
2001	$0	0.78941	$0	0
2002	$0	0.76642	$0	0
2003	$0	0.74409	$0	0
2004	$0	0.72242	$0	0
2005	$0	0.70138	$0	0
2006	$0	0.68095	$0	0
2007	$0	0.66112	$0	0
2008	$0	0.64186	$0	0
2009	$0	0.62317	$0	0
2010	$0	0.60502	$0	0
2011	$0	0.58739	$0	0
2012	$0	0.57029	$0	0
2013	$328,432	0.55368	$181,845	0
2014	$0	0.53755	$0	0
2015	$0	0.52189	$0	0
2016	$0	0.50669	$0	0
2017	$0	0.49193	$0	0
2018	$0	0.47761	$0	0
2019	$0	0.46369	$0	0
2020	$0	0.45019	$0	0
2021	$0	0.43708	$0	0
2022	$0	0.42435	$0	0
2023	$0	0.41199	$0	0
2024	$0	0.39999	$0	0
2025	$0	0.38834	$0	0
2026	$0	0.37703	$0	0
2027	$0	0.36604	$0	0
2028	$0	0.35538	$0	0
2029	$0	0.34503	$0	0
2030	$0	0.33498	$0	0
2031	$0	0.32523	$0	0
2032	$0	0.31575	$0	0
2033	$328,432	0.30656	$100,683	0
2034	$0	0.29763	$0	0
2035	$0	0.28896	$0	0
2036	$0	0.28054	$0	0
2037	$0	0.27237	$0	0
2038	$0	0.26444	$0	0
2039	$0	0.25674	$0	0
2040	$0	0.24926	$0	0
2041	$0	0.24200	$0	0
2042	$0	0.23495	$0	0
2043	$0	0.22811	$0	0

SUM OF PRESENT WORTHS	$1,817,726
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$70,647

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.9 SOUTH JETTY CONSTRUCTION (FROM TERMINAL GROIN)

		CONSTRUCTION	
CONTINGENCY	15%	MOB COST	$50,000
E&D&S&A	10%	10140 T ROCK @ $75/	$760,500
		660 T ROCK @ $50/T	$33,000
		FABRIC @ $7.20/CY	$18,238
		MAINTENANCE EA 20 YR	$212,000

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH
1993	$1,090,097	1.00000	$1,090,097
1994	$0	0.97087	$0
1995	$0	0.94260	$0
1996	$0	0.91514	$0
1997	$0	0.88849	$0
1998	$0	0.86261	$0
1999	$0	0.83748	$0
2000	$0	0.81309	$0
2001	$0	0.78941	$0
2002	$0	0.76642	$0
2003	$0	0.74409	$0
2004	$0	0.72242	$0
2005	$0	0.70138	$0
2006	$0	0.68095	$0
2007	$0	0.66112	$0
2008	$0	0.64186	$0
2009	$0	0.62317	$0
2010	$0	0.60502	$0
2011	$0	0.58739	$0
2012	$0	0.57029	$0
2013	$268,180	0.55368	$148,485
2014	$0	0.53755	$0
2015	$0	0.52189	$0
2016	$0	0.50669	$0
2017	$0	0.49193	$0
2018	$0	0.47761	$0
2019	$0	0.46369	$0
2020	$0	0.45019	$0
2021	$0	0.43708	$0
2022	$0	0.42435	$0
2023	$0	0.41199	$0
2024	$0	0.39999	$0
2025	$0	0.38834	$0
2026	$0	0.37703	$0
2027	$0	0.36604	$0
2028	$0	0.35538	$0
2029	$0	0.34503	$0
2030	$0	0.33498	$0
2031	$0	0.32523	$0
2032	$0	0.31575	$0
2033	$268,180	0.30656	$82,212
2034	$0	0.29763	$0
2035	$0	0.28896	$0
2036	$0	0.28054	$0
2037	$0	0.27237	$0
2038	$0	0.26444	$0
2039	$0	0.25674	$0
2040	$0	0.24926	$0
2041	$0	0.24200	$0
2042	$0	0.23495	$0
2043	$0	0.22811	$0

SUM OF PRESENT WORTHS	$1,320,794
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$51,333

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.10 SOUTH JETTY AND REVETMENT CONSTRUCTION

		CONSTRUCTION	
CONTINGENCY	15%	JETTY 300 LF	$861,738
E&D&S&A	10%	REVETMENT 1050 LF	$1,213,595
		MAINTENANCE EA 20 YR	$421,630

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH	SAND VOLUME (CY)
1993	$2,562,046	1.00000	$2,562,046	10,000
1994	$0	0.97087	$0	0
1995	$0	0.94260	$0	0
1996	$0	0.91514	$0	0
1997	$0	0.88849	$0	0
1998	$0	0.86261	$0	0
1999	$0	0.83748	$0	0
2000	$0	0.81309	$0	0
2001	$0	0.78941	$0	0
2002	$0	0.76642	$0	0
2003	$0	0.74409	$0	0
2004	$0	0.72242	$0	0
2005	$0	0.70138	$0	0
2006	$0	0.68095	$0	0
2007	$0	0.66112	$0	0
2008	$0	0.64186	$0	0
2009	$0	0.62317	$0	0
2010	$0	0.60502	$0	0
2011	$0	0.58739	$0	0
2012	$0	0.57029	$0	0
2013	$533,362	0.55368	$295,310	0
2014	$0	0.53755	$0	0
2015	$0	0.52189	$0	0
2016	$0	0.50669	$0	0
2017	$0	0.49193	$0	0
2018	$0	0.47761	$0	0
2019	$0	0.46369	$0	0
2020	$0	0.45019	$0	0
2021	$0	0.43708	$0	0
2022	$0	0.42435	$0	0
2023	$0	0.41199	$0	0
2024	$0	0.39999	$0	0
2025	$0	0.38834	$0	0
2026	$0	0.37703	$0	0
2027	$0	0.36604	$0	0
2028	$0	0.35538	$0	0
2029	$0	0.34503	$0	0
2030	$0	0.33498	$0	0
2031	$0	0.32523	$0	0
2032	$0	0.31575	$0	0
2033	$533,362	0.30656	$163,506	0
2034	$0	0.29763	$0	0
2035	$0	0.28896	$0	0
2036	$0	0.28054	$0	0
2037	$0	0.27237	$0	0
2038	$0	0.26444	$0	0
2039	$0	0.25674	$0	0
2040	$0	0.24926	$0	0
2041	$0	0.24200	$0	0
2042	$0	0.23495	$0	0
2043	$0	0.22811	$0	0

SUM OF PRESENT WORTHS	$3,020,861
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$117,407

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.11 MODIFY TERMINAL GROIN (SHORTEN BY 75 FEET)

		ROCK REMOVAL	
CONTINGENCY	15%	MOBILIZATION	$50,000
E&D&S&A	10%	REMOVE 795 T ROCK	$39,750

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH
1993	$113,534	1.00000	$113,534
1994	$0	0.97087	$0
1995	$0	0.94260	$0
1996	$0	0.91514	$0
1997	$0	0.88849	$0
1998	$0	0.86261	$0
1999	$0	0.83748	$0
2000	$0	0.81309	$0
2001	$0	0.78941	$0
2002	$0	0.76642	$0
2003	$0	0.74409	$0
2004	$0	0.72242	$0
2005	$0	0.70138	$0
2006	$0	0.68095	$0
2007	$0	0.66112	$0
2008	$0	0.64186	$0
2009	$0	0.62317	$0
2010	$0	0.60502	$0
2011	$0	0.58739	$0
2012	$0	0.57029	$0
2013	$0	0.55368	$0
2014	$0	0.53755	$0
2015	$0	0.52189	$0
2016	$0	0.50669	$0
2017	$0	0.49193	$0
2018	$0	0.47761	$0
2019	$0	0.46369	$0
2020	$0	0.45019	$0
2021	$0	0.43708	$0
2022	$0	0.42435	$0
2023	$0	0.41199	$0
2024	$0	0.39999	$0
2025	$0	0.38834	$0
2026	$0	0.37703	$0
2027	$0	0.36604	$0
2028	$0	0.35538	$0
2029	$0	0.34503	$0
2030	$0	0.33498	$0
2031	$0	0.32523	$0
2032	$0	0.31575	$0
2033	$0	0.30656	$0
2034	$0	0.29763	$0
2035	$0	0.28896	$0
2036	$0	0.28054	$0
2037	$0	0.27237	$0
2038	$0	0.26444	$0
2039	$0	0.25674	$0
2040	$0	0.24926	$0
2041	$0	0.24200	$0
2042	$0	0.23495	$0
2043	$0	0.22811	$0

SUM OF PRESENT WORTHS	$113,534
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$4,413

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.12. MONITOR ONLY

CONTINGENCY 25% SURVEY & ANALYSIS $50,000

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH
1993	$62,500	1.00000	$62,500
1994	$0	0.97087	$0
1995	$0	0.94260	$0
1996	$0	0.91514	$0
1997	$0	0.88849	$0
1998	$0	0.86261	$0
1999	$0	0.83748	$0
2000	$0	0.81309	$0
2001	$0	0.78941	$0
2002	$0	0.76642	$0
2003	$0	0.74409	$0
2004	$0	0.72242	$0
2005	$0	0.70138	$0
2006	$0	0.68095	$0
2007	$0	0.66112	$0
2008	$0	0.64186	$0
2009	$0	0.62317	$0
2010	$0	0.60502	$0
2011	$0	0.58739	$0
2012	$0	0.57029	$0
2013	$0	0.55368	$0
2014	$0	0.53755	$0
2015	$0	0.52189	$0
2016	$0	0.50669	$0
2017	$0	0.49193	$0
2018	$0	0.47761	$0
2019	$0	0.46369	$0
2020	$0	0.45019	$0
2021	$0	0.43708	$0
2022	$0	0.42435	$0
2023	$0	0.41199	$0
2024	$0	0.39999	$0
2025	$0	0.38834	$0
2026	$0	0.37703	$0
2027	$0	0.36604	$0
2028	$0	0.35538	$0
2029	$0	0.34503	$0
2030	$0	0.33498	$0
2031	$0	0.32523	$0
2032	$0	0.31575	$0
2033	$0	0.30656	$0
2034	$0	0.29763	$0
2035	$0	0.28896	$0
2036	$0	0.28054	$0
2037	$0	0.27237	$0
2038	$0	0.26444	$0
2039	$0	0.25674	$0
2040	$0	0.24926	$0
2041	$0	0.24200	$0
2042	$0	0.23495	$0
2043	$0	0.22811	$0

SUM OF PRESENT WORTHS	$62,500
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$2,429

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.13. JET PUMP WITH FLUIDIZER

CONTINGENCY	25%	CONSTRUCTION	$1,745,403
E&D&S&A	15%	ANNUAL OPS & MAINT	$270,000

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH	SAND VOLUME MOVED (CY/YR)
1993	$3,132,000	1.00000	$3,132,000	32,000
1994	$337,500	0.97087	$327,670	32,000
1995	$337,500	0.94260	$318,126	32,000
1996	$337,500	0.91514	$308,860	32,000
1997	$337,500	0.88849	$299,864	32,000
1998	$337,500	0.86261	$291,130	32,000
1999	$337,500	0.83748	$282,651	32,000
2000	$337,500	0.81309	$274,418	32,000
2001	$337,500	0.78941	$266,426	32,000
2002	$337,500	0.76642	$258,666	32,000
2003	$337,500	0.74409	$251,132	32,000
2004	$337,500	0.72242	$243,817	32,000
2005	$337,500	0.70138	$236,716	32,000
2006	$337,500	0.68095	$229,821	32,000
2007	$337,500	0.66112	$223,127	32,000
2008	$337,500	0.64186	$216,628	32,000
2009	$337,500	0.62317	$210,319	32,000
2010	$337,500	0.60502	$204,193	32,000
2011	$337,500	0.58739	$198,246	32,000
2012	$337,500	0.57029	$192,472	32,000
2013	$337,500	0.55368	$186,866	32,000
2014	$337,500	0.53755	$181,423	32,000
2015	$337,500	0.52189	$176,139	32,000
2016	$337,500	0.50669	$171,008	32,000
2017	$337,500	0.49193	$166,028	32,000
2018	$337,500	0.47761	$161,192	32,000
2019	$337,500	0.46369	$156,497	32,000
2020	$337,500	0.45019	$151,939	32,000
2021	$337,500	0.43708	$147,513	32,000
2022	$337,500	0.42435	$143,217	32,000
2023	$337,500	0.41199	$139,046	32,000
2024	$337,500	0.39999	$134,996	32,000
2025	$337,500	0.38834	$131,064	32,000
2026	$337,500	0.37703	$127,246	32,000
2027	$337,500	0.36604	$123,540	32,000
2028	$337,500	0.35538	$119,942	32,000
2029	$337,500	0.34503	$116,448	32,000
2030	$337,500	0.33498	$113,057	32,000
2031	$337,500	0.32523	$109,764	32,000
2032	$337,500	0.31575	$106,567	32,000
2033	$337,500	0.30656	$103,463	32,000
2034	$337,500	0.29763	$100,449	32,000
2035	$337,500	0.28896	$97,524	32,000
2036	$337,500	0.28054	$94,683	32,000
2037	$337,500	0.27237	$91,925	32,000
2038	$337,500	0.26444	$89,248	32,000
2039	$337,500	0.25674	$86,649	32,000
2040	$337,500	0.24926	$84,125	32,000
2041	$337,500	0.24200	$81,675	32,000
2042	$337,500	0.23495	$79,296	32,000
2043	$337,500	0.22811	$76,986	32,000

SUM OF PRESENT WORTHS	$11,815,795
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$459,227

REDFISH PASS (LEE CO.) INLET MANAGEMENT PLAN
ENGINEERING ALTERNATIVES COST ESTIMATE

ALTERNATIVE: B.14 CONSTRUCT TERMINAL GROIN ON NORTH CAPTIVA I.

		CONSTRUCTION	
CONTINGENCY	15%	MOB COST	$100,000
E&D&S&A	10%	9000 T ROCK @ $75/T	$675,000
		FABRIC @ $7.20/CY	$15,200
		MAINTENANCE EA 20 YR	$185,000

YEAR	FUTURE WORTH	PRESENT WORTH FACTOR	PRESENT WORTH
1993	$999,600	1.00000	$999,600
1994	$0	0.97087	$0
1995	$0	0.94260	$0
1996	$0	0.91514	$0
1997	$0	0.88849	$0
1998	$0	0.86261	$0
1999	$0	0.83748	$0
2000	$0	0.81309	$0
2001	$0	0.78941	$0
2002	$0	0.76642	$0
2003	$0	0.74409	$0
2004	$0	0.72242	$0
2005	$0	0.70138	$0
2006	$0	0.68095	$0
2007	$0	0.66112	$0
2008	$0	0.64186	$0
2009	$0	0.62317	$0
2010	$0	0.60502	$0
2011	$0	0.58739	$0
2012	$0	0.57029	$0
2013	$234,000	0.55368	$129,560
2014	$0	0.53755	$0
2015	$0	0.52189	$0
2016	$0	0.50669	$0
2017	$0	0.49193	$0
2018	$0	0.47761	$0
2019	$0	0.46369	$0
2020	$0	0.45019	$0
2021	$0	0.43708	$0
2022	$0	0.42435	$0
2023	$0	0.41199	$0
2024	$0	0.39999	$0
2025	$0	0.38834	$0
2026	$0	0.37703	$0
2027	$0	0.36604	$0
2028	$0	0.35538	$0
2029	$0	0.34503	$0
2030	$0	0.33498	$0
2031	$0	0.32523	$0
2032	$0	0.31575	$0
2033	$234,000	0.30656	$71,734
2034	$0	0.29763	$0
2035	$0	0.28896	$0
2036	$0	0.28054	$0
2037	$0	0.27237	$0
2038	$0	0.26444	$0
2039	$0	0.25674	$0
2040	$0	0.24926	$0
2041	$0	0.24200	$0
2042	$0	0.23495	$0
2043	$0	0.22811	$0

SUM OF PRESENT WORTHS	$1,200,894
CAPITAL RECOVERY FACTOR	0.03887
AVERAGE ANNUAL VALUE	$46,673

REDFISH PASS INLET JETPUMP SAND TRANSFER SYSTEM

ITEM	QUANTITY	UNIT	UNIT PRICE	COST IN $1000
MOB.DEMOB	1	JOB	$80,000	$80
JET	2	EA	$10,000	$20
CLEAR WATER PUMP				
JET PUMP(270 hp)	1	EA	$47,500	$48
SLURRY PUMP(270 hp)	1	EA	$58,400	$58
POWERLINE	1	JOB	$126,000	$126
MOTOR CONTROL CENTER	1	JOB	$134,000	$134
WIRING & ELECTRICAL CONTROLS	1	JOB	$90,000	$90
VALVING & PNEUMATIC CONTROLS	1	JOB	$140,000	$140
AIR COMPRESSOR	1	EA	$10,000	$10
FLUIDIZER MANIFOLD	800	L.F.	$135	$108
OPERATION BUILDING 1500 SF	1	JOB	$75,000	$75
PIPE				
STEEL 3/8" WALLS				
12" SUBMERGED	1,200	L.F.	$25	$30
12" OTHER	200	L.F.	$24	$5
STEEL 3/4" WALLS				
12" SUBMERGED	1,200	L.F.	$60	$72
12" OTHER	1,900	L.F.	$59	$112
FLEXIBLE(12 inch)	300	L.F.	$100	$30
HD PE(14" 110 psi)	2,050	L.F.	$27	$55
SUBTOTAL				$1,192
CONTINGENCIES (25%)				$298
TOTAL CONSTRUCTION				$1,490
E&D, S&A (15%)				$224
TOTAL COST				$1,714

APPENDIX D

ENVIRONMENTAL ASSESSMENT OF BYPASSING AND SAND SOURCE ALTERNATIVES

A. Close the Inlet

The physical closure of the inlet would have both positive and negative environmental impacts. Construction of the sheet pile structure and subsequent sand placement would result in some localized, increased turbidity and sedimentation. However, if quality (low silt/clay), beach compatible sand is used, any increases in turbidity or sedimentation should be temporary. The resulting turbidity and sedimentation are not expected to directly impact seagrass beds east of Redfish Pass.

Construction of the sheet pile structure and subsequent sand placement would result in loss of the infauna within the project footprint. Nevertheless, this loss is not expected to significantly impact the surrounding environment.

Additionally, some of the impacts associated with dredge sites and sand placement are also valid for this alternative. These impacts include the loss of benthic infauna at the dredge site (CSA, 1987; Bowen and Marsh, 1988), as well as increased turbidity. Since benthic infauna tend to quickly re-populate disturbed areas (Turbeville and Marsh, 1982; Nelson, 1985; Bowen and Marsh, 1988; Saunders, unpublished), this loss is expected to be temporary. On the other hand, increased turbidity at the dredge site may negatively affect surrounding seagrass beds or exposed hardbottom communities (CSA, 1987). Therefore, it is recommended that dredge sites in proximity to seagrass beds, or within 400-500 feet of exposed hardbottom, be avoided.

Initially, this alternative would result in the loss of some of the remaining beach ecosystem. However, this alternative would ultimately increase the amount of beach ecosystem in the vicinity of Redfish Pass. This would result in a corresponding increase in the amount of available sea turtle nesting habitat. However, if construction of the sheet pile structure or sand placement occur during the sea turtle nesting season, a sea turtle monitoring and nest relocation program would be required by the Florida Department of Environmental Protection (DEP) and the U.S. Fish and Wildlife Service (USFWS) (Florida Statute 370.12, F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished). Although shorebirds do not currently nest within the study area, the increase in available beach ecosystem would increase the amount of potential shorebird nesting habitat.

Depending upon the quality silt/clay content and sand grain size of the sand used, sand placement could also result in increased turbidity in the nearshore zone. However, if quality (low silt/clay content), beach compatible sand is used, any increases in turbidity should be temporary.

And finally, closure of the inlet could adversely impact the surrounding estuarine environment and its associated flora and fauna. Inlet closure could result in some stagnation of the surrounding estuarine waters. Water quality and dissolved oxygen concentrations of the estuarine waters adjacent to Redfish Pass may decrease as a result of inlet closure. Organisms immediately adjacent to the pass which rely on tidal currents to provide food or other nutrients, or to remove waste products or pollutants, may perish. Migratory estuarine-marine species, such as common snook and seatrout, would be denied ready access to nursery grounds and spawning sites.

B. Inlet Bypassing Systems

Many of the proposed sand bypassing alternatives for Redfish Pass involve the placement of sand from a borrow site onto the beach. If implemented, these alternatives would have similar impacts on the surrounding environment. A majority of these impacts are expected to be minimal, temporary, or can be minimized by using specific procedures. These impacts will be discussed as a group in the following paragraphs. Environmental impacts which are specific to a given alternative are discussed later.

All the proposed sand bypassing alternatives which involve the placement of sand on the beach will have both positive and negative environmental impacts. Depending upon the quantity of the sand used, sand placement would either help maintain, or would increase, the amount of available sea turtle nesting habitat. However, if sand placement occurs during the sea turtle nesting season, a sea turtle monitoring and nest relocation program would be required by DEP and USFWS (Florida Statute 370.12; F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished). Although shorebirds do not currently nest within the study area, the increase in available beach ecosystem would increase the amount of potential shorebird nesting habitat.

In addition to the quantity of sand placed on the beach, the quality of sand (silt/clay content and sand grain size) could also affect the surrounding environment. Sand placement could result in increased turbidity in the nearshore zone. However, if quality (low silt/clay content), beach compatible sand is used, any increase in turbidity should be temporary. This temporary increase in turbidity is not expected to adversely affect the surrounding sand bottom habitat.

Sand placement will also have a temporary, negative impact on the beach infaunal community. Beach infauna will be buried by sand placement, but is expected to quickly recolonize any affected areas (Nelson, 1985; Saunders, unpublished).

Bypassing alternatives which involve the dredging of sand from the ebb tidal shoal, flood shoal, or offshore borrow area would also have some adverse environmental impacts. These impacts include the loss of benthic infauna at the dredge site (CSA, 1987; Bowen and Marsh, 1988), as well as increased turbidity. Since infauna tend to quickly recolonize disturbed areas (Turbeville and Marsh, 1982; Nelson, 1985; Bowen and Marsh, 1988; Saunders, unpublished), the loss of benthic infauna is expected to be temporary. On the other hand, increased turbidity at the dredge site may negatively affect surrounding seagrass beds or exposed hardbottom communities (CSA, 1987). Therefore, it is recommended that dredge sites in proximity to seagrass beds, or within 400-500 feet of hardbottom, be avoided. It should be noted that, since the flood shoal is located within the Pine Island Sound Aquatic Preserve, the permitting requirements for dredging the flood shoal would likely be more rigorous than those associated with either ebb shoal or offshore borrow area dredging.

B-1 Status Quo

The environmental impacts associated with this alternative will be concentrated at three locations: at the dredge site, in the vicinity of sand placement and along the northern shoreline of Captiva Island. The impacts associated with dredge sites and sand placement have been discussed previously. The impacts which will occur along the northern shoreline of Captiva Island are discussed in the following paragraph.

Although this alternative provides storm protection and erosion control for Captiva Island's gulf shoreline, it does not mitigate for the continued erosion of the northern tip of the island. The resulting southerly migration of the northern shoreline on Captiva Island will result in the loss of much of the remaining beach ecosystem which borders Redfish Pass. As the shoreline continues to migrate southward, some of the dune system along the northwest portion of the island will also be lost.

B-2 No Action and Discontinue Captiva Island Beach Maintenance Program

This alternative will have some significant environmental impacts. If erosion downdrift of Redfish Pass is unchecked, it will eventually result in the loss of much of the beach ecosystem on Captiva Island. This would result in a corresponding loss of sea turtle nesting habitat. Continued beach erosion could also result in the loss of much of the dune system, as well as any remaining native upland vegetation located adjacent to the beach/dune system.

B-3 Remove the Terminal Groin

Removal of the terminal groin would result in the loss of some of the beach ecosystem just south of the groin. Depending upon the extent of this loss, some dune vegetation south of the groin may also be lost. Although accretion northeast of the groin will mitigate for some of the lost beach, an overall decrease in the amount of dry beach is expected.

B-4 Change the Borrow Area

The abandonment of the ebb shoal as a borrow source is not expected to cause any adverse environmental impacts. However, since this alternative would continue the Captiva Island Maintenance Nourishment Program, the environmental impacts associated with dredge sites and sand placement would still be valid.

B-5 Add a Feeder Beach to the Captiva Island Maintenance Nourishment Program

The impacts associated with dredge sites and sand placement are valid for this alternative.

B-6 Construct Deposition Basin

This alternative may cause considerable loss of the beach ecosystem and the associated sea turtle nesting habitat north of Redfish Pass. If erosion is extensive, some of the vegetation adjacent to the beach could be lost. Although a majority of the vegetation lost would be Australian pines, some remaining native vegetation may also be affected.

The environmental impacts associated with dredge sites and sand placement are also valid for this alternative.

B-7 Beach Nourishment of Interior Shoreline

The environmental impacts associated with dredge sites and sand placement are valid for this alternative.

B-8 Revet Interior Shoreline

By itself, this alternative will have limited environmental impact. Construction of the revetment would help stop the southerly migration of the shoreline south of the inlet, as well as the subsequent loss of dune vegetation. Construction of the revetment will eliminate most of the dry beach ecosystem north of the structure. However, due to the eroded nature of the shoreline, this loss is not expected to have a significant impact on the surrounding environment. Furthermore, the intertidal and submerged portions of the revetment would provide habitat for a variety of marine/estuarine organisms. If revetment construction is to occur during the sea turtle nesting season, a sea turtle monitoring and nest relocation program would be required by DEP and USFWS (Florida Statute 370.12; F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished).

B-9 Construct South New Terminal Groin

This alternative would result in a slight increase in the amount of beach ecosystem south of the new terminal groin. However, this alternative would not mitigate for the continued erosion of the northern tip of the island. The resulting southerly migration of the northern shoreline on Captiva Island will result in the loss of most of the remaining beach ecosystem which borders Redfish Pass. As the shoreline continues to migrate southward, some of the dune system along the northwest portion of the island may also be lost.

The addition of a new terminal groin south of Redfish Pass could provide additional habitat and shelter for a variety of fishes and motile invertebrates, as well as an attachment site for certain algae and sessile invertebrates. However, if new terminal groin construction is to occur during the sea turtle nesting season, a sea turtle monitoring and nest relocation program would be required by DEP and USFWS (Florida Statute 370.12; F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished).

Construction of the new terminal groin would result in the loss of infauna within the project footprint. Nevertheless, this loss is not expected to significantly impact the surrounding habitat.

B-10 New Terminal Groin and Revetment Construction

The construction of a new terminal groin and revetment would have both positive and negative environmental impacts. Unlike alternative B-9, this alternative would help stop the southerly migration of the shoreline south of the inlet, as well as the subsequent loss of dune vegetation. The amount of beach south of the new terminal groin would increase slightly. However, this alternative would eliminate most of the dry beach north of the new terminal groin and revetment.

Construction of the new terminal groin and revetment could provide additional habitat and shelter for a variety of fishes and motile invertebrates, as well as attachment sites for various algae and sessile invertebrates. However, if construction of the structures is to occur during sea turtle nesting season, a sea turtle monitoring and nest relocation program would be required by DEP and USFWS (Florida Statute 370.12; F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished).

Construction of the new terminal groin and revetment would result in the loss of infauna within the project footprint. Nevertheless, this loss is not expected to significantly impact the surrounding habitat.

B-11 Modify Terminal Groin

Although this alternative could slightly increase the amount of dry beach north of the terminal groin, this increase would be offset by a significant decrease in the dry beach south of the groin. A landward movement of the shoreline could result in the loss of much of the beach ecosystem immediately south of the groin. This would result in a corresponding loss of sea turtle nesting habitat. In addition, some of the dune vegetation south of the groin may also be lost due to shoreline recession.

The terminal groin currently provides some limited habitat for certain intertidal organisms. Modification of the groin would result in the loss of some of this habitat. Additionally, if construction is to occur during sea turtle nesting season, a sea turtle monitoring and nest relocation program would be required by DEP and USFWS (Florida Statute 370.12; F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished).

B-12 Monitor Only

The environmental impacts associated with this alternative are similar to those described in alternative B-1 "Status Quo".

B-13 Experimental System: Jet Pump with Fluidizer Collector

The environmental impacts associated with this alternative will be limited to three areas: the location of the pump house, in the vicinity of sand placement and at the ebb shoal. Depending upon its location, construction of the pump house could result in the loss of some dune vegetation. The impacts associated with sand placement have been previously discussed, whereas the impacts at the ebb shoal are discussed below.

The construction and operation of the jet pump system are expected to cause some localized turbidity and sedimentation over the ebb shoal. While the amount of turbidity and sedimentation will depend upon the quality (silt/clay content and sand grain size) of the material transported by the system, normal gulf tides and currents are expected to quickly dissipate any resulting turbidity. The increased turbidity and sedimentation are not expected to adversely impact the surrounding sand bottom habitat. However, if construction is to occur during sea turtle nesting season, a sea turtle monitoring and nest relocation program would be required by DEP and USFWS (Florida Statute 370.12; F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished).

B-14 Construct Terminal Groin on North Captiva Island

This alternative would have both direct and indirect environmental impacts. Construction of the terminal groin would directly result in the loss of the infauna within the project footprint. Nevertheless, this loss is not expected to significantly impact the surrounding environment. On the other hand, construction of the groin would provide additional habitat and shelter for a variety of organisms. If construction is to take place during sea turtle nesting season, however, a sea turtle monitoring and nest relocation program would be required by DEP and USFWS (Florida Statute 370.12; F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished).

Construction of a terminal groin would increase the amount of beach ecosystem north of the groin. This would result in a corresponding increase in the amount of available sea turtle nesting habitat and an increase in potential shorebird nesting habitat. On the other hand, construction of the groin may contribute to the erosion of the north interior shoreline. This may result in the loss of some of the Australian pines adjacent to the beach. Depending upon the extent of the erosion, some native upland mangrove vegetation along the interior shoreline may also be lost.

C. Recommended Plan - Construct a Terminal Groin, Revetment and Feeder Beach on Captiva Island, and a Groin on North Captiva Island

The implementation of the recommended plan would have both positive and negative impacts. Since this alternative includes the construction of a feeder beach, the impacts associated with dredge and fill would be valid.

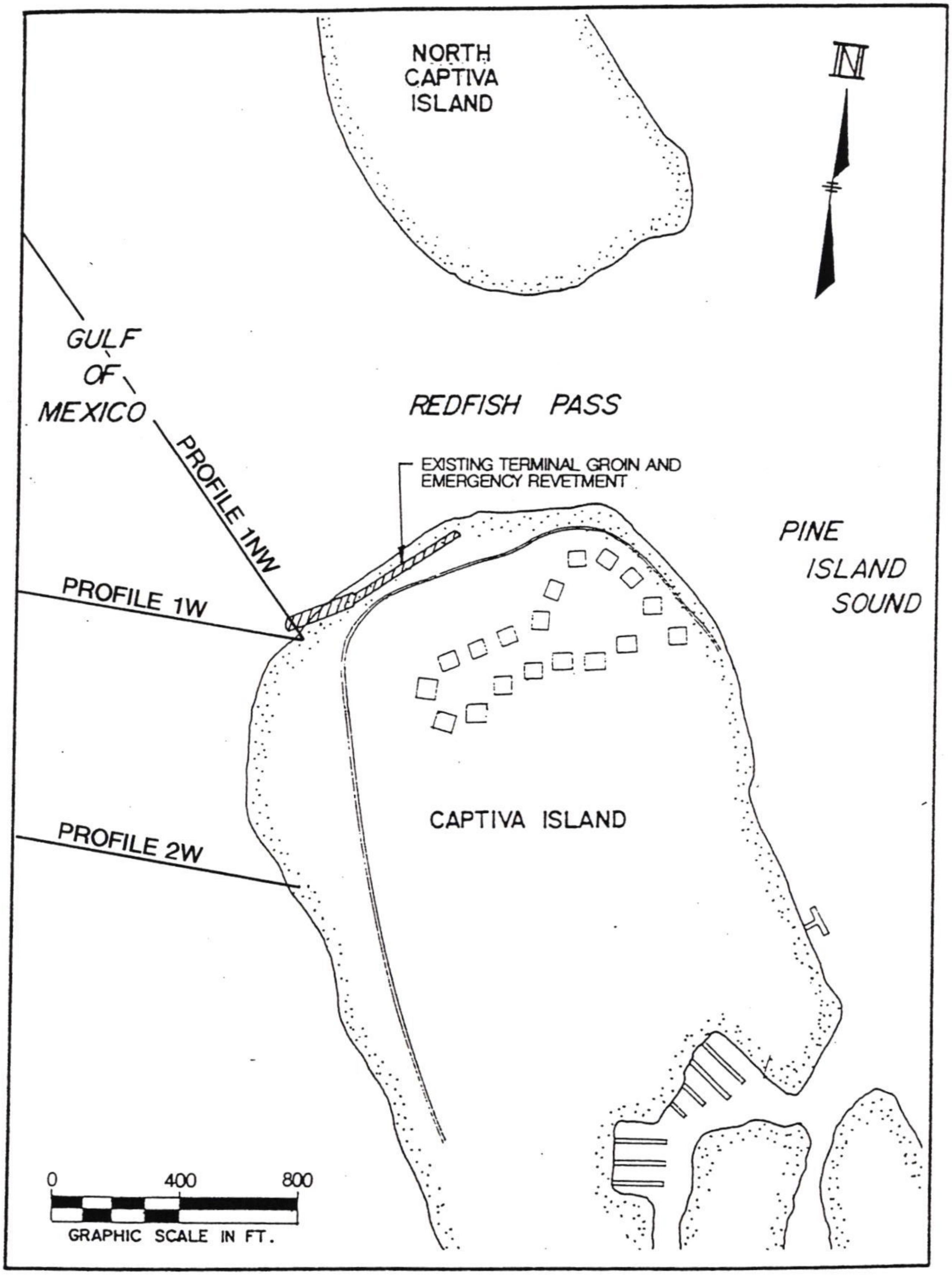
Construction of the structures would result in the loss of infauna within the structure footprints. Nevertheless, this loss is not expected to significantly impact the surrounding environment. Construction of the two groins would provide additional habitat and shelter for a variety of organisms. Construction of the structures may also result in a temporary increase in the turbidity adjacent to the project area.

This alternative would help increase the amount of dry beach south of the terminal groin on Captiva Island and north of the groin on North Captiva Island. This alternative would, however, most likely result in a loss of available dry beach habitat north of the revetment and south of the North Captiva groin. Overall, this alternative would help maintain the dry beach area adjacent to Redfish Pass and, as a result, would help maintain the available sea turtle nesting habitat and potential shorebird nesting habitat. If construction of the structures is to take place during sea turtle nesting season, however, a sea turtle monitoring and nest relocation program would be required by DEP and USFWS (Florida Statute 370.12; F.A.C. 16B-41; Endangered Species Act of 1973; Futch, unpublished).

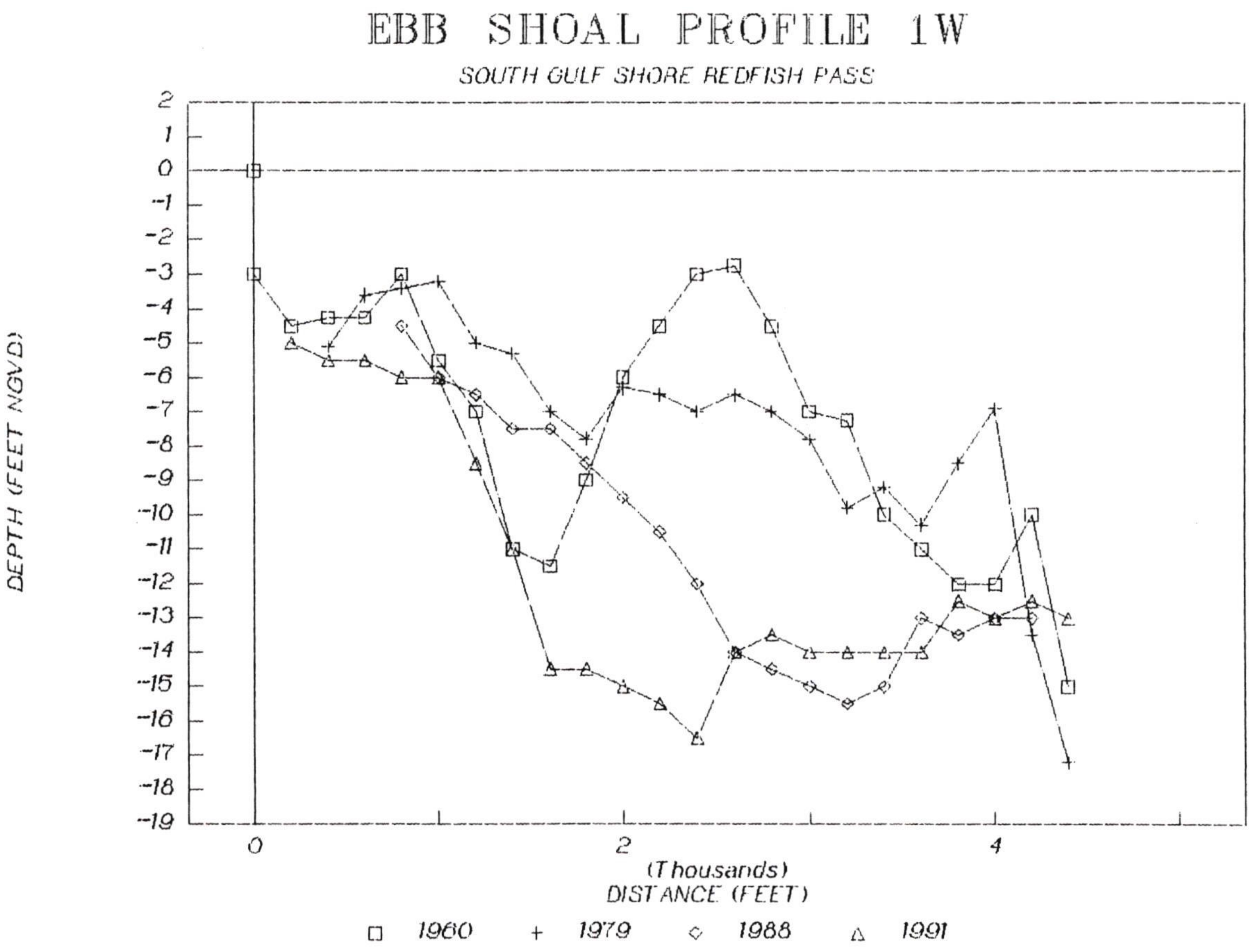
APPENDIX E

EBB SHOAL PROFILES

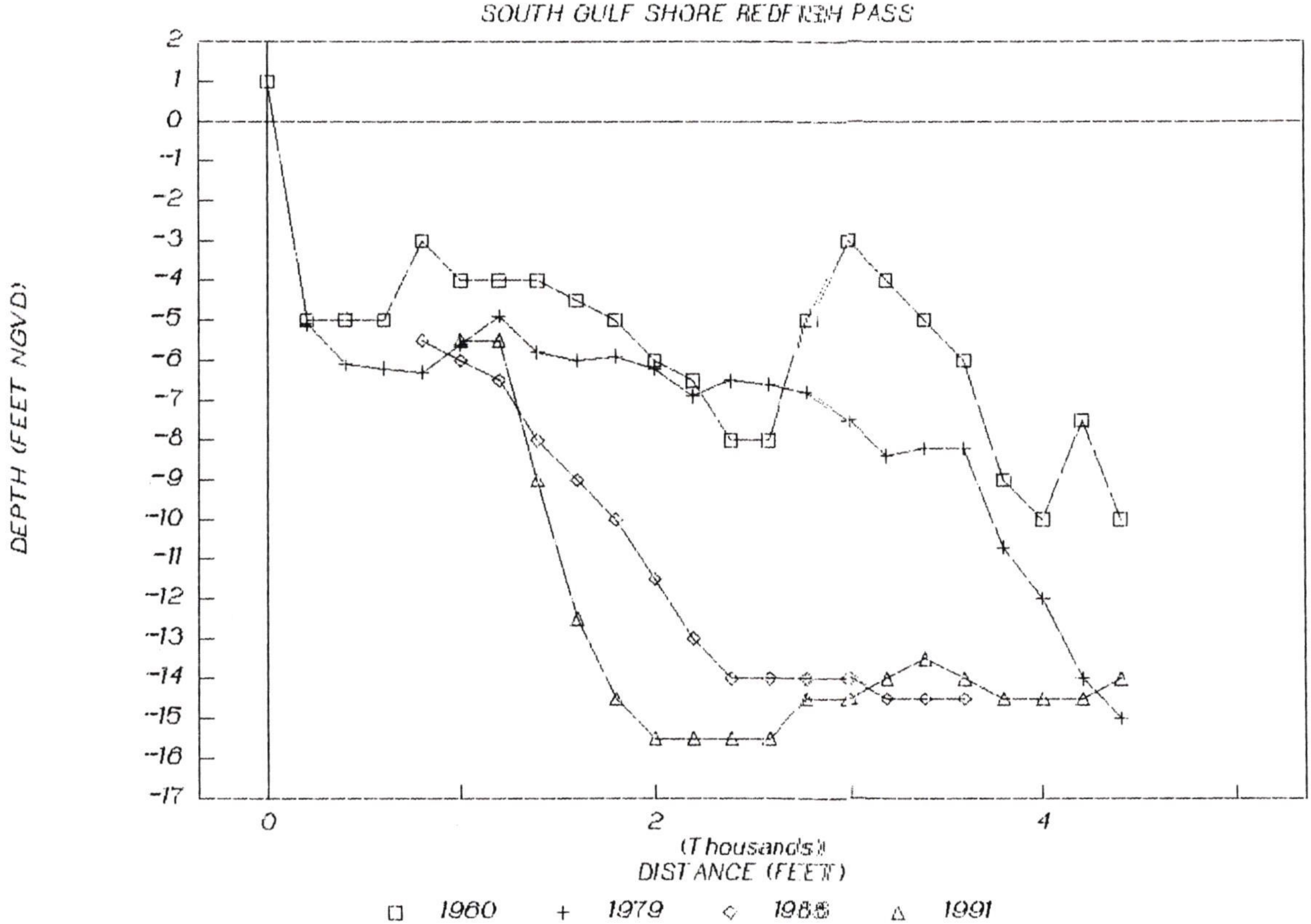
1961 - 1991

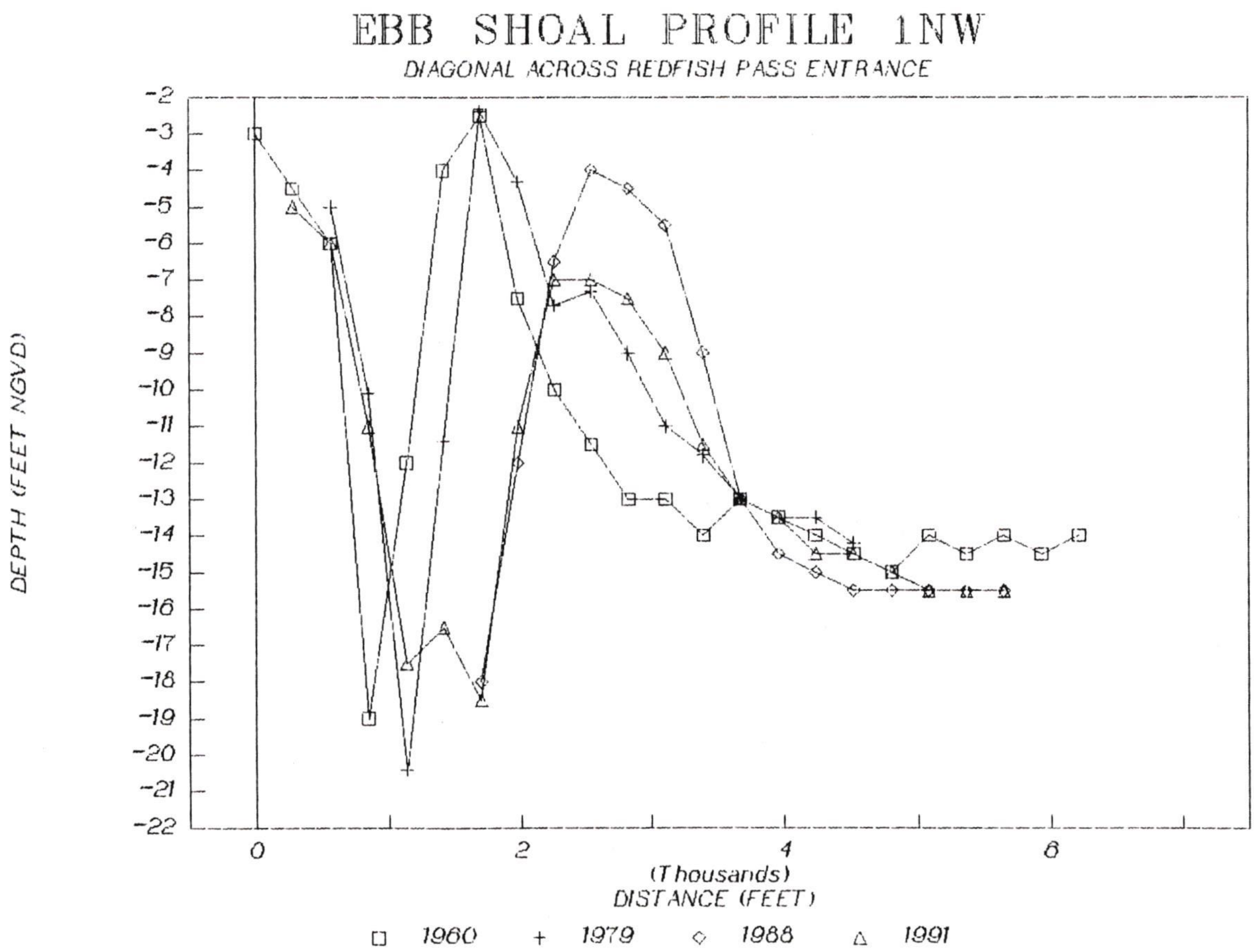


EBB SHOAL PROFILE LOCATIONS


EBB SHOAL PROFILE 1W
SOUTH GULF SHORE REDFISH PASS
DEPTH (FEET NGVD)
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
0
2
4
(Thousands)
DISTANCE (FEET)
1960
1979
1988
1991

EBB SHOAL PROFILE 2W





EBB SHOAL PROFILE 1NW
DIAGONAL ACROSS REDFISH PASS ENTRANCE
DEPTH (FEET NGVD)
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
-22
0
2
4
6
(Thousands)
DISTANCE (FEET)
1960
1979
1988
1991

APPENDIX F

CAPTIVA ISLAND SEDIMENT CHARACTERISTICS

APPENDIX F

CAPTIVA ISLAND SEDIMENT CHARACTERISTICS

1. Introduction

This discussion of sediment characteristics is a summary of four sand search reports prepared by Coastal Planning & Engineering, Inc. for the Captiva Erosion Prevention District. Previous sand search reports were summarized in the 1990 CPE report. The latest report, in preparation, covers the detailed investigation of Borrow Area III (western borrow area) in support of the next nourishment project for Captiva Island.

Figure F1 shows the location of the seven areas investigated as potential borrow sources, including the shoals of Redfish and Blind Passes. Additional areas have been identified as potential borrow areas to include the shoals of Captiva Pass and a new sand wave area south of Borrow Area III, but detailed investigation of these areas have not been done. Historic composite grain size curves are shown in Figure F2. These curves represent sediment characteristics prior to the major nourishment project on Captiva Island conducted in the 1980's.

2. Geographic and Geological Setting

Captiva Island is located on the southwest coast of Florida and is one of a series of barrier islands to the east of Pine Island Sound in Lee County (Figure F1). Captiva Island is separated to the north from North Captiva Island by Redfish Pass and to the south from Sanibel Island by Blind Pass.

Captiva Island was formed as a barrier island off the Florida peninsula. The southwest Florida lowlands represent an area of submergence during the general rise of sea level that occurred toward the end of the Pleistocene period, 18,000 years ago. Massive amounts of water were released by glaciers and ice that were formed during the Pleistocene ice age. During this period of time the sea level rose approximately 350 feet to its present level. A period of stabilization occurred approximately 5,000 years ago and numerous barrier islands were formed and prograded south at this time. The islands are composed of primarily post Pleistocene deposits derived from rivers and erosion of the Florida peninsula. Longshore currents from the north continue to erode and prograde some of these islands including Captiva Island. This erosion results in a loss of beach front on the western margin of the island.

A somewhat irregular limestone base material is overlain in this area by unconsolidated post-Pleistocene sands, silts, clays and shell material. A minor regression after stabilization, approximately 5,000 years ago, produced an oxidized layer of cemented sand/shell material which has been referred to as limestone. This layer varies from 1 to 5 ft. thick and represents a barrier to dredging. Recent sediments consisting of sand,

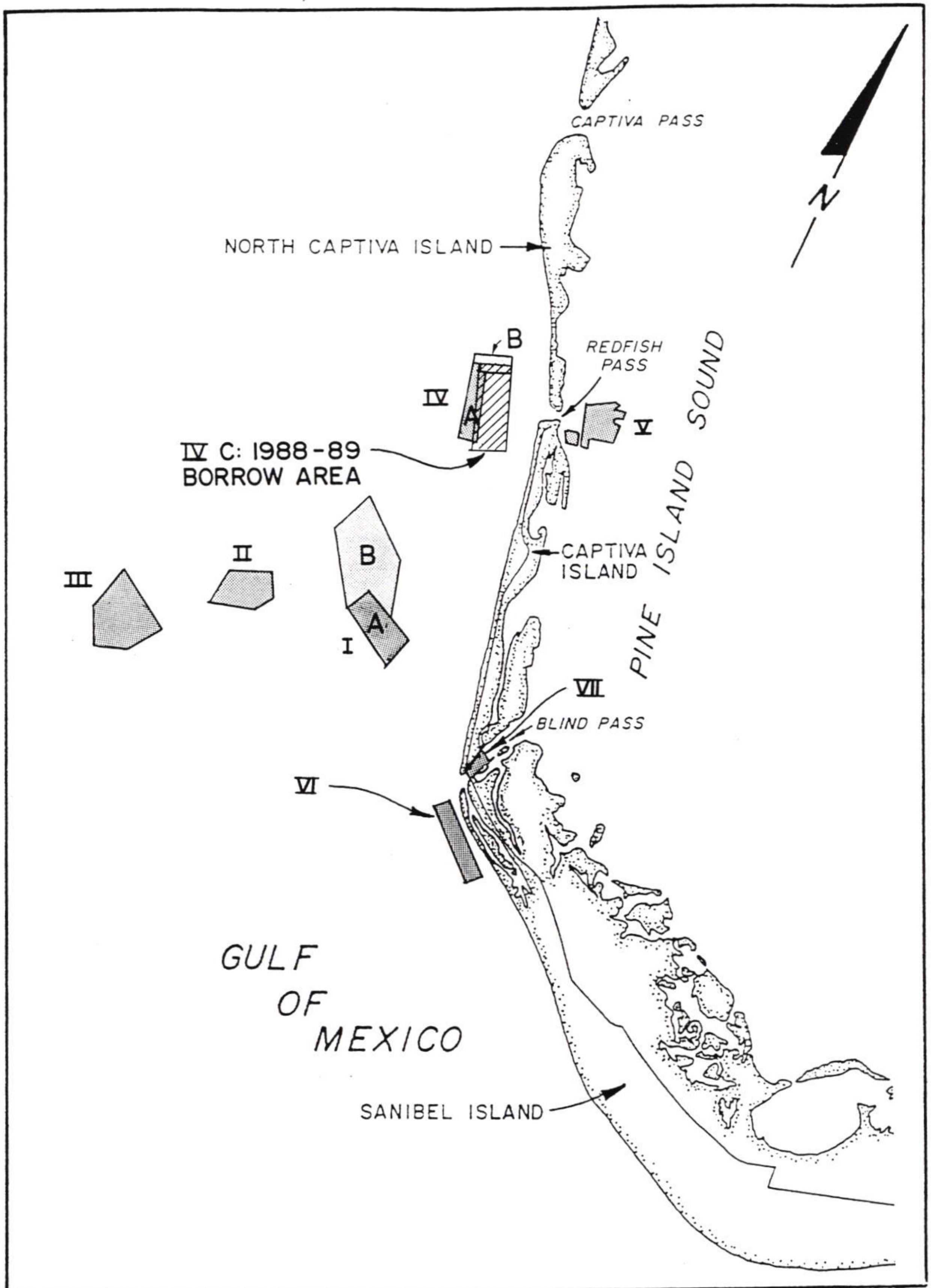


FIGURE F1

CAPTIVA ISLAND
SAND SEARCH POTENTIAL BORROW AREAS

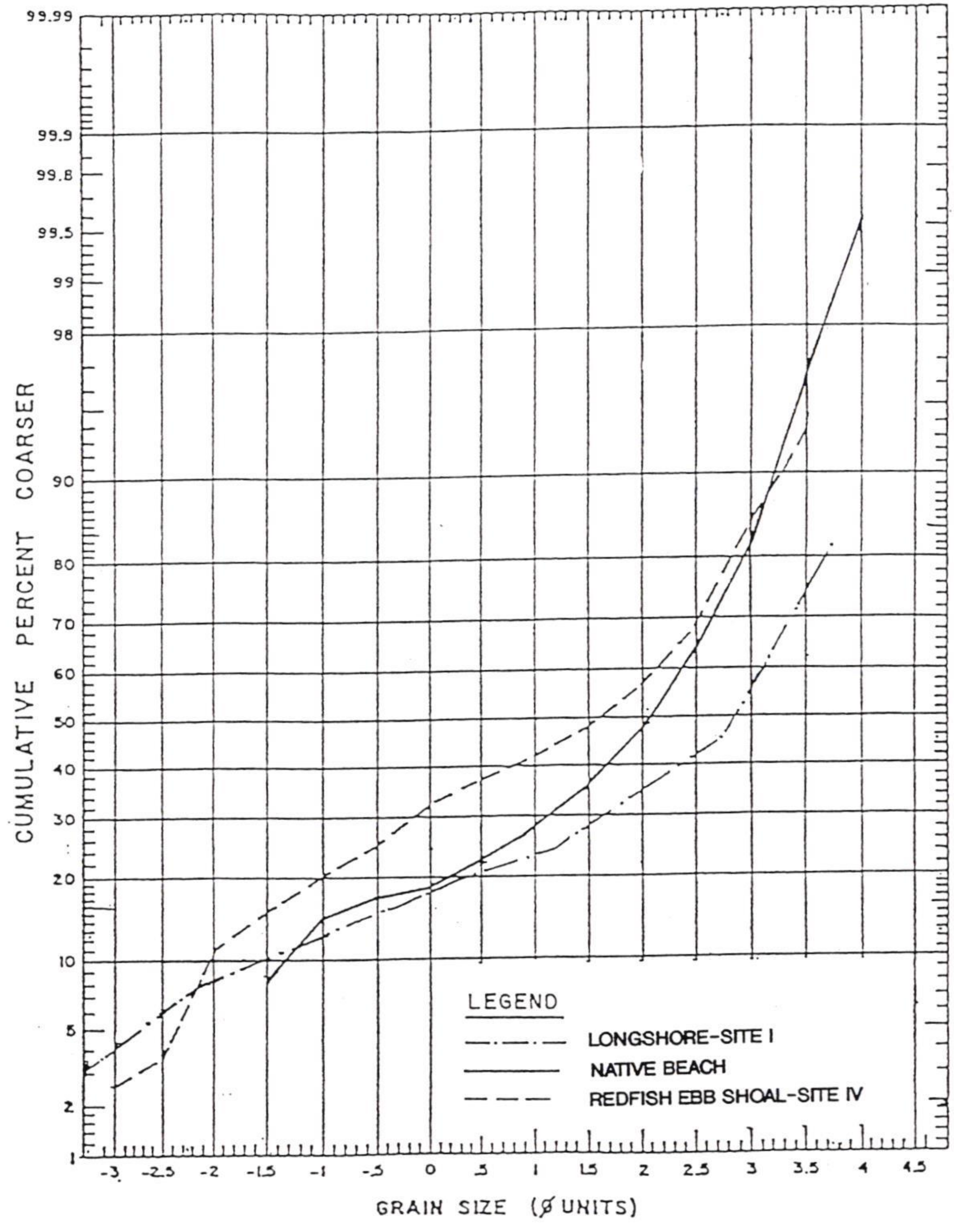


FIGURE F2

COMPOSITE GRAIN SIZE

DISTRIBUTION

shell, and silt overlay this layer with variable thicknesses generally from 0 to 15 ft. The limestone layer often outcrops at the seafloor at areas approximately 2 to 3 miles offshore in irregular patches. Some erosional channels and trenches were formed in this harder material when it was exposed at sea level. Most of these small channels are discontinuous and relatively narrow in size, but some of them appear to have over 10 ft of sand material deposited within these channels.

3. Previous Studies

Several previous reconnaissance level investigations have been performed offshore of Captiva Island to determine the location of suitable sediment deposits for beach nourishment borrow areas. These investigations include 55 vibracores and a seismic survey. There have also been 42 vibracore samples taken within the ebb tidal shoal of Redfish Pass.

The Corps of Engineers obtained 7 cores offshore of Captiva Island in 1967. Tetra Tech, under contract to the Captiva Erosion Prevention District (CEPD) cored 48 locations offshore of Captiva in 1980. Twenty-seven (27) sites were also cored by Tetra Tech in 1979 on the ebb tidal shoal of Redfish Pass. An additional 15 vibracores were obtained in July 1988 by Alpine Ocean Seismic Survey, Inc. These vibracores were obtained from Redfish Pass ebb tidal shoal, prior to the 1988-1989 beach restoration project.

A seismic survey offshore of Captiva Island was conducted by Van Reenan International, Inc. in January 1980. Approximately 40 miles of seismic lines were run within one mile of shore (Tetra Tech, 1980).

Other studies of the general area around Captiva Island include Missimer's (1973) study of Sanibel Island, the U.S. Army Corps of Engineers', 1969, Erosion Control Study of Lee County, Florida and a University of Florida study of the hydraulics and geology in Lee County (1981).

Coastal Planning & Engineering, Inc. has conducted four additional sand search studies since 1988. These studies have included new bathymetric, seismic and side scan sonar surveys in addition to vibracore and grab samples of sediments. Additional investigations by CPE included the Redfish Pass ebb and flood shoals, Blind Pass flood shoal, and Borrow Area III.

4. Sediment Texture Analysis

For analysis conducted by CPE, the cores were split in half, and one half was left undisturbed and archived. Samples for sieve analyses were taken from the other half. Visual descriptions, including an estimate of the effective length of each sample, were determined by texture changes. Samples for analysis were taken from distinct layers within the core and mechanical sieve analysis was performed on all samples.

Sieve analyses of samples were performed in accordance with the American Society of Testing and Materials (ASTM) Standard Methods Designation D 422-63 for particle-size analysis of soils (ASTM, 1987). This method covers the quantitative determination of the distribution of sand size particles. For sediment finer than the No. 200 sieve (3.75 phi) the ASTM Standard Test Method, Designation D 1140-54 was used (ASTM, 1987). The mean grain size of each sample was calculated using the five point method.

To compute the mean grain size and sorting of each core within the proposed borrow areas, the results of the sieve analysis for each sample taken were weighted by the length of the core which the sample represented. The average mean grain size and sorting for each borrow area was computed from a composite gradation table. The composite gradation table is composed of the averages of each grain size increment for all the cores in the borrow areas.

5. Delineation of Potential Sand Sources

Seven potential borrow areas have been evaluated based on the results of the seismic, vibracore and side scan sonar results, and previous studies. The location of these is shown on Figure F1.

A. Offshore Borrow Area

Three sites offshore of Captiva Island were evaluated as potential borrow sites (CPE 1990 and 1991). The first offshore site (I) is located approximately 1.5 miles offshore at the center of Captiva Island. The second proposed borrow area (II) lies directly offshore of the first at a distance of three (3) miles from shore. This borrow area consists of filled erosional channels and sand waves. The third proposed borrow site (III) is offshore and to the south of the first two, at a distance of five miles from land. Borrow Area III also consists of sand waves over filled erosion trenches, similar to borrow area II.

(1) First (Eastern) Offshore Borrow Area (I)

Borrow Area I-A has a mean grain size of 0.29 mm (1.78ϕ), a sorting value of 1.91ϕ and an average silt content of 16.6%. Seven recent vibracores were taken within this borrow area. Water depths range from 21 to 25 feet NGVD. Sediment thickness ranged from 4 to 10 feet with an average thickness of 5.3 feet. The total available sand volume within this site is 2,170,000 cubic yards.

The borrow area lies just north of the northern limits of the surface "shell deposit" area and just offshore of the surface silt zone.

The average depth of the surficial sand as found by the seven cores is 6.5 feet. All cores consist of various layers of fine silty gray sand and shell hash. The high percent of the shell hash results in the overall high mean grain size. A secondary borrow site I-B lies north and west of Borrow Area I-A. Four recent vibracores were taken within this area. The cores in this area consist of sediment similar to those in Borrow Area I-A. The average sediment depth is 5.0 feet. An additional volume of 4,700,000 cubic yards available is within this site.

(2) Second (Middle) Offshore Borrow Area (II)

The second offshore borrow area (II) has a mean grain size of 0.19 mm (2.40 ϕ), a sorting value of 0.66 ϕ and an average silt clay content of 9.0%. Seven cores were taken within this borrow area. Water depth ranged from 26 to 31 feet NGVD. Sediment thickness ranges from 4 to 8 feet. This borrow area consists of approximately 1,990,000 cubic yards of sand.

It is apparent from bathymetric chart and supported by isopach charts that the adjacent areas show an approximate depth of 32 feet NGVD while the depth at the highest point within the borrow area is less than 26 feet. The sand ridge to which the borrow is defined, has an average sediment thickness of 5.4 feet as determined from the isopach. Filled erosional channels below the sand waves are also mapped on the isopach chart.

The seven vibracores taken within this borrow area all consist of light gray clean fine sand with small amounts of shell and shell hash. The average core depth of surface sand is six feet with a maximum of 8.8 feet and a minimum of 4.2 feet.

(3) Third (Western) Offshore Borrow Area (III)

The third offshore borrow area (III) has a mean of 0.37 mm (1.43 ϕ), a sorting value of 0.98 ϕ and an average silt content of 3.5% (Figure F3). Eight vibracore locations were obtained within this borrow area. The depths range from 28 to 32 feet NGVD. Sediment thickness ranges from 6 feet to less than 2 feet. This borrow area consists of approximately 1,900,000 cubic yards of clean sand. Preliminary results from a new sand search study now in progress show the grain size decreasing slightly to 0.35 mm.

The sand waves are highest along the southern side of the borrow area thinning to the north. The cores taken on top of the sand were generally over five feet in length. Those taken along the northern side of the borrow area are only 2 to 3 feet in length.

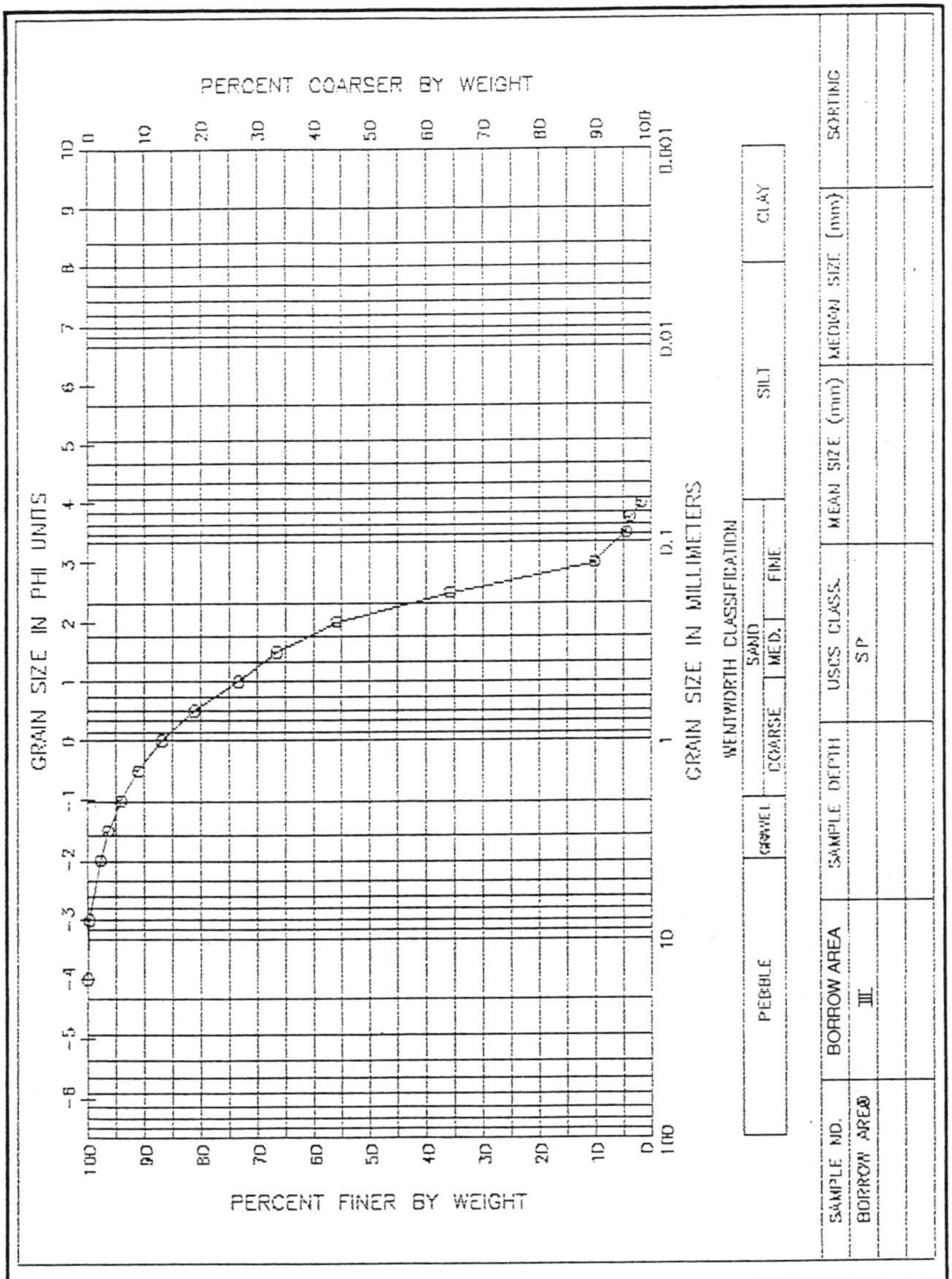


FIGURE F3

GRAIN SIZE DISTRIBUTION CURVE
CAPTIVA ISLAND SAND SEARCH

COASTAL PLANNING & ENGINEERING, INC. • BOCA RATON • SARASOTA • JACKSONVILLE

The depths of the adjacent areas like that near Site II is 32 feet NGVD. The "pseudo" limestone layer was found to be at or just below the surface in the adjacent areas and is relatively level between three (3) and five (5) miles offshore.

B. Redfish Pass Borrow Areas

Redfish Pass, like most inlets, is a sediment sink for material transported from erosion of updrift coastal areas. Both the flood tidal shoal (inside) and the ebb tidal shoal (outside) were investigated for available sediment for future restoration projects.

(1) Redfish Pass Ebb Tidal Shoal Borrow Area (IV)

A seismic survey investigated the seaward edge of the ebb tidal shoal of Redfish Pass offshore of the previously used borrow sites. Ten cores were obtained within this area. Water depth ranged from 11 to 20 feet NGVD. Sediment thickness averages 7 feet with a range from 4 to 12 feet. The mean grain size for this area was found to be 0.20 mm (2.30 ϕ) with a phi sorting of 0.58 and an average silt content of 6.6%. A volume of 1,300,000 cubic yards was located by the seismic and vibracore survey. This borrow area is referred to as IV-A in Figure F1.

An additional 360,000 cubic yards is remaining along the northern edge of the 1988/1989 borrow area. The southern half of this area (IV-B) was permitted as additional fill but was never used. The northern section of this area lies off the shoal in water depth of 15 to 17 feet NGVD. Sediment parameters for this area (IV-B) were calculated from three (3) cores taken in 1988 by Alpine Ocean Seismic Survey. Gradation analysis reports and grain size distribution curves were generated by CPE from data provided in Alpine's report (1988). The mean grain size is 0.36 mm (1.47 ϕ), the phi sorting 1.27, and the percent silt was computed to be 3.6% (Figure F4).

(2) Redfish Pass Flood Tidal Shoal (V)

Redfish Pass flood tidal shoal was investigated by bathymetric survey, surface sediment samples (CPE 1990) and vibracores. Five 20-foot long vibracores were obtained on top of the shoal during high tides. Clean coarse sand was found only within the upper few feet of each core. The average thickness of good sand was found to be 3.3 feet (bottom areas shallower than 5' depth). The sediments in this upper zone have a mean grain size of 0.49 mm (1.03 ϕ), a phi sorting value of 1.27, and an average silt content of 3.5%. The volume of fill available in the zone is 350,000 cubic yards (Figure F4).

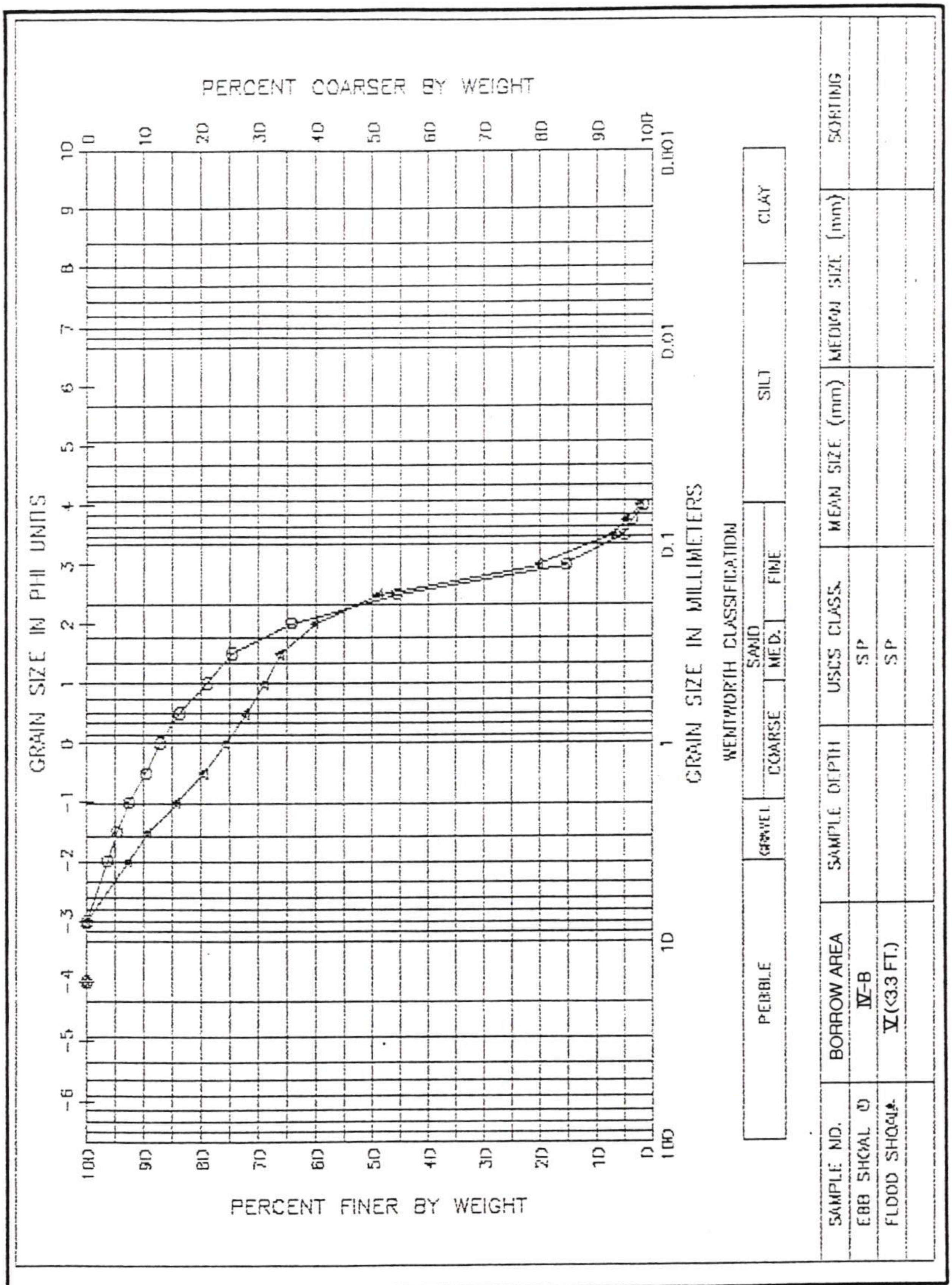


FIGURE F4

GRAIN SIZE DISTRIBUTION CURVE
REDFISH PASS SHOALS

The sediment below the clean surface sand is less desirable as beach fill. This sediment consists of silt, fine gray sand, shell fragments and shell hash. The mean grain size is 0.24 mm (2.06 ϕ) with a phi sorting of 1.4 and an average silt content of 17%. Silt content ranges up to 23% within the zone.

An analysis of the total area and total length of all cores was also computed. The mean grain size is 0.31 mm (1.69 ϕ) with a phi sorting of 1.3 and an average silt content of 13.5%. The total available volume, depending on the depth of the cut (-6 to -10 feet NGVD), ranges from 300,000 cubic yards to 1,000,000 cubic yards.

The proposed borrow site of Redfish Pass flood tidal shoal is traversed by a subaqueous electric cable. This cable would have to be field located prior to any dredging operations. Composite grain size curves for Redfish Pass shoals are shown in Figures F2 and F4.

C. Blind Pass Shoals

Blind Pass and its shoals have decreased in size since the opening of Redfish Pass. There are indications that the flood shoal has grown and that remnants of the ebb shoal still remain. A preliminary investigation of both shoals was conducted to examine their use as a potential borrow area.

(1) Blind Pass Ebb Shoal

Blind Pass has migrated and opened at various locations over the past 130 years along the shoreline of Sanibel Island. Based on this information it can be assumed that the development of a shoal would be spread out across the total area of the pass outlets. To determine if this was the case, a bathymetric contour chart was computer-generated using the October 1989 beach monitoring profile data between DNR monuments R105 and R116. It is apparent from this chart that the contours become widely spaced to the south indicating the shallowness of the profile offshore of Sanibel. Approximately 1000 feet offshore of R107 the water depth is 16.5 feet while 1000 feet offshore of R114, the depth is only 11.0 feet. This could be an indication of the remnants of the ebb shoal.

The depth of the profile north of Blind Pass is over 5 feet deeper at 1000 feet offshore than to the south. Figure F1 shows an area of the shoal 6000 feet long and 1000 feet wide approximately 1000 feet offshore. If this area could be dredged 4 feet below the existing bottom, a volume of 890,000 cubic yards of sediment would be available.

Only one previous core is in the area designated as the remnant shoal area. An additional core lies seaward of the shoal. The sediment was found to consist of shell and fine sand with a silt content of 19.2 percent based on these two cores. One vibracore lies in the center at the northern end of the shoal. The vibracore log shows clean shell and fine sand to 13 feet below the surface. A re-analysis of this core found the average silt content to be 21%. The second vibracore lies just on the outside edge of the shoal. The core log for this vibracore also shows clean sand and shell to a depth of eleven feet. The sieve re-analysis for this core found the average silt content to be 15.5% throughout this length. A composite gradation curve for these two cores is shown in Figure F5.

(2) Blind Pass Flood Shoal

A survey was conducted of the Blind Pass flood shoal in 1989 by Coastal Planning & Engineering, Inc. A comparison of this survey with USCGS 1956-60 survey shows a volume change of 61,500 c.y. over the 28-year period. The possibility of beach quality sand shoaling in the flood shoal was sufficient reason to investigate it as a sand source.

Six sediment sand samples were obtained at the time of a 1989 survey of the Blind Pass flood shoal to help identify areas of beach compatible material. Four samples were surface samples and two sand samples were taken at a depth of 2 feet below the surface. Sample area is shown on Figure F1. All samples were visually examined.

Areas of beach quality sand were identified by visual examination of the sand samples and the inspection of the area by the surveyors. Area "A" (located in the first 900 feet east of the bridge) consisted of median grain beach quality sand and shell with a low silt content. Area "B" (located between 900 and 1400 feet east of the bridge) contained fine sediment with a high quantity of silt.

A volume analysis of the sand present in area "A" found that to a depth of -3 feet (NGVD) a quantity of 51,350 cubic yards of sand is available. At a dredge depth of -4 feet (NGVD) a total volume of 68,800 cubic yards is present.

Blind Pass flood tidal shoal lies within the Pine Island Sound Aquatic Preserve. The establishment of aquatic preserves was instituted by the State to provide regulation of human activity within the preserve. This includes, among other regulations, a ban on dredging for the sole or primary purpose of providing fill. This could present a problem in the permitting of its use. Due to the low volume of beach quality sediment available and the fact that the flood tidal shoal lies in the Pine Island

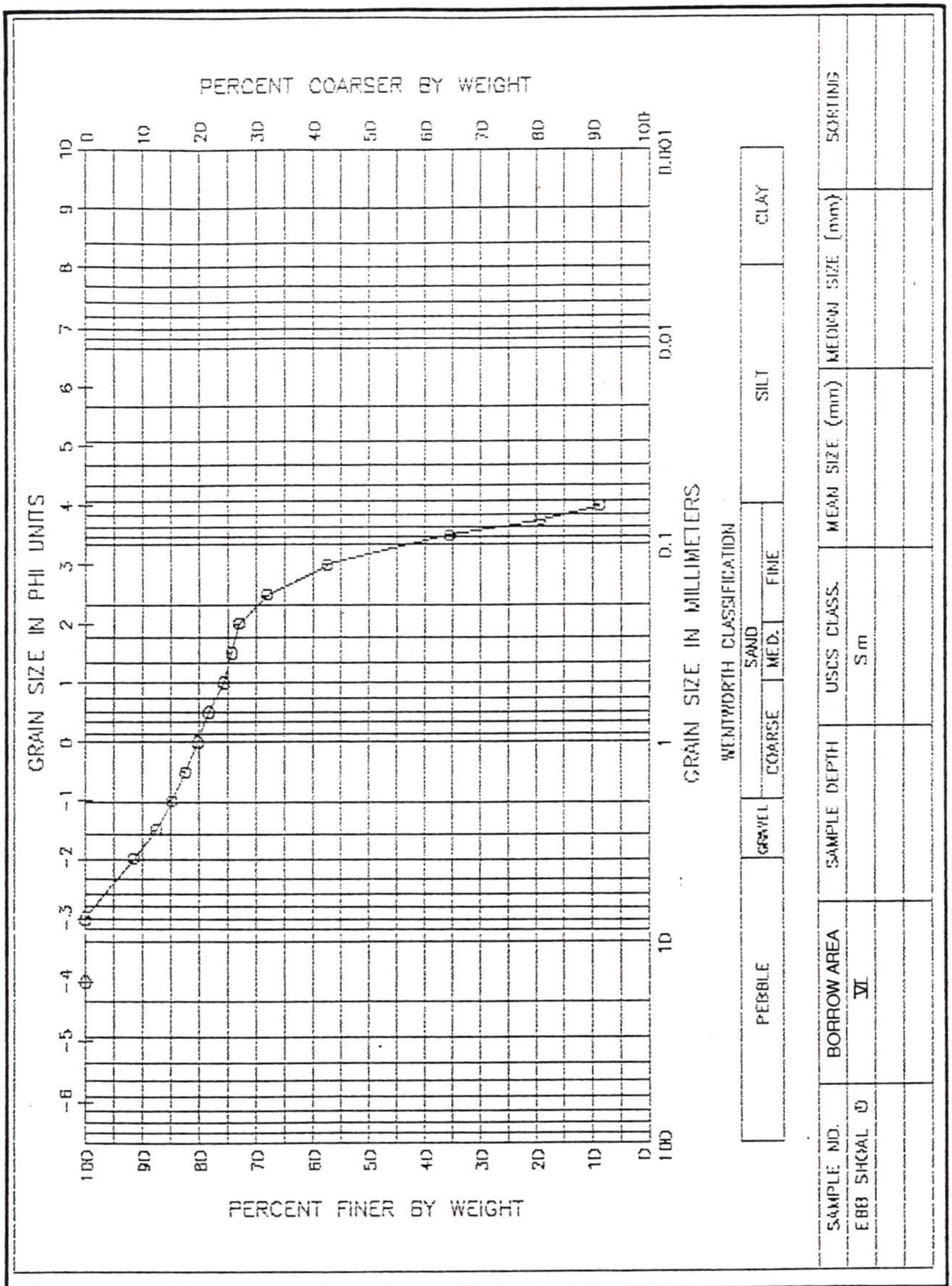


FIGURE F5

GRAIN SIZE DISTRIBUTION CURVE
BLIND PASS EBB SHOAL

Sound Aquatic Preserve, detailed analysis of sediment samples was not conducted.

6. Sediment Compatibility Analysis and Results

Three methods of sediment compatibility have been analyzed on each of the proposed borrow sites investigated in this study. Each method provides insight into the nature of the fill sediments and/or the fill's response to the nearshore and beach environment.

A. Native Beach Sediment Characteristics

Native beach characteristics were developed based on the September 1990 Captiva Monitoring Survey. Offshore borrow area sediment characteristics were obtained from analysis of the cores obtained in the study as previously discussed.

A sediment sampling program was carried out by Tetra Tech (1981) for the CEPD beach nourishment project along the length of Captiva Island south of South Seas Plantation. Samples were obtained across the active profile from the beach backshore to a depth of 12 feet NGVD. Sampling depths were backshore, foreshore, -3, -6, -9 and -12 feet MSL. Onshore samples were taken at approximately 1000 foot intervals along 10,500 feet of gulf shoreline extending south from Redfish Pass. Offshore samples were collected at 5 alongshore points.

Although suitability analyses were performed as part of the Tetra Tech (1981) report, the values for median, mean and sorting were not provided. However, using the composite grain size distribution curves provided, a set of sediment parameters was computed. The mean grain size of the native beach is 0.43 mm (1.22 ϕ), the median 0.25 mm, and the phi sorting is 1.7. The mean grain size of 0.43 mm has been used to estimate historical erosion rates required for the recession analysis.

The effective grain size of the existing beach was calculated based on the slope of the existing beach profiles. Dean (1977) developed the equilibrium beach profile theory which suggests that the slope of the profile below the waterline can be described by an exponential relation to sediment size. The September 1990 beach survey data was curve fit from the shoreline to a depth of 12 feet NGVD for profiles R86-R109. Profiles R83-R85 were not included in the curve fitting since they are affected by the Redfish Pass shoal. The analysis indicated that based on existing profile slope, the beach behaves like it consists of an effective grain size of 0.47 mm. This representative beach grain size was selected for use in the following fill compatibility analysis. Tables F1 and F2 summarize sediment characteristics and compatibility.

TABLE F-1
SEDIMENT CHARACTERISTICS
CAPTIVA ISLAND AND VICINITY

SAND SOURCE NAME	MEAN GRAIN SIZE (mm)	MEAN GRAIN SIZE (PHI)	SORTING COEFFICIENT (PHI)	SILT CONTENT (%)	NOTE
NATIVE BEACH	0.43	1.22	1.70	1.5	1
SITE I-A	0.29	1.78	1.91	16.6	
SITE II	0.19	2.40	0.66	9.0	
SITE III	0.37	1.43	0.98	3.5	4
SITE-IV RFP EBB	0.59	0.75	2.15	LOW	3
SITE 1V-A RFP EBB	0.20	2.30	0.58	6.6	
SITE IV-B RFP EBB	0.36	1.47	1.27	3.6	
SITE V RFP FLOOD	0.31	1.69	1.30	13.5	
SITE V RFP FLOOD <3.3	0.49	1.03	1.27	3.5	2
SITE VI BP EBB	0.34	1.55	2.33	19.2	
SITE VII BP FLOOD	N/A	N/A	N/A	LOW	

1. MEAN GRAIN SIZE BASED ON EQUILIBRIUM SLOPE= .47 mm
2. TOP 3.3 FEET OF SHOAL
3. PRE-DREDGING GRAIN SIZE
4. PRELIMINARY RESULTS

TABLE F-2
SEDIMENT COMPATIBILITY ANALYSIS
CAPTIVA ISLAND AND VICINITY

SAND SOURCE NAME	MEAN GRAIN SIZE (mm)	SILT CONTENT (%)	'A' FACTOR (FT^1/3)	SLOPE ADJUSTMENT VOLUME (%)	K-FACTOR RATIO (%)	INCREASED EROSION VOLUME (%)	TOTAL NOURISHMENT VOLUME (%)	
NATIVE BEACH	0.47	1.5	0.27	0%	1.0	0%	100%	
SITE I-A	0.29	16.6	0.19		NC--SILT CONTENT			
SITE II	0.19	8.1	0.13	177%	1.7	72%	349%	NC
SITE III	0.37	3.5	0.24	12%	1.1	14%	126%	C
SITE-IV RFP EBB	0.59	LOW			NU--INSUFFICIENT VOLUME			
SITE 1V-A RFP EBB	0.20	6.6	0.14		NU--INSUFFICIENT VOLUME			
SITE IV-B RFP EBB	0.36	3.6	0.23		NU--INSUFFICIENT VOLUME			
SITE V RFP FLOOD	0.31	13.5	0.21		NC--SILT CONTENT			
SITE V RFP FLOOD -3.3	0.49	3.5	0.28		NU--SENSITIVE AREA			
SITE VI BP EBB	0.34	19.2	0.22		NC--SILT CONTENT			
SITE VII BP FLOOD	N/A	LOW			NU--SENSITIVE AREA			

NC: NOT COMPATIBLE
NU: NOT USEABLE
C: COMPATIBLE

B. Compatibility Analysis

The adjusted SPM fill factor method allows for the calculation of the amount of overfill required when the textures of the borrow area and native beach sediment are dissimilar. This is the standard method used by the Corps of Engineers. The SPM method assumes that a unimodal grain size distribution exists for both composites from the beach and borrow area. Hobson (1977) indicates that in situations where bi-modal composites are present the modified SPM method may be inappropriate.

A second method of analysis developed by CPE analyzes the expected performance of the fill. The shape of the profile and the rate of erosion are used to analyze the way the 'advanced fill' will perform when it is replaced. A third performance measure, storm recession, was not used because it would apply only to the design beach remaining at the time of renourishment. The summary of this analysis shows results for Borrow Areas II and III only, since the other potential sources do not meet other screening criteria (Table F2).

(1) Equilibrium Slope Requirements

Dredged material placed on the beaches of Captiva which is finer than the existing beach sand will assume a flatter offshore equilibrium slope. Since some of the considered borrow sources have smaller mean grain sizes than the beach, an amount of fill will need to be placed in the next maintenance project to provide for this slope adjustment. The slope adjustment volume would be a one time placement to develop the seaward portion of the profile. The projected slope adjustment shape for material from selected borrow areas is presented in Figure F6. To calculate the slope adjustment volume, the area under the equilibrium curve for the existing beach sand (0.47 mm) was subtracted from the area of each borrow area curve. The resulting area differential was then multiplied by the construction length. A similar amount of slope adjustment volume would be needed in the second renourishment because only half of the shoreline is expected to be renourished at one time. Subsequent renourishments with the same borrow source would not require slope adjustment volumes. The required slope adjustment volume (by percent) associated with selected borrow area sediments is represented in Table F2.

(2) Increased Erosion Requirements

The advance fill requirement for the next maintenance fill project is estimated at 600,000. If sand which is finer than the native beach is placed on Captiva, it will erode at a rate higher than the historical rate which formed the basis for the advance fill estimate. The estimated increased erosion rate associated with finer fill material was calculated as

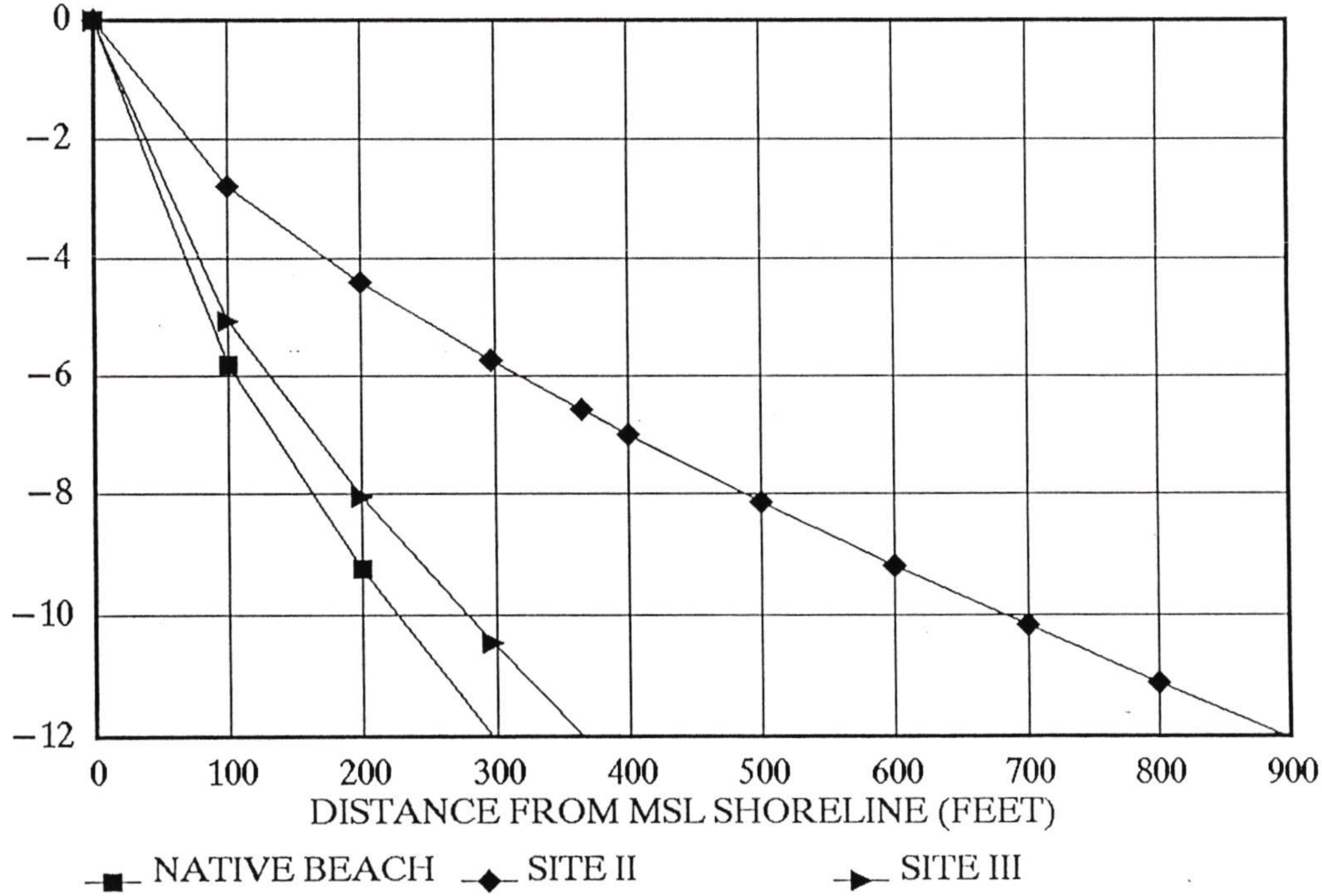


FIGURE F6

EQUILIBRIUM PROFILE COMPARISON
SLOPE ADJUSTMENT REQUIREMENTS

the ratio of K factors for the 1980 native beach grain size of 0.43 mm and borrow sources applied to the 600,000 cubic yard advance fill estimate. The K factor is a dimensionless empirical sand transport coefficient. The quantity of sand required due to the increased erosion of borrow material is presented in Table F2.

(3) Total Required Maintenance Fill Volume

The total required maintenance fill volume was taken as the sum of the slope adjustment volume, the advance fill volume and the increased erosion volume. The total required maintenance fill volume estimated for each borrow source is presented in Table F2.

7. New Native Beach Samples

In April 1994, a new sediment sampling program was carried out by Coastal Planning & Engineering, Inc. Samples were obtained at every fifth Florida Department of Environmental Protection profile line between R-87 and R-107 on Captiva Island. Samples were obtained across the active profile from the base of the dune at approximately 6 feet NGVD to the closure depth at -12 feet NGVD. A composite grain size curve was developed for each profile line by a weighted average of samples taken along the profile line. The samples were weighted by their effective range of depth, which is calculated by taking the difference in depth between adjacent samples and dividing by two. For example, a sample bracketed by samples at -3 and -9 feet would have an effective range of depth of 3 feet. The new mean grain size of the native beach is 0.48 mm (.07ϕ), the median is 0.29 mm, and the phi sorting is 1.85. The native beach cumulative frequency plot for the composite distribution data is plotted on Figure F-7. The new composite grain size is coarser than the grain size measured by Tetra Tech in 1980. The increase in sediment size reflects the coarse sand dredged from Redfish Pass in 1981 and 1988.

8. Conclusions

Borrow Area III has the most compatible sand in quantity and quality to support the next maintenance nourishment of Captiva Island. The other borrow areas are deficient in at least one prime characteristic. If a small quantity of sand is required to implement the inlet management plan, other sources could be viable, especially Redfish Pass ebb shoal, which is slowly infilling.

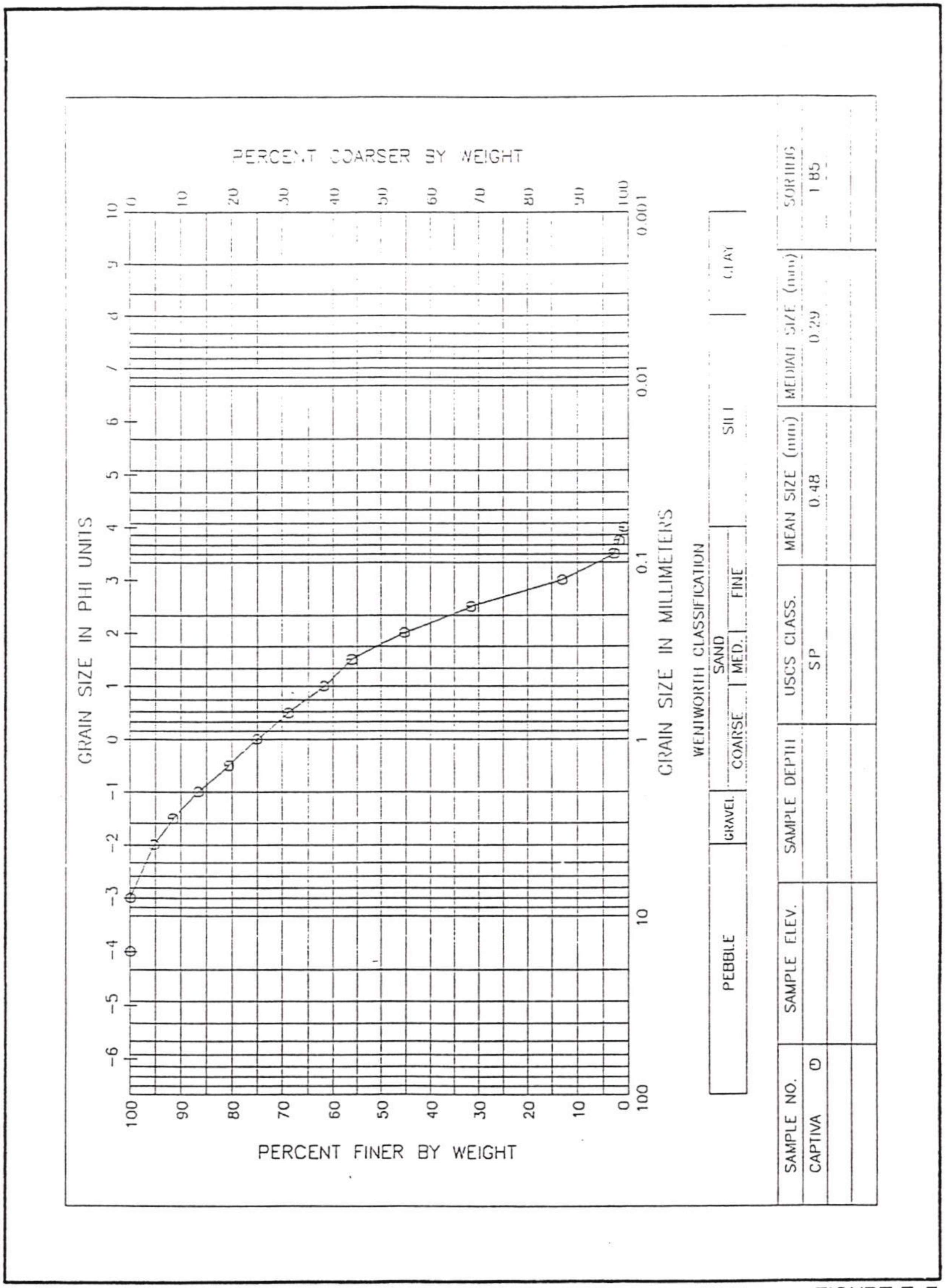


FIGURE F-7

GRAIN SIZE DISTRIBUTION CURVE
CAPTIVA NATIVE BEACH COMPOSITE 1994

9. References

Alpine Ocean Seismic Survey, Inc., 1988, Report on Vibracore Sampling for Captiva Erosion Prevention District, Norwood, New Jersey.

American Society for Testing and Materials (ASTM), 1987, Annual Books of ASTM Standards. Volume 04.08 ASTM, Philadelphia, PA.

Balsillie, J.H., Memorandum, subject "Redfish Pass IMP," Comments on CPE January 5, 1994 comment letter and November 1993 Draft IMP.

Coastal Planning & Engineering, Inc. (CPE), 1989, Lee County, Florida, Beach Erosion Control Project, Captiva Island Segment, General & Detailed Design Memorandum, Boca Raton, Florida.

Coastal Planning & Engineering, Inc. (CPE), 1990, Captiva Island Beach Maintenance Nourishment Project, Phase I Sand Search, Boca Raton, Florida.

Coastal Planning & Engineering, Inc. (CPE), 1991, Captiva Island Beach Maintenance Nourishment Project, Phase II Sand Search, Boca Raton, Florida.

Coastal Planning & Engineering, Inc. (CPE), 1992, Captiva Island Beach Maintenance Nourishment Project, Phase II Sand Search, Addendum I, Boca Raton, Florida.

Coastal Planning & Engineering, Inc. (CPE), 1993, Captiva Island Beach Maintenance Nourishment Project, Phase III Sand Search (in preparation), Boca Raton, Florida.

Coastal Planning & Engineering, Inc. (CPE), Design Memorandum for the First Renourishment Project, Captiva Island Segment, Lee County, Florida, July 1994.

Dean, R.G., 1977, Equilibrium Beach Profiles: U.S. Atlantic and Gulf Coast, Ocean Engineering Report No. 12, Dept. of Civil Engineering, University of Delaware.

Hobson, R. D., 1977, "Review of Design Elements for Beach-Fill Evaluation," T. P. No. 77-6, U.S. Army Corps of Engineers, CERC, Fort Belvoir, VA.

Krumbein, W.C. 1957. A Method for Specification of Sand for Beach Fills, Technical Memorandum No. 102, U.S. Army Corps of Engineers, Beach Erosion Board.

Missimer, Thomas M., 1973, "The Depositional History of Sanibel Island, Florida," M.S. Thesis, Florida State University, Florida.

Stauble, D.K., Sainberg, J.C. and Knight, J.M., 1984, Erosion Control/Permit Monitoring Program, Beaches and Shores Report CZM-84-1, Florida Department of Natural Resources, Tallahassee, Florida.

Tetra Tech, Inc., 1980a, "An Evaluation of Offshore Sand Sources at Captiva Island, Florida," Tetra Tech, Contract No. 3362-05, Jacksonville, Florida.

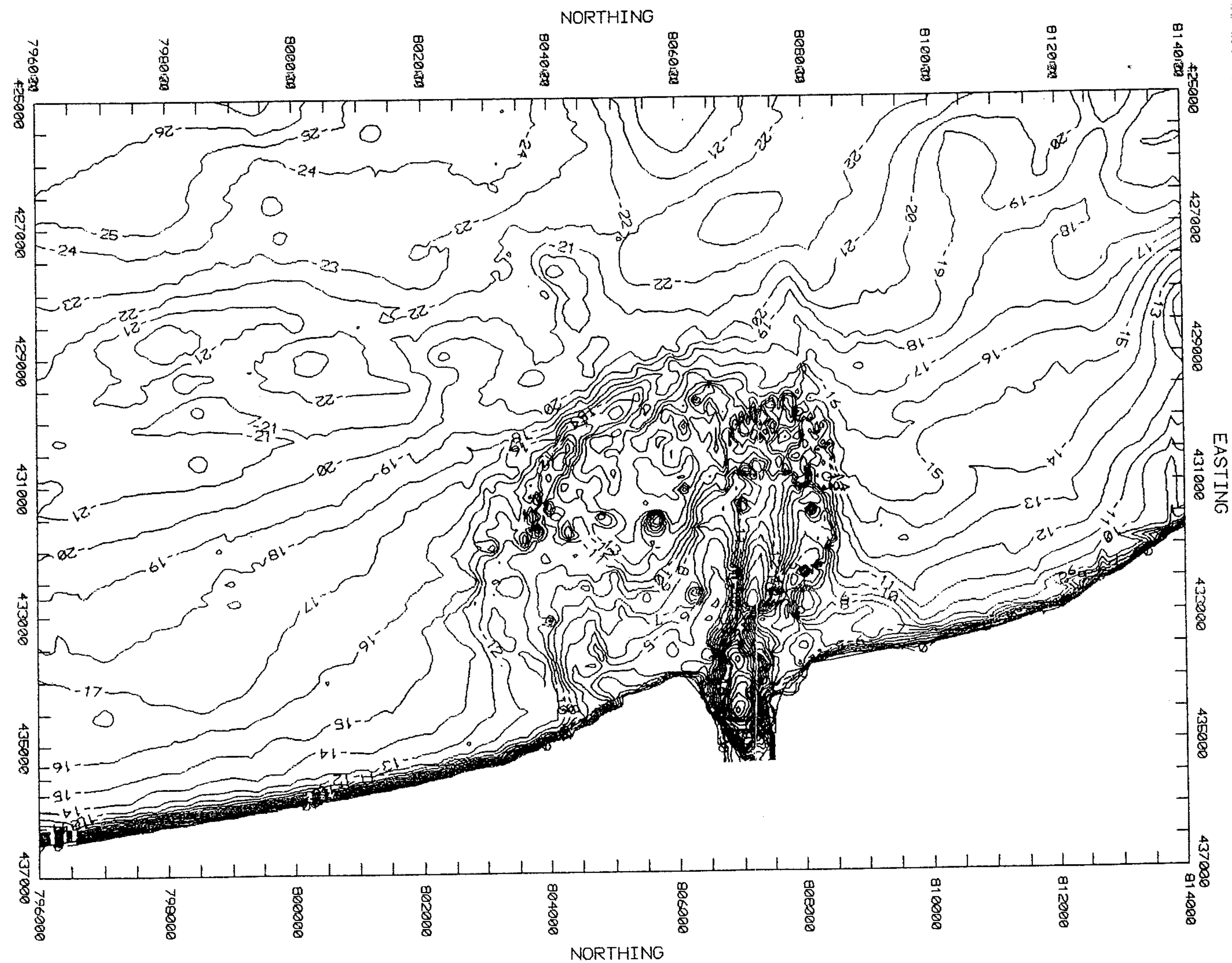
Tetra Tech, Inc., 1980b, "Geotechnical Exploration of Offshore Sand Sources at Captiva Island, Florida," Tetra Tech, Contract No. 3362-07, Jacksonville, Florida.

Tetra Tech, Inc., 1981, "Engineering Report for Captiva Erosion Prevention District Beach Nourishment Project," Tetra Tech, Contract No. TC-3362, Jacksonville, Florida.

University of Florida, 1981, "Hydraulics and Geology Related to Beach Restoration in Lee County, Florida, Department of Civil Engineering, Gainesville, Florida.

U.S. Department of the Army, Jacksonville District, Corps of Engineers, 1969, "Beach Erosion Control Study on Lee County, Florida," Jacksonville District, Corps of Engineers, Jacksonville, Florida.

Van Reenan, E., 1980, "Captiva Island Profiling Study," Van Reenan International, Inc., Houston, Texas.

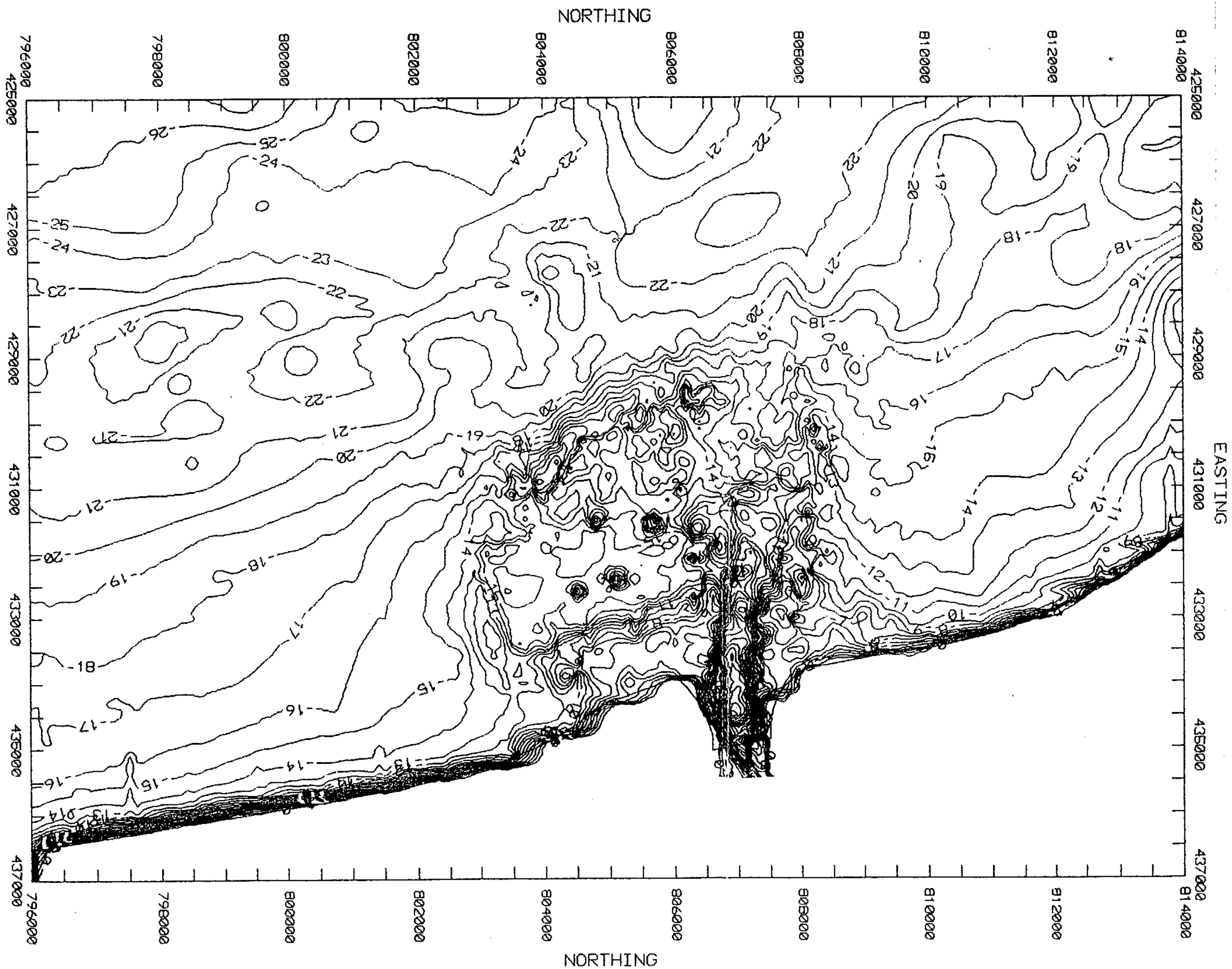


SCALE 1 inch = 1800 FEET

REDFISH PASS
1988 PRE-DREDGE
BATHYMETRY

COASTAL PLANNING & ENGINEERING, INC.
2481 N.W. BOCA RATON BOULEVARD.
BOCA RATON, FL 33431

FIGURE G3



SCALE 1 inch = 1800 FEET

REDFISH PASS
1991 2 YEAR POST-DREDGE
BATHYMETRY

COASTAL PLANNING & ENGINEERING, INC.
2481 N.W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431

FIGURE G4

TABLE G1

REDFISH PASS, 1966 PRE-DREDGE BATHYMETRY, 200 FT. X 200 FT. DEPTH GRID (FEET, NGVD)

21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	20	20	20	20	20	20	21	21	21	21	21	21	21	21	20	20	20	20	20	20	20	19	20	20	19	20	20	19	19	18	18	19	19	19	20	20	20	19	19	19	19	19	19	18	18	18
21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	20	20	20	20	20	20	20	20	20	20	20	20	20	20	19	19	19	18	18	18	18	17	18	18	18	19	19	19	19	18	18	19	19	19	19	19	19	19	19	19	19	19	18	18	18	18
21	21	21	21	21	21	21	21	21	21	21	21	21	20	20	20	21	21	21	21	21	21	21	20	20	20	20	20	20	20	20	20	20	20	20	20	20	18	17	17	17	17	17	17	16	16	17	17	17	18	18	18	18	18	18	18	18	19	19	19	19	19	19	19	19	18	18	18	17	17
21	21	21	21	21	21	21	21	21	21	21	21	21	20	20	20	20	20	20	20	20	20	20	20	19	19	19	19	19	20	20	20	20	20	19	18	18	16	15	15	15	17	17	16	15	15	16	16	16	17	17	17	17	17	17	18	18	18	18	18	18	18	18	18	18	18	18	17	17	17
21	21	21	21	21	21	21	21	21	21	20	20	20	20	20	20	20	20	20	20	20	20	19	19	19	19	19	19	19	19	19	19	19	18	16	16	15	14	13	14	16	16	16	15	12	12	13	14	16	17	17	17	17	15	17	17	18	18	18	18	18	18	18	18	18	17	17	17	17	17
20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	19	19	19	19	19	19	19	19	19	18	18	18	18	18	17	17	17	17	15	13	13	14	14	14	16	16	13	13	14	14	13	14	15	16	16	16	16	15	16	17	17	17	17	17	17	17	17	17	17	17	16	16	16	16
20	20	20	20	20	20	20	20	20	20	20	20	20	19	19	19	19	19	19	19	18	18	18	18	18	18	18	17	17	16	16	15	14	12	12	15	16	16	15	15	14	13	13	13	14	14	13	14	15	15	15	15	15	15	15	16	17	17	17	17	17	17	17	17	17	16	16	16	16	16
20	20	20	19	19	19	19	19	19	19	19	19	19	19	19	19	19	18	18	18	18	18	18	17	17	17	17	16	16	16	15	13	10	10	13	15	16	15	15	14	14	14	13	13	14	14	13	13	13	15	14	13	14	14	15	16	17	17	17	17	17	17	16	16	16	16	16	15	15	15
19	19	19	19	19	19	19	19	19	19	19	19	19	18	18	18	18	18	18	18	17	17	17	17	17	17	16	15	15	15	13	11	10	12	15	15	15	15	15	15	15	14	14	14	14	14	13	14	15	15	15	14	13	13	15	16	16	16	16	16	16	16	16	16	15	15	15	16	16	16
19	19	19	19	19	19	19	19	19	18	18	18	18	18	18	18	18	18	17	17	17	17	17	16	16	16	15	14	14	14	13	11	12	12	14	14	15	15	15	15	15	14	15	14	14	14	13	13	13	15	14	14	13	13	14	16	16	16	16	16	16	16	15	15	15	15	15	15	15	15
19	19	19	19	18	18	18	18	18	18	18	18	18	18	18	18	18	17	17	17	17	17	16	16	16	15	14	13	14	14	14	12	13	13	13	14	15	15	15	15	15	15	15	14	13	14	12	12	12	14	14	14	13	14	14	15	16	16	16	16	16	15	15	15	15	15	15	15	15	15
18	18	18	18	18	18	18	18	18	18	18	18	18	18	17	17	17	17	17	17	16	16	16	16	15	14	13	13	13	13	13	12	12	12	13	14	14	15	15	15	15	15	14	12	12	11	10	11	11	13	14	14	12	12	14	15	15	16	16	16	15	15	15	15	15	15	15	15	15	15
18	18	18	18	18	18	18	18	18	17	17	17	17	17	17	17	17	17	17	17	16	16	16	15	15	14	14	12	13	13	12	11	12	12	12	12	13	14	14	14	14	14	13	10	9	9	9	10	11	12	11	11	11	11	14	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
18	18	18	18	18	18	18	18	17	17	17	17	17	17	17	17	17	17	17	16	16	16	16	15	14	13	13	12	12	12	11	11	12	12	12	11	11	12	13	13	14	14	11	9	9	9	11	11	12	11	9	8	10	11	14	15	15	15	15	15	15	15	15	15	15	15	14	14	14	14
18	18	18	18	18	18	18	18	17	17	17	17	17	17	17	17	17	17	16	16	16	16	16	15	14	12	12	11	11	11	11	11	11	11	12	13	14	14	13	13	13	12	9	8	8	9	11	12	12	10	8	8	8	11	14	14	15	15	15	15	15	15	15	15	14	14	14	14	14	14
18	18	18	18	18	18	17	17	17	17	17	17	17	17	17	17	16	16	16	16	16	16	15	15	15	12	12	12	11	10	10	10	10	10	11	12	13	13	13	13	12	10	8	7	7	9	12	13	12	10	7	7	7	11	13	14	15	15	15	15	15	15	15	15	14	14	14	14	14	14
18	18	18	18	18	17	17	17	17	17	17	17	17	17	16	16	16	16	16	16	16	15	15	14	13	12	12	12	12	10	10	9	10	10	10	10	12	13	12	12	10	8	7	6	7	10	13	14	12	9	7	7	7	11	13	14	14	14	14	15	15	15	14	14	14	14	14	14	14	14
17	17	17	17	17	17	17	17	17	17	17	16	16	16	16	16	16	16	16	15	15	15	14	13	12	12	11	11	11	10	9	9	9	9	9	9	11	12	11	11	9	8	6	6	7	11	15	15	12	9	6	6	7	11	13	13	14	14	14	14	14	14	14	14	14	13	13	13	13	13
17	17	17	17	17	17	17	17	17	17	16	16	16	16	16	16	16	16	15	15	15	14	14	13	12	11	11	11	11	10	9	8	8	8	9	9	10	10	10	9	8	7	6	5	7	13	16	15	11	7	5	5	9	11	12	13	13	13	14	14	14	14	13	13	13	13	13	13	13	13
17	17	17	17	17	17	17	17	17	16	16	16	16	16	16	16	16	16	15	15	15	14	14	13	12	11	11	11	11	10	9	7	7	7	8	7	8	8	8	8	8	7	5	5	9	15	17	14	8	6	6	7	9	11	12	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
17	17	17	17	17	17	17	16	16	16	16	16	16	16	16	16	16	15	15	15	15	15	14	14	13	11	11	11	11	9	8	7	6	6	7	7	7	8	8	7	7	7	5	5	11	15	15	12	6	5	6	7	10	11	11	12	12	13	13	13	13	13	12	12	12	12	12	12	12	12
17	17	17	17	17	16	16	16	16	16	16	16	16	16	16	15	15	15	15	15	15	14	14	14	13	12	12	12	11	9	7	6	5	6	7	7	6	6	6	6	6	5	5	7	13	16	15	9	6	9	9	9	9	10	10	11	11	12	12	12	12	12	12	12	12	12	12	12	12	11
16	16	16	16	16	16	16	16	16	16	16	15	15	15	15	15	15	15	15	15	15	14	14	14	13	13	12	12	12	10	6	6	5	5	6	6	6	5	5	5	5	5	6	10	14	8	5	4	4	9	9	8	9	9	9	9	10	11	12	12	12	11	12	12	11	11	11	11	11	11
16	16	16	16	16	16	15	15	15	15	15	15	15	15	15	15	15	15	15	15	14	14	14	14	13	12	12	12	12	10	6	5	5	5	5	5	5	5	5	5	5	10	14	14	8	5	4	4	8	8	7	7	7	7	8	9	10	11	11	11	11	11	11	11	11	11	11	10	10
15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	14	14	14	14	13	13	12	12	12	11	10	7	5	4	3	4	4	4	4	4	5	5	5	13	16	14	9	7	5	6	6	6	6	7	7	7	7	8	9	11	11	10	10	10	10	10	10	10	10	9	8
15	15	15	15	15	15	15	15	14	14	14	14	14	14	14	14	14	14	14	14	14	14	13	13	13	12	12	12	11	11	8	6	4	3	3	3	3	3	2	4	5	6	13	19	19	12	8	5	6	6	6	6	6	6	7	7	7	8	9	9	9	9	9	9	9	8	8	9	8	8
14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	13	13	13	12	12	12	12	11	10	8	6	5	4	0	-2	-2	-2	-2	-2	2	9	17	21	19	12	7	6	6	5	2	1	1	2	3	3	4	4	4	5	5	5	5	5	4	3	2	2	0	-2
13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	12	12	12	11	11	11	10	9	7	5	0	-2	-2	-2	-2	-2	-2	-2	2	13	24	22	18	9	5	4	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
8	8	9	10	10	11	11	11	11	11	11	11	11	12	12	11	12	11	12	12	11	11	11	11	10	9	9	8	3	1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	0	12	23	23	15	3	1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
0	0	1	1	2	2	2	3	3	3	4	4	4	4	4	5	5	5	4	4	4	3	3	4	2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	14	23	22	10	2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	15	22	22	15	3	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

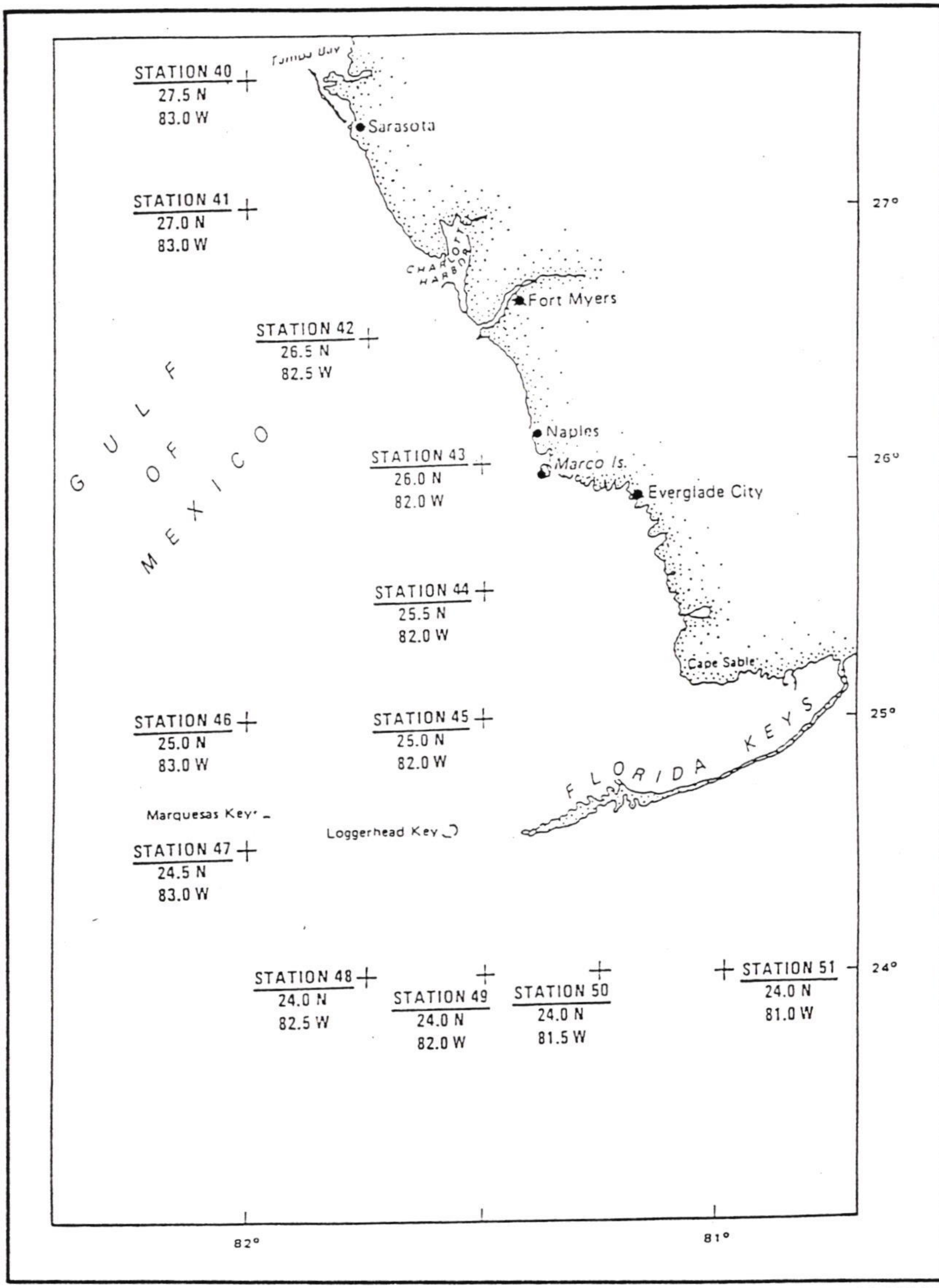


FIGURE G5

LOCATION OF WIS STATION 42

STATION 42 26.50N 82.50W FOR ALL DIRECTIONS
PERCENT OCCURRENCE(X1000) OF HEIGHT AND PERIOD FOR ALL DIRECTIONS

HEIGHT(METERS)	<4.2	4.2-5.3	5.4-6.5	6.6-7.4	7.5-8.7	8.8-9.5	9.6-10.5	10.6-11.8	11.9-13.3	13.4-LONGER	TOTAL
0. - 0.49	2748	3588	2063	.	.	.	.	.	.	.	8399
0.50 - 0.99	15189	33391	5816	165	30	6	1	.	.	.	54598
1.00 - 1.49	25	20407	8822	1081	367	11	8	.	.	.	30721
1.50 - 1.99	1	59	3755	1124	515	27	.	.	.	.	5481
2.00 - 2.49	.	.	268	241	181	3	.	.	.	.	693
2.50 - 2.99	.	.	11	15	53	8	.	.	.	.	87
3.00 - 3.49	.	.	.	.	.	3	.	.	.	.	3
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00+	.	.	.	.	.	.	.	.	.	.	0
TOTAL	17963	57445	20735	2626	1146	58	9	0	0	0	

MEAN HS(M) = 0.9 LARGEST HS(M) = 3.1 MEAN TP(SEC) = 4.8 TOTAL CASES = 58440.

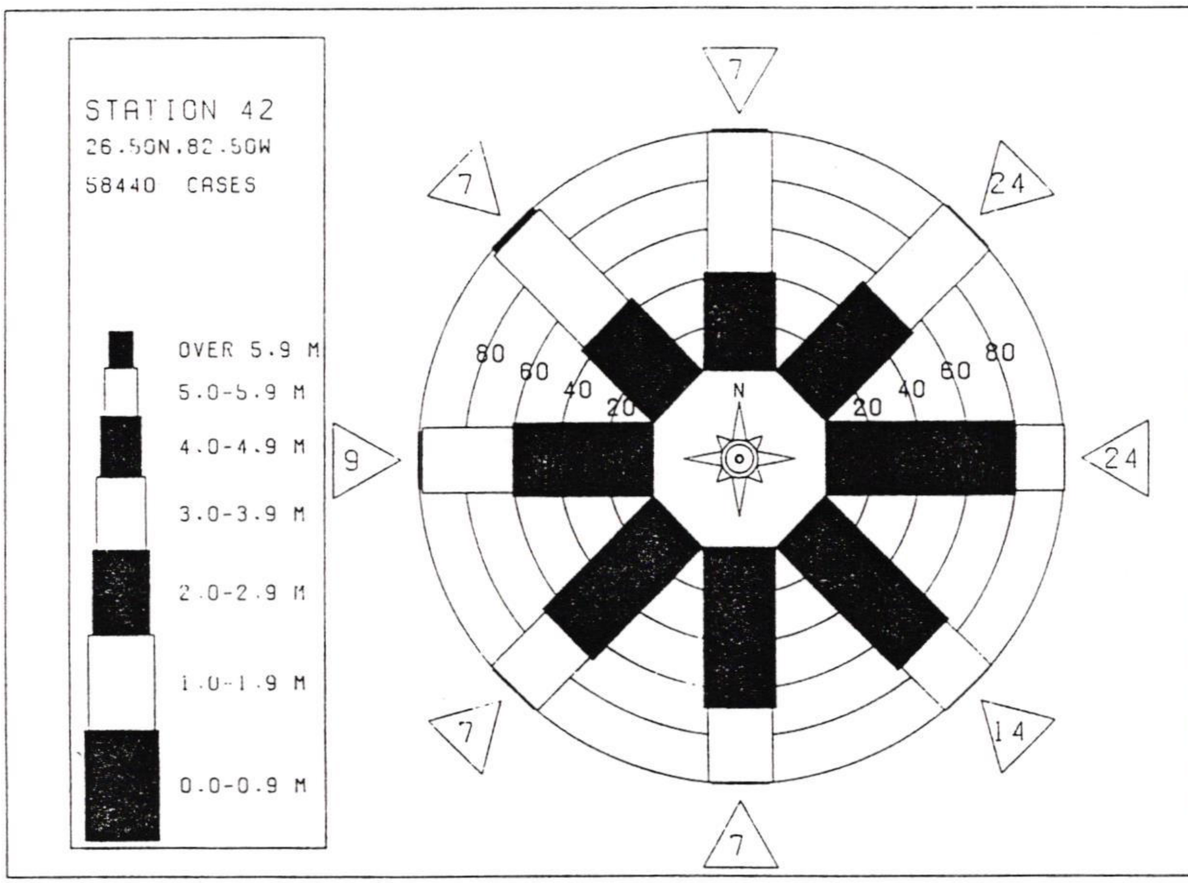


FIGURE G6

WAVE ROSE FOR WIS STATION 42

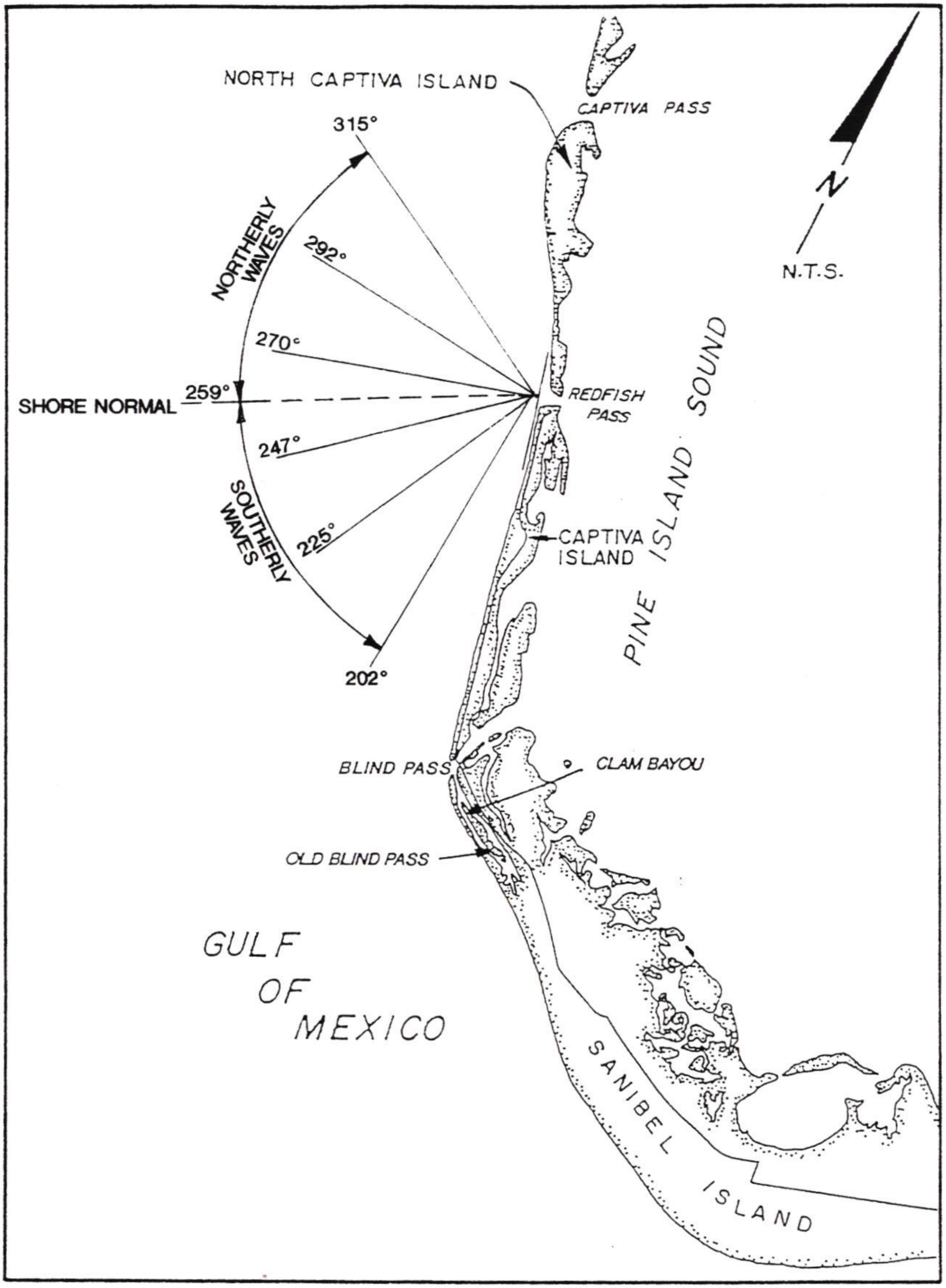


FIGURE G7

LONGSHORE ORIENTATION SHORE NORMAL AND PRIMARY DIRECTIONS OF WAVE PROPAGATION study area coastline from 247°, 225°, and 202° will be referred to as southerly waves. Southerly waves will generally cause a northerly sediment transport.

Twelve representative wave conditions were selected for analysis which correspond to average sea and swell conditions for each of the six wave sectors to which Captiva and North Captiva are exposed. For the purposes of this study, sea conditions are defined as significant wave heights or waves of less than six-second peak periods. Swell conditions are defined as significant wave heights for peak wave periods of six seconds or greater.

Table G2 presents a statistical wave summary at WIS Station 42. The table presents average significant wave heights and wave periods as well as the associated annual percent occurrence for the six selected wave sectors. The table also presents the annual percent occurrence of total wave energy for each of the six wave directions. The directional spectrum and energy spectrum for Station 42 is presented in Figure G8. Since WIS Station 42 is located in deep water and the seaward boundary of the model grid was approximately the 20 foot depth contour, Snell's Law was used to refract the waves to the west boundary of the grid system.

IV. METHODOLOGY

A. Wave Refraction

The propagation of ocean waves into decreasing water depths results in wave refraction and diffraction. Wave refraction is defined as the process by which the portion of a wave moving in shallow water at an angle to the depth contours moves more slowly than the part still advancing in deeper water, causing the wave crest to bend toward alignment with the underwater contours (SPM, 1984). Wave diffraction is defined as the phenomenon by which energy is transmitted laterally along a wave crest when a part of a wave train is interrupted by a barrier such as a shallow inlet shoal (SPM, 1984). Diffraction results in propagation of waves into the sheltered region within the barrier's geometric shadow.

The impact of the existing and post-dredged shoal configuration at Redfish Pass on wave refraction and diffraction was predicted using the University of Delaware's REF/DIF 1.0 (Version 2.3) computer program. The program is a non-linear combined refraction-diffraction (REF-DIF) model. The REF/DIF model is based on a Stokes expansion of the water wave problem. Application of the model involves the use of a parabolic equation and the use of finite difference techniques for the wave amplitude which results in tridiagonal matrices. A complete description of both model theories and application is provided in the REF/DIF documentation manual and user's manual (Dalrymple and Kirby, 1991).

Although the REF/DIF model has been demonstrated to accurately compute wave fields, it must be noted that the model results are based on the best available input data. The best data source at present is the WIS wave hindcast database. Use of the WIS data tends to overpredict potential sediment transport rates. Therefore, this analysis evaluates

TABLE G2

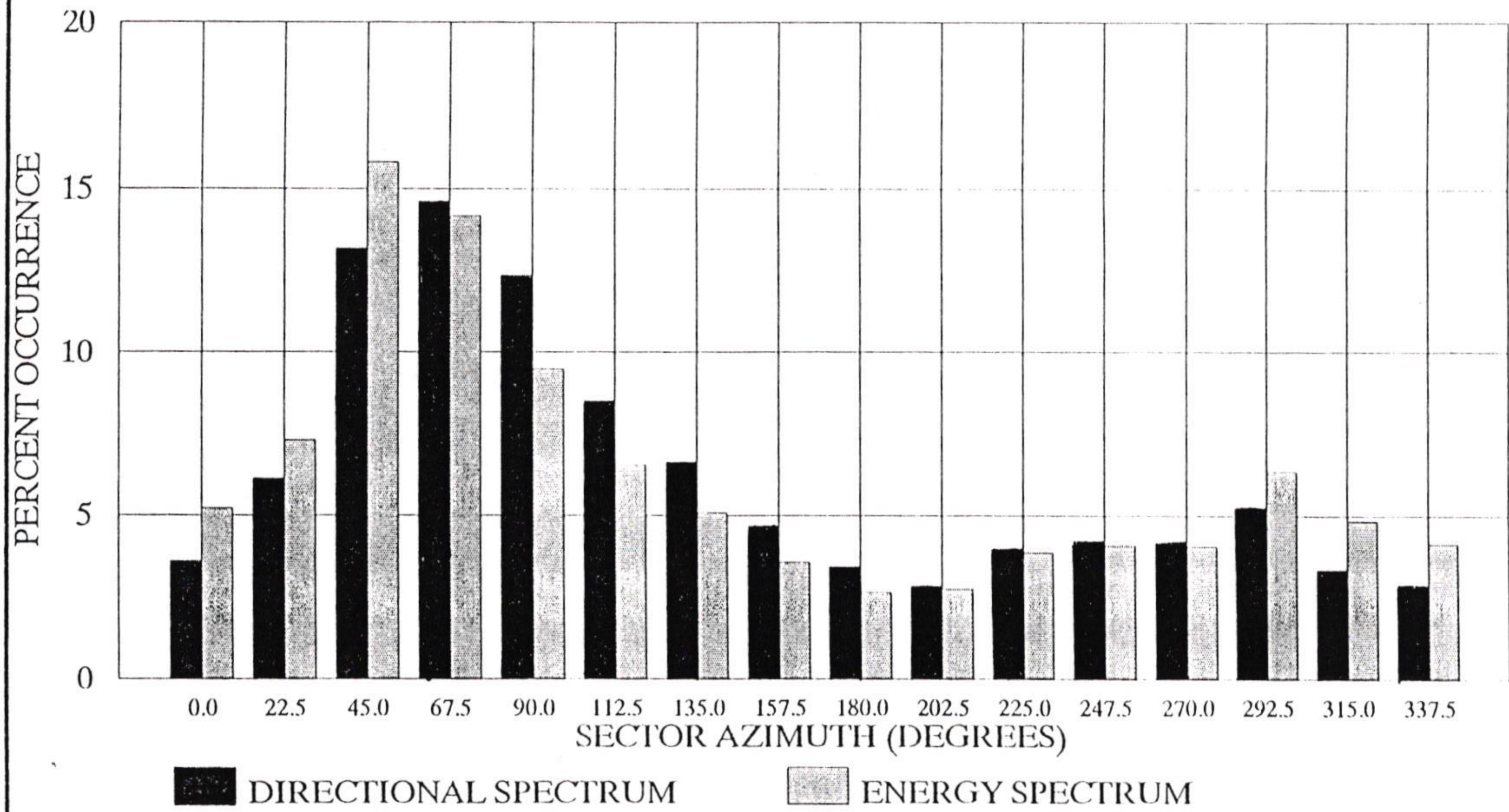
STATISTICAL WAVE SUMMARY AT WIS STATION 42

WAVE DIRECTION TRUE NORTH (DEGREES)	WAVE DIRECTION SHORE NORMAL (DEGREES)	WAVE TYPE	MEAN SIGNIFICANT WAVE HEIGHT (FEET)	MEAN WAVE PERIOD (SECONDS)	PERCENT OCCURRENCE (%)	(1) WEIGHTED ENERGY OCCURRENCE (%)	TOTAL ENERGY OCCURRENCE (%)
202 (191-214)	57	SEA	2.9	4.8	2.7	22.7	8.59
		SWELL	5.6	7.0	0.13	4.1	1.54
225 (214-236)	34	SEA	2.8	4.9	3.7	29.0	10.97
		SWELL	5.2	7.2	0.32	8.7	3.27
247 (236-259)	12	SEA	2.7	4.8	3.7	27.0	10.20
		SWELL	5.2	7.6	0.53	14.3	5.42
270 (258-281)	-11	SEA	2.7	4.9	3.2	23.3	8.82
		SWELL	4.9	7.6	0.95	22.8	8.63
292 (281-304)	-33	SEA	2.9	4.9	4	33.6	12.72
		SWELL	4.9	7.5	1.31	31.5	11.90
315 (304-327)	-56	SEA	3.6	5.1	3.2	41.5	15.69
		SWELL	6.1	7.1	0.16	6.0	2.25
TOTAL						264.4	100.00

(1) OCCURRENCE WEIGHTED BASED ON SQUARE OF WAVE HEIGHT

FIGURE G8

DIRECTIONAL SPECTRUM & ENERGY SPECTRUM
WIS STATION 42, GULF OF MEXICO, 26.5 N, 85.5 W



NOTE: ONLY SECTORS 202 – 315 AFFECT THE SHORELINE OF CAPTIVA the difference between existing and post-project wave climates and resulting sand transport rates to describe the North Captiva and Captiva beach volume changes.

B. Sediment Transport

Wave energy can be used as an indicator of sediment transport along a coastline. The longshore energy flux (P_{ls}) is the standard measure of potential energy in breaking waves. This longshore energy flux factor is also referred to as the sediment transport potential factor in the following sections. Based on the model grid system developed for Redfish Pass, a positive value of P_{ls} indicates northerly sediment transport. A negative value of P_{ls} indicates southerly sediment transport.

When the available wave data is in terms of significant heights, the sediment transport potential factor (longshore energy flux) can be computed at each grid intersection by the *Shore Protection Manual* (1984) equation:

$$P_{ls} = \frac{\rho g}{16} H^2{}_{sb}\, C_{gb} \sin 2\alpha_b$$

The term H_{sb} is the significant breaking wave height at each grid cell and is computed at the point prior to the initialization of wave breaking. The term α_b is the breaking wave angle and C_{gb} is the broken wave group velocity.

The main purpose of the wave refraction modelling effort is to evaluate the potential changes to sediment transport based on the pre-dredging and post-dredging shoal conditions. The sediment transport potential for each of the twelve wave conditions was weighted by the percent occurrence of wave energy. These weighted values for each grid cell were then added to compute the average annual transport potential along each longshore grid cell. The total average annual transport potential can then be compared at each grid cell for pre and post-construction conditions in order to predict potential sediment transport changes resulting from a modification of wave refraction patterns.

V. WAVE REFRACTION ANALYSIS

A. General

Wave refraction simulations were modelled for both the 1988 (pre-dredge) bathymetry and 1991 (post-dredging) bathymetric conditions at Redfish Pass. Wave refraction simulations on both bathymetries were run for the twelve wave conditions described in Section III. This required a total of 24 individual wave refraction model runs which are described in detail in the following sections.

B. Pre-Dredge Conditions

This section describes the wave refraction patterns and sediment transport which occurred in the area of Redfish Pass prior to the dredging of the borrow area.

As waves approach the coastline from offshore, they tend to refract or become more perpendicular to the shoreline as they enter shallow water. When entering shallow water, waves also tend to shoal and break, thereby reducing their wave heights. Wave vector diagrams were plotted for each model run. A typical wave vector plot for Redfish Pass is presented in Figure G9. The location of the grid is plotted relative to a distance north or south of the channel centerline. Distances north of the channel are designated (+), while distances south are designated (-). The arrows in the wave vector plots represent wave heights and directions at each model grid point for one set of wave conditions. The length of each wave vector represents the wave height. The initial wave height is defined at the bottom of the figure. The angle of each arrow with respect to shore normal represents the wave direction. The wave angle at the offshore grid boundary is defined at the bottom of the figure. As waves move from deep water to shallow water, the wave height (arrow length) decreases and the wave angle tends to refract and become more perpendicular to the shoreline or shoal.

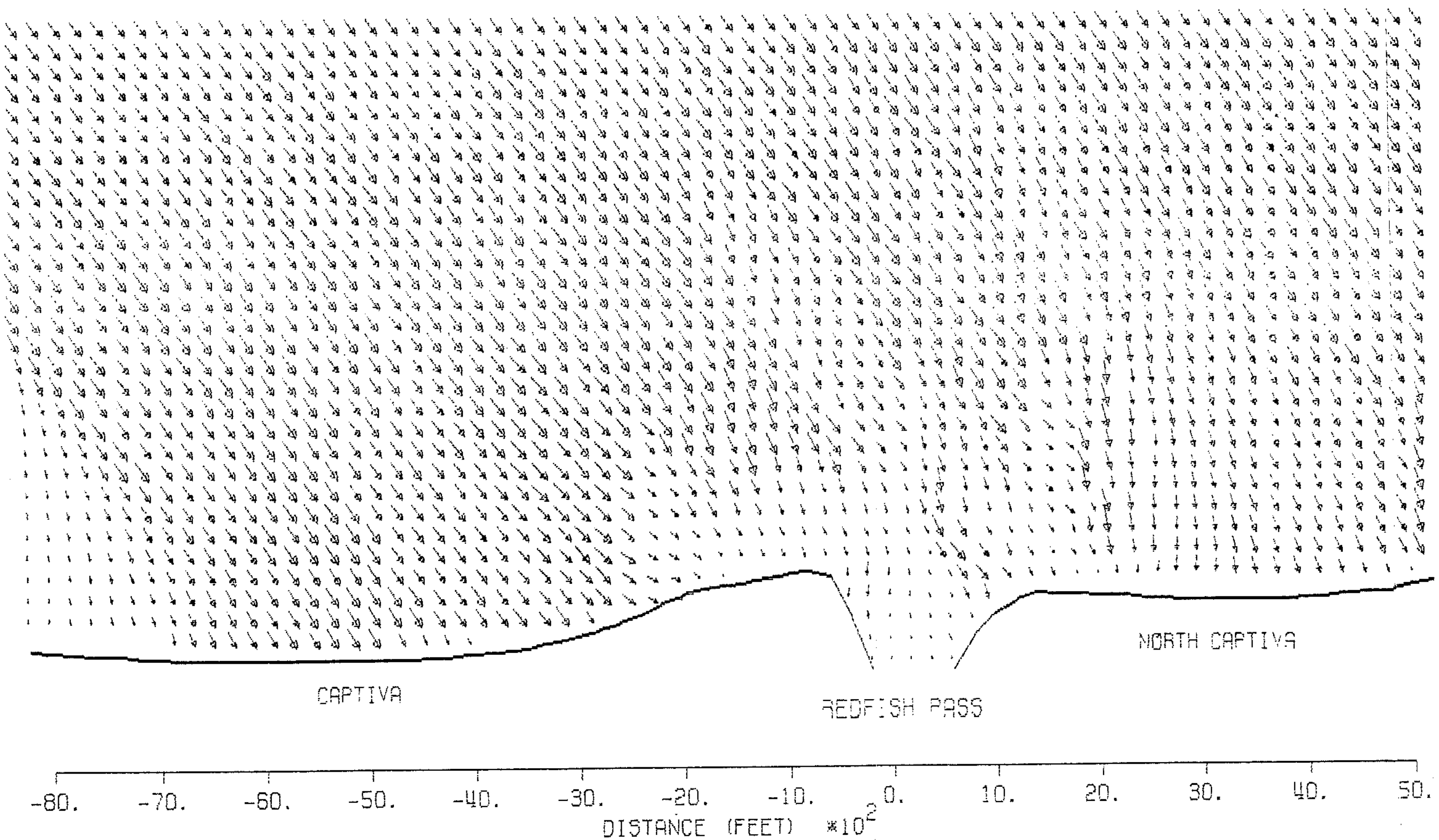
The simulation of long period swells generally resulted in more obvious refraction changes than the shorter period sea conditions. Waves from 225°, 247°, 270° and 292° experienced lesser wave refraction. The most significant wave refraction predicted by the model for the existing pre-dredged bathymetry at Redfish Pass occurs along the seaward section of the ebb shoal (Appendix 1). Wave refraction is most evident during long-period swell conditions.

C. Post-Dredging Conditions

Refraction patterns at Redfish with the post-dredged condition visually appear similar to the pre-dredged condition (Appendix 2). The seaward edge of the shoal tends to have the greatest influence on wave refraction. The borrow area allows longer period waves to propagate further across the borrow area before significant wave refraction is initiated closer to the coastline than compared to the pre-dredging conditions.

VI. SEDIMENT TRANSPORT ANALYSIS

Due to the orientation of the wave refraction model grid system, negative transport potential factors are an indication of southerly sediment transport and positive transport potential factors indicate northerly sand transport. All stationing referenced in the following discussion is based relative to the centerline of the channel at Redfish Pass.



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 4.7 FEET
WAVE PERIOD = 7.0 SECONDS
WAVE DIRECTION = 35.3 DEGREES

REDFISH PASS
EBB SHOAL BORROW AREA
PRE-DREDGE CONDITION

COASTAL PLANNING & ENGINEERING, INC.
2481 N.W. BOCA RATON BOULEVARD
BOCA RATON, FL 33431

FIGURE G9

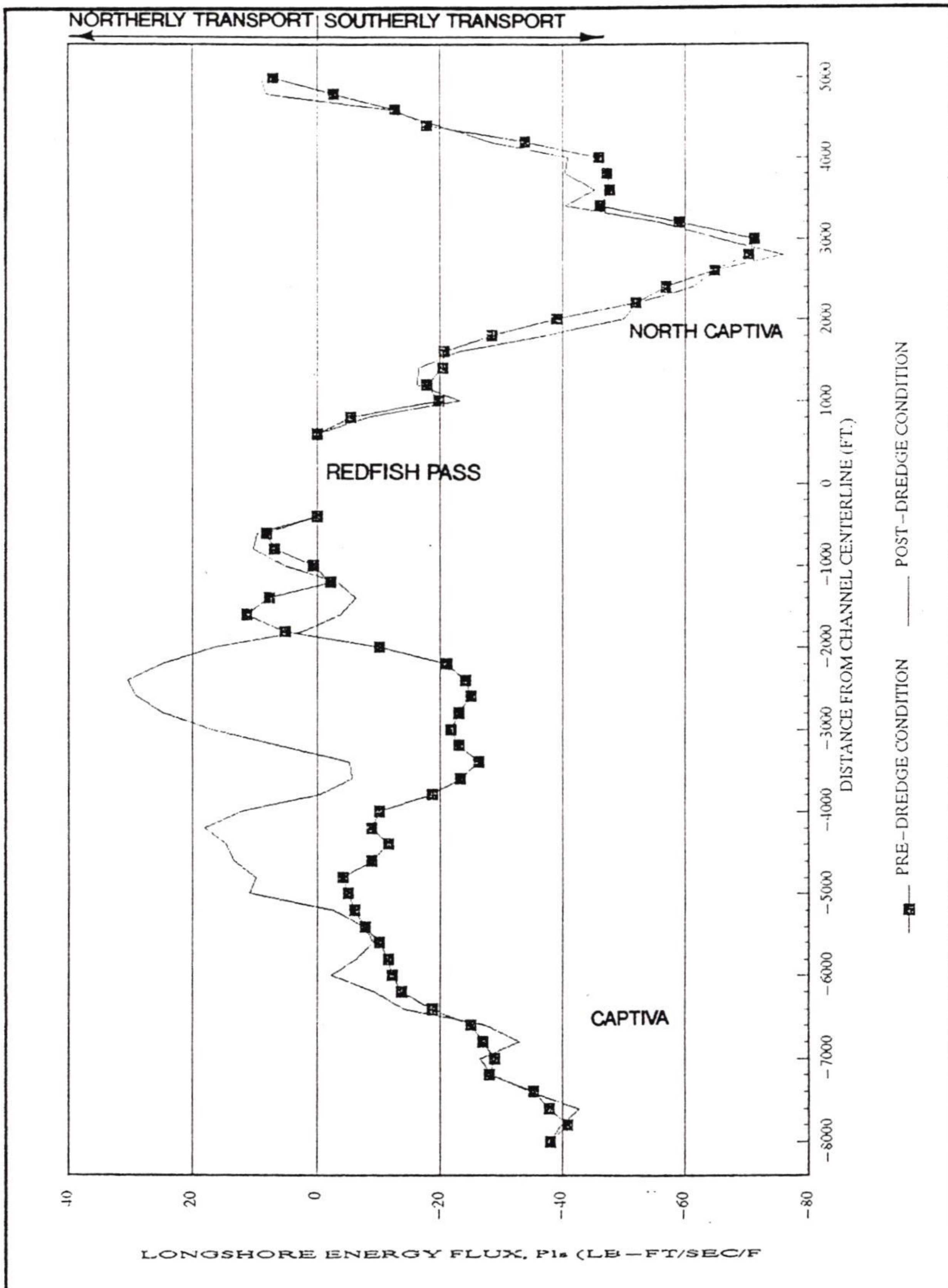


FIGURE G10

1988 PRE-DREDGING AND 1991 POST-DREDGING CONDITIONS LONGSHORE TRANSPORT POTENTIAL FOR SHORELINES ADJACENT TO REDFISH PASS

COASTAL PLANNING & ENGINEERING, INC. • BOCA RATON • SARASOTA • JACKSONVILLE

VII. CONCLUSIONS

A) The dredging of the Redfish Pass ebb shoal borrow area had no significant impact on wave refraction/diffraction and the resulting sediment transport along the southern mile of North Captiva Island.

B) Dredging of the Redfish Pass borrow area had a significant beneficial impact on wave refraction/diffraction and sediment transport along the first mile of Captiva south of the Pass. Erosion along the northern mile of Captiva Island was reduced as a result of the dredging. The borrow area dredging had an insignificant impact on waves and sediment transport along the second mile south of Redfish Pass.

C) Dredging of the borrow area increased northerly transport in Mile S1. Dredging of the Redfish Pass borrow area caused the nodal point on Captiva to shift from a point 2,000 ft. south of the inlet to a point 5,000 ft. south of the inlet.

VIII. REFERENCES

Coastal Planning & Engineering, Inc., "Draft - Redfish Pass Inlet Management Plan Interim Report," Boca Raton, 1993.

Coastal Engineering Research Center, "Shore Protection Manual," 1984.

Dalrymple, Robert A. and James T. Kirby, "Documentation Manual, Combined Refraction/Diffraction Model, REF/DIF Version 2.3," University of Delaware, January 1991.

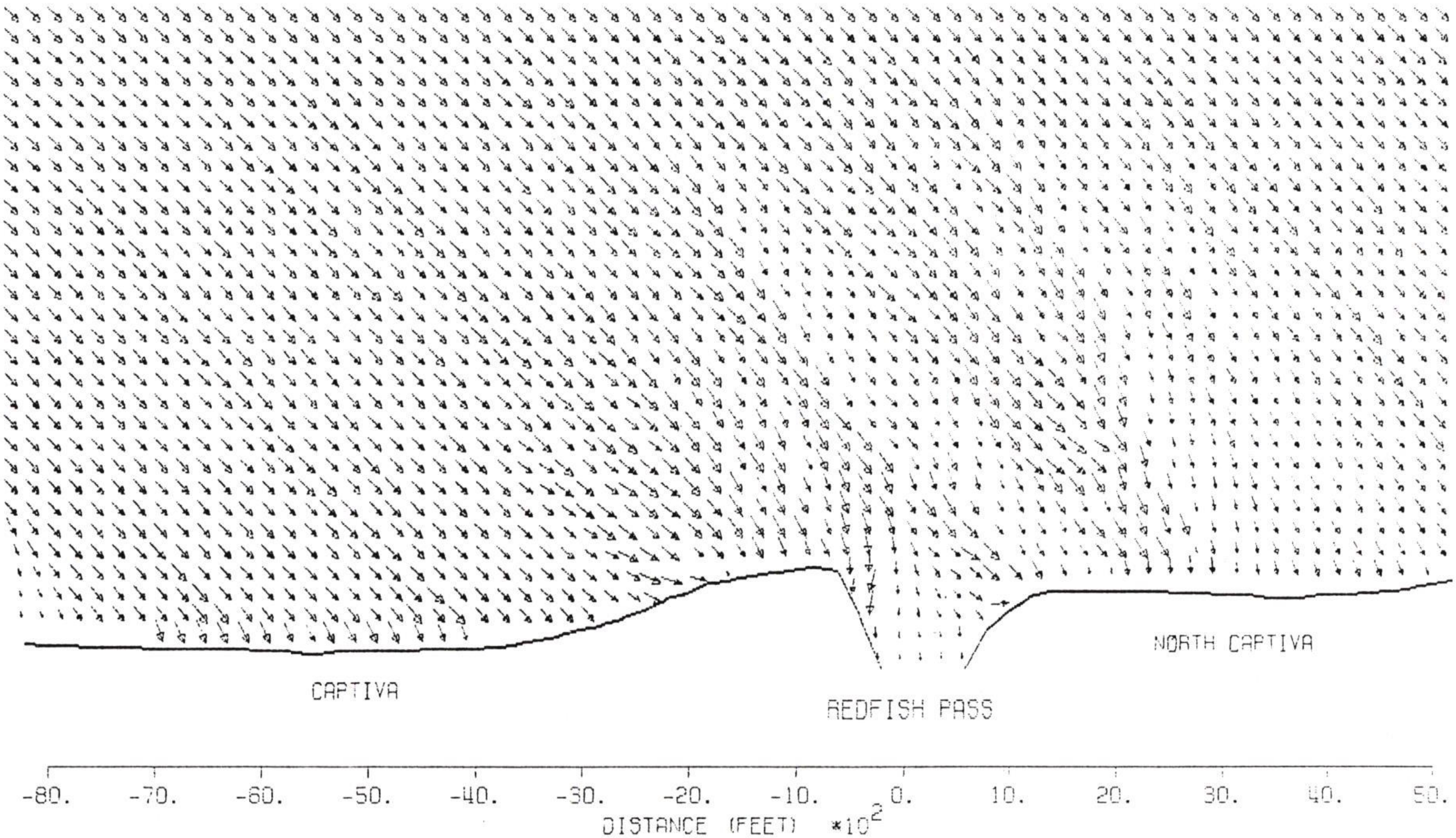
Hubertz, J. M. and R. M. Brooks, "Gulf of Mexico Hindcast Wave Information," WIS Report #18, U.S. Army Waterways Experiment Station, May 1989.

cap04:waveref

APPENDIX G-1

REDFISH PASS WAVE REFRACTION PATTERNS

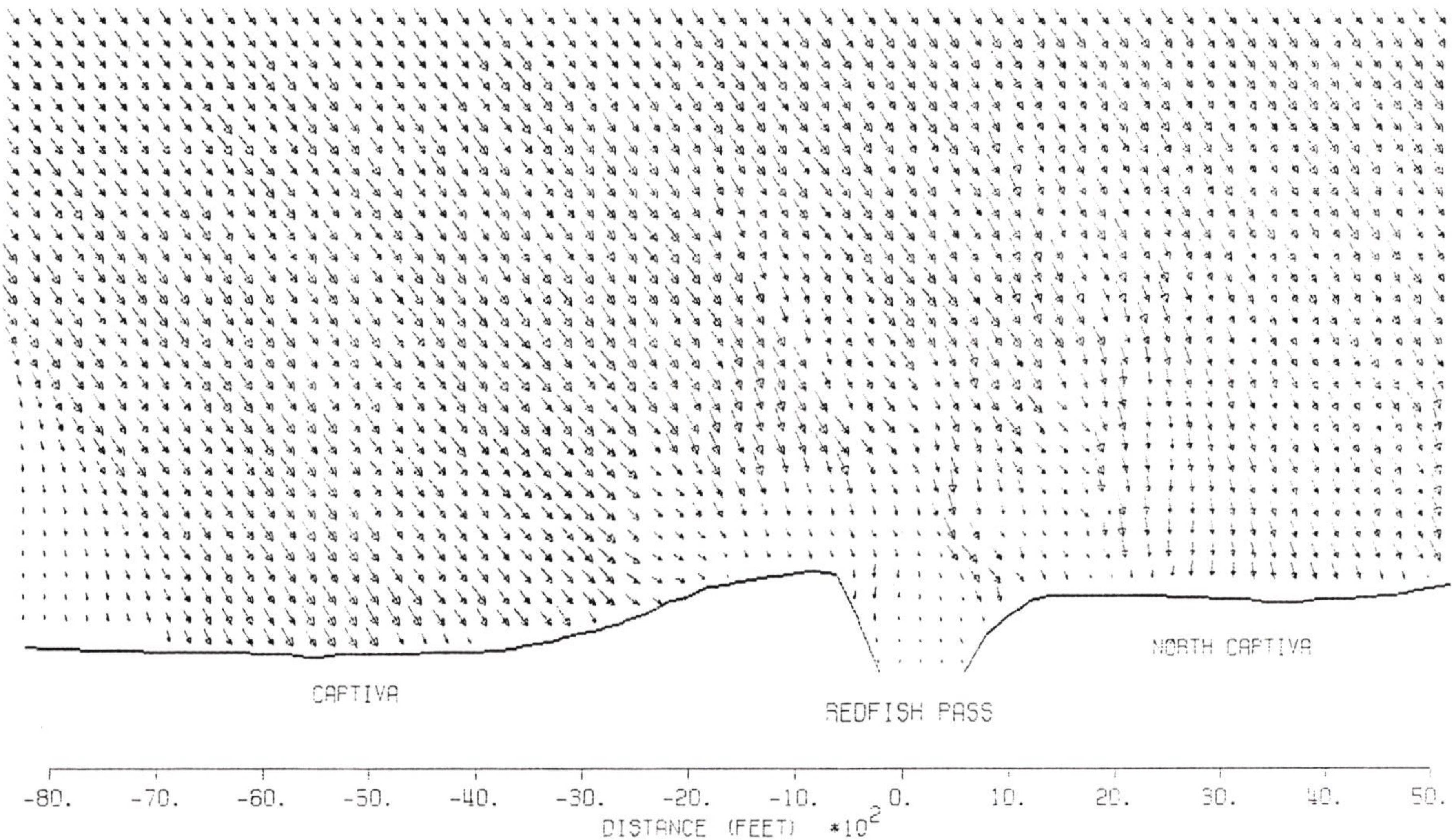
1988 PRE-DREDGING CONDITIONS



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.3 FEET
WAVE PERIOD = 4.8 SECONDS
WAVE DIRECTION = 45.4 DEGREES

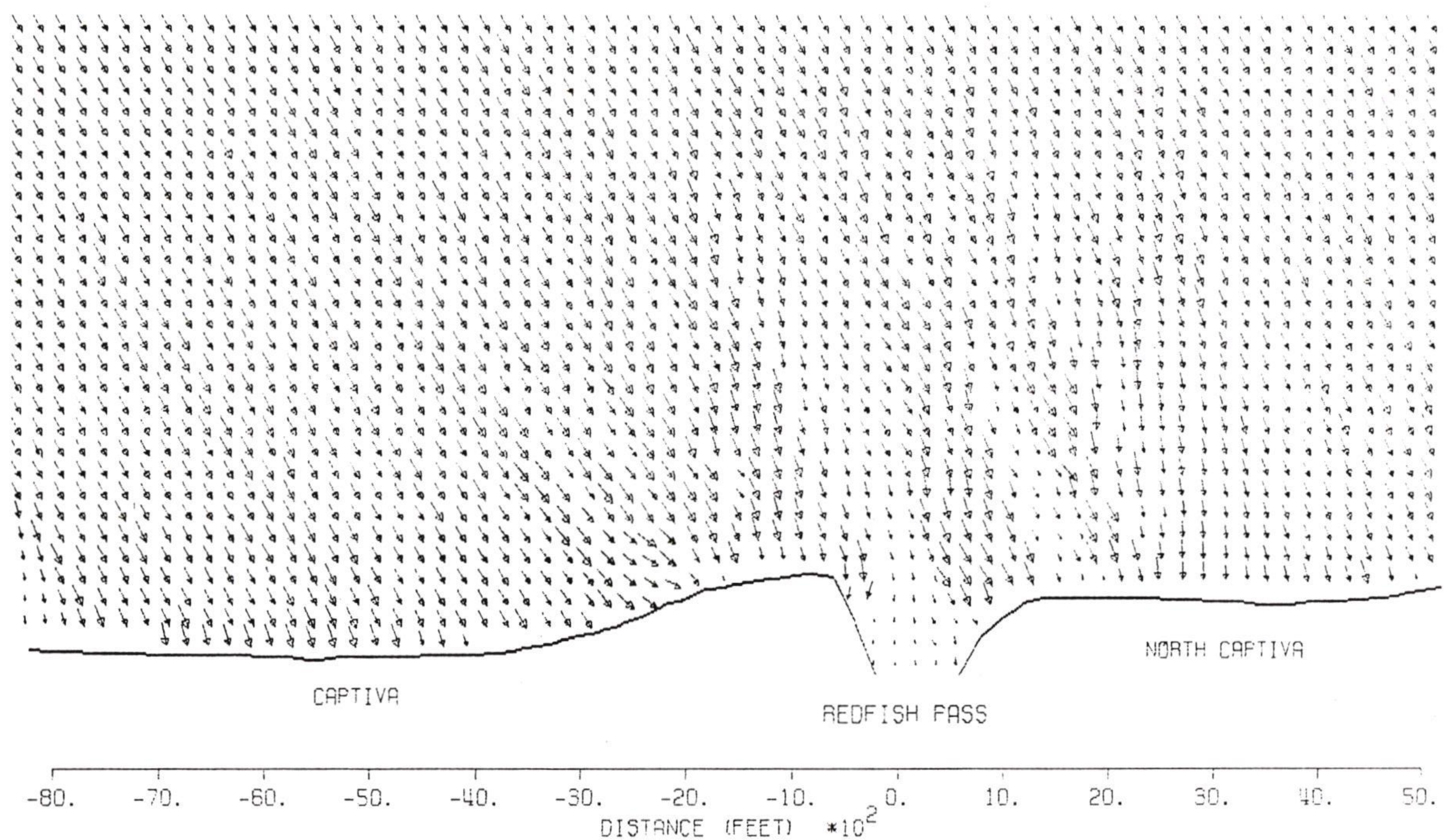
N

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



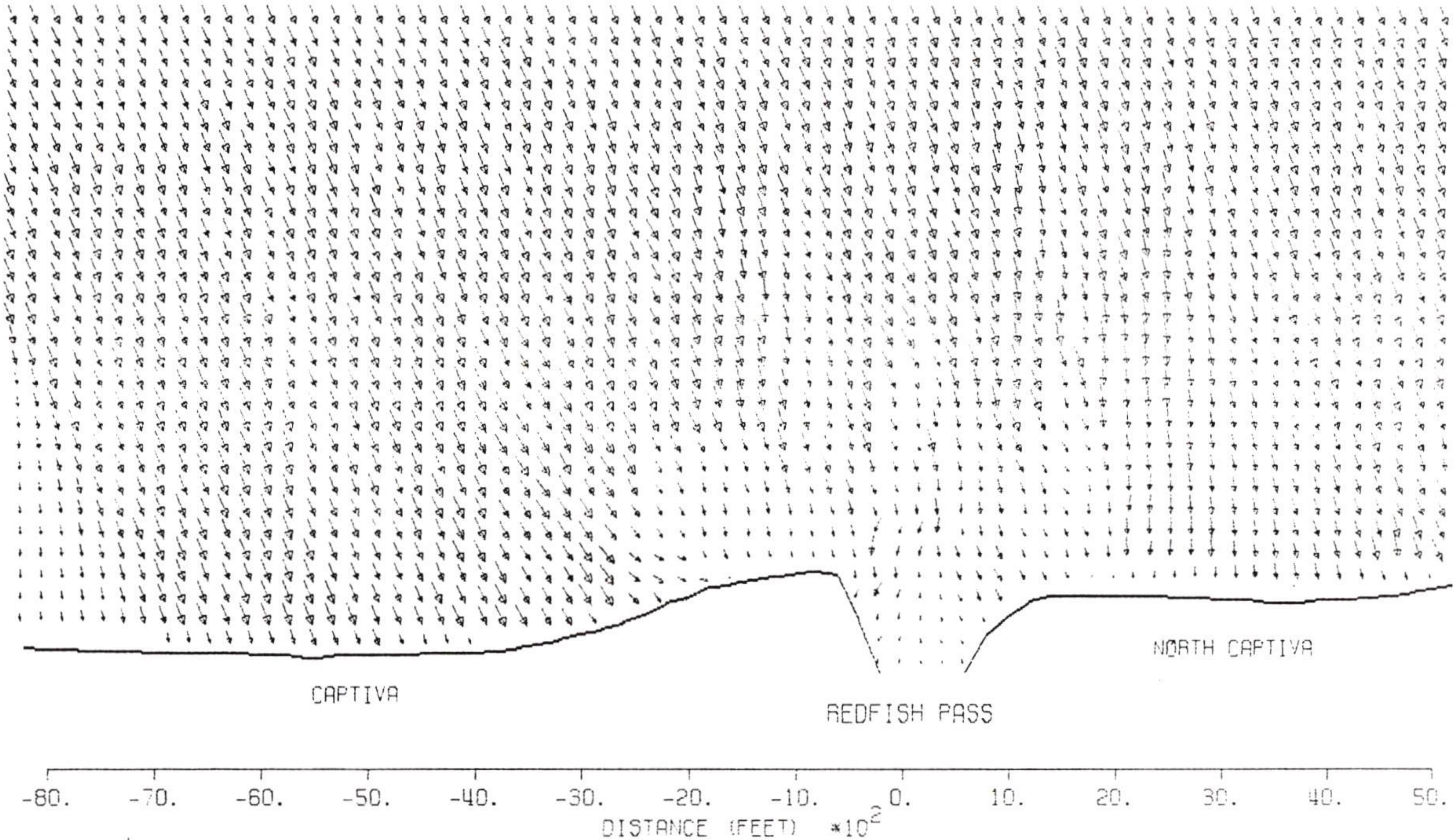
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 4.7 FEET
WAVE PERIOD = 7.0 SECONDS
WAVE DIRECTION = 35.3 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



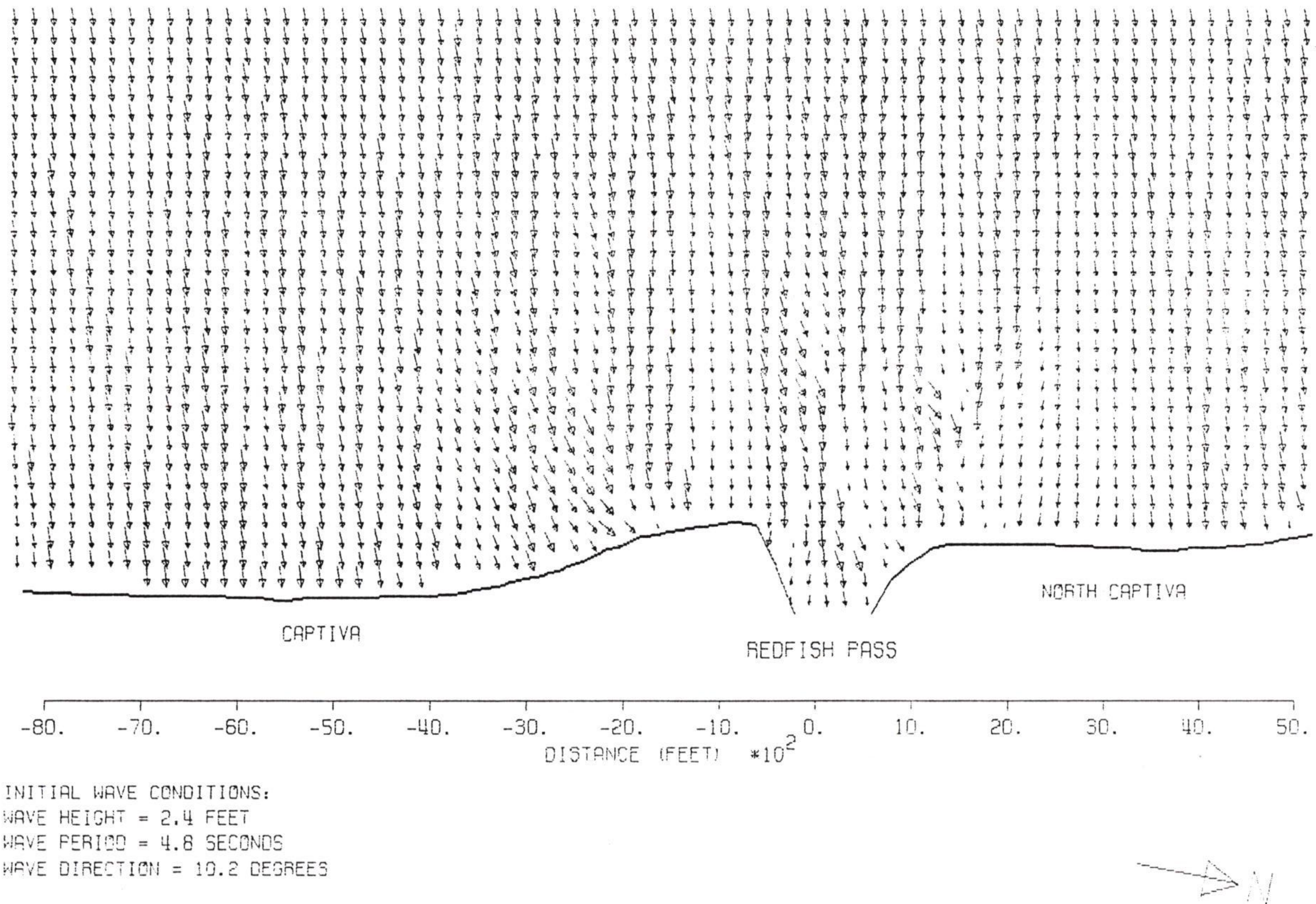
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.5 FEET
WAVE PERIOD = 4.9 SECONDS
WAVE DIRECTION = 28.4 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION

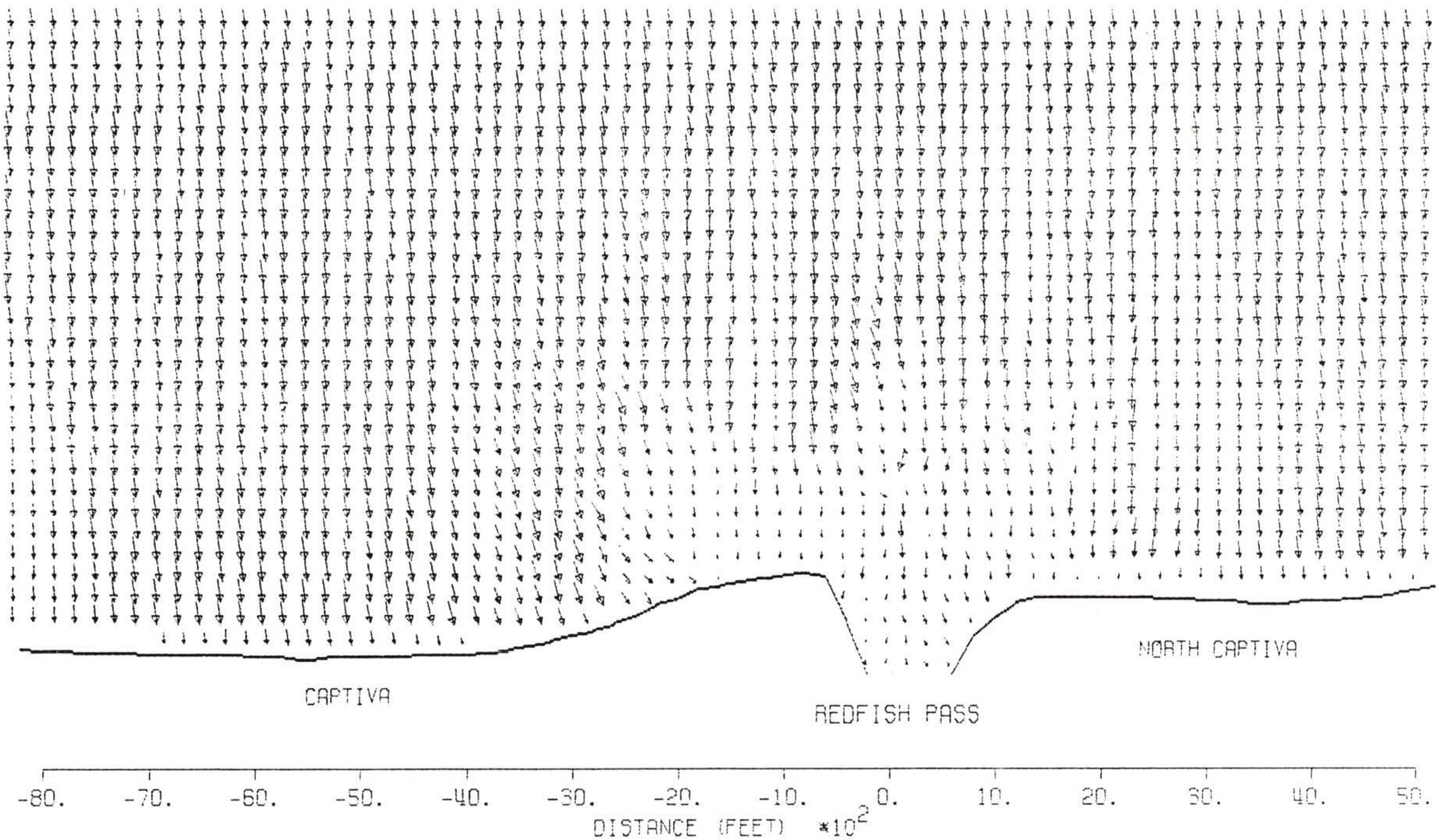


INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 5.1 FEET
WAVE PERIOD = 7.2 SECONDS
WAVE DIRECTION = 22.3 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION

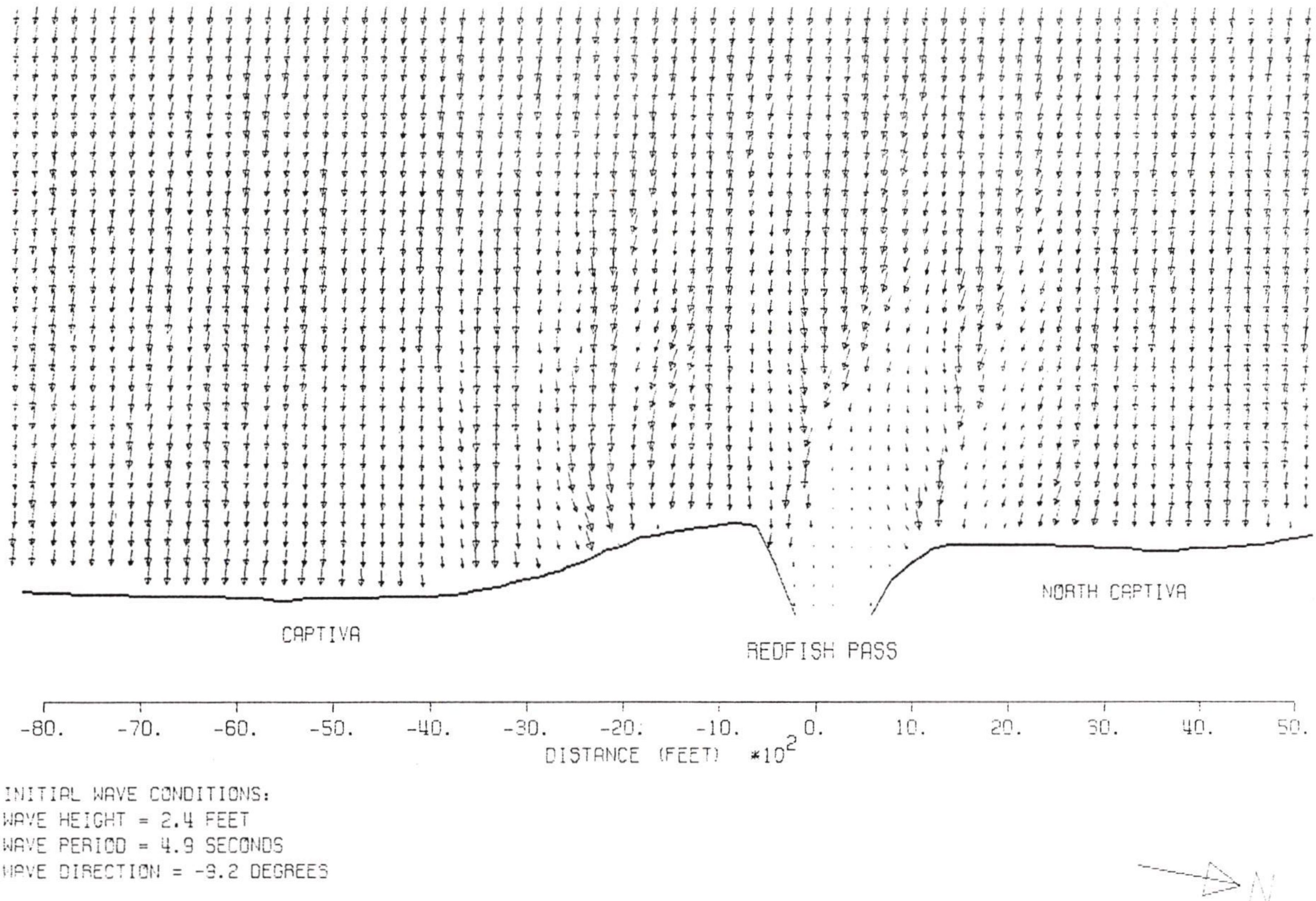


REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



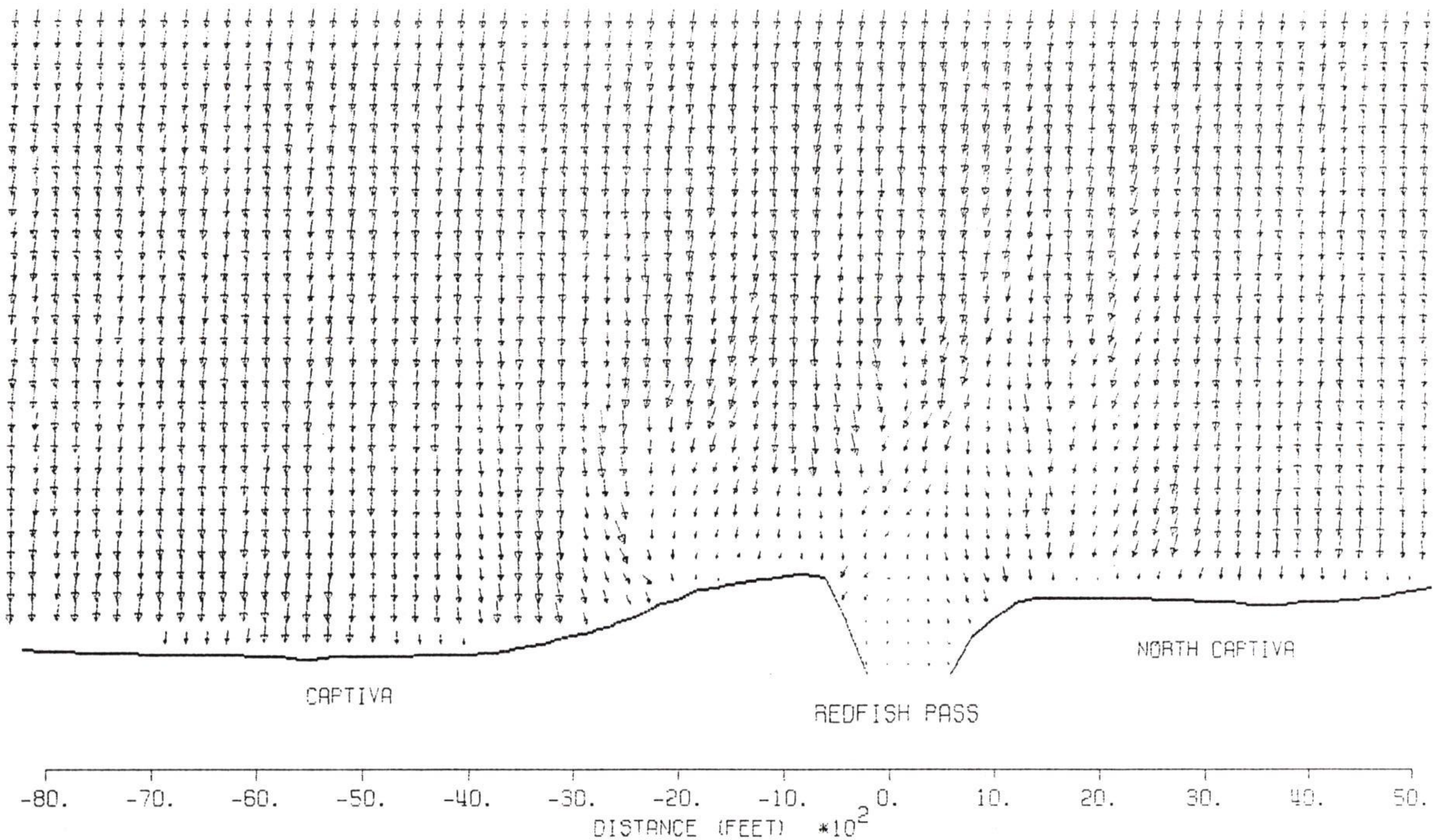
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 5.4 FEET
WAVE PERIOD = 7.6 SECONDS
WAVE DIRECTION = 7.9 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



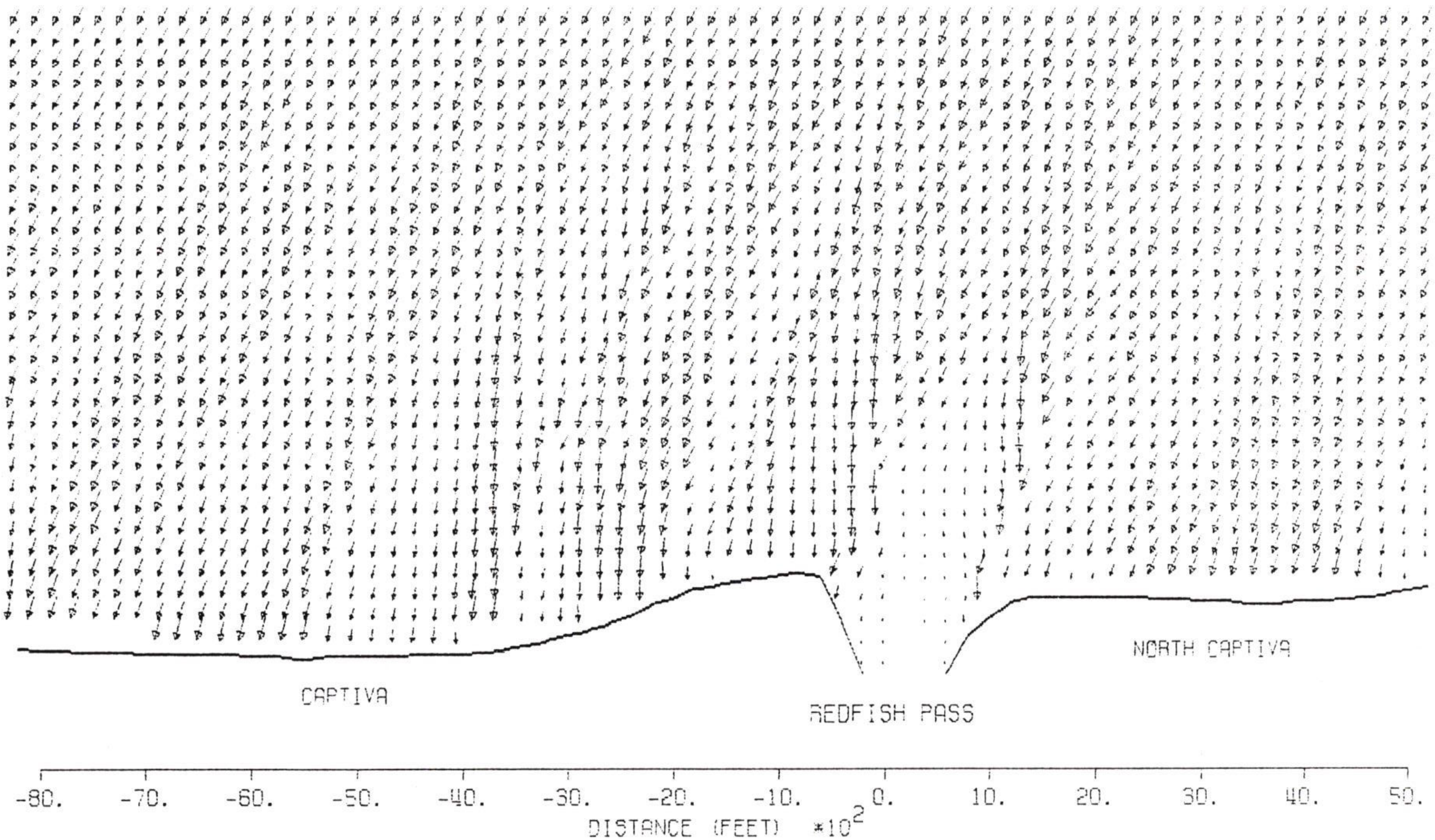
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.4 FEET
WAVE PERIOD = 4.9 SECONDS
WAVE DIRECTION = -9.2 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



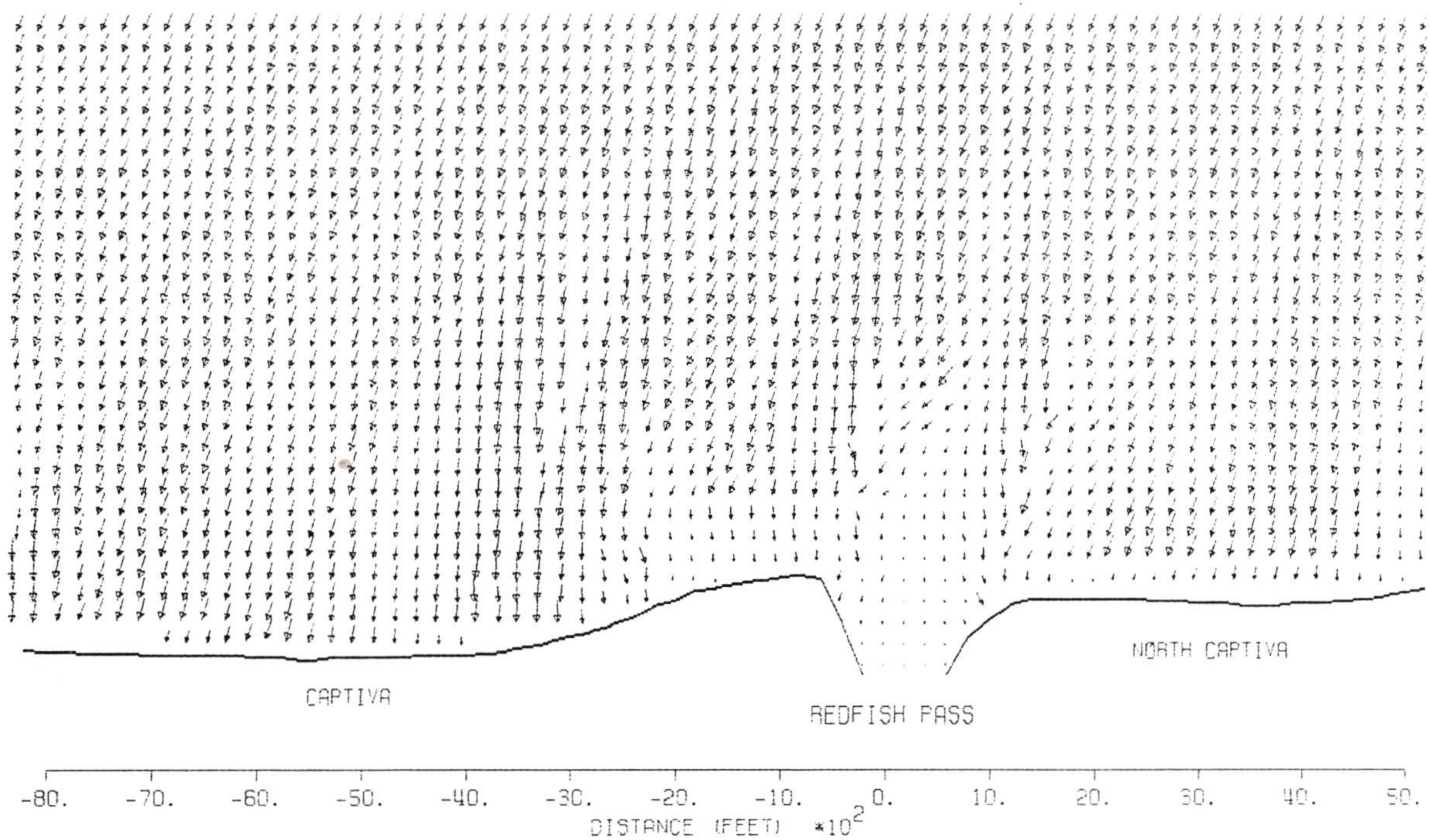
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 5.1 FEET
WAVE PERIOD = 7.6 SECONDS
WAVE DIRECTION = -7.3 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



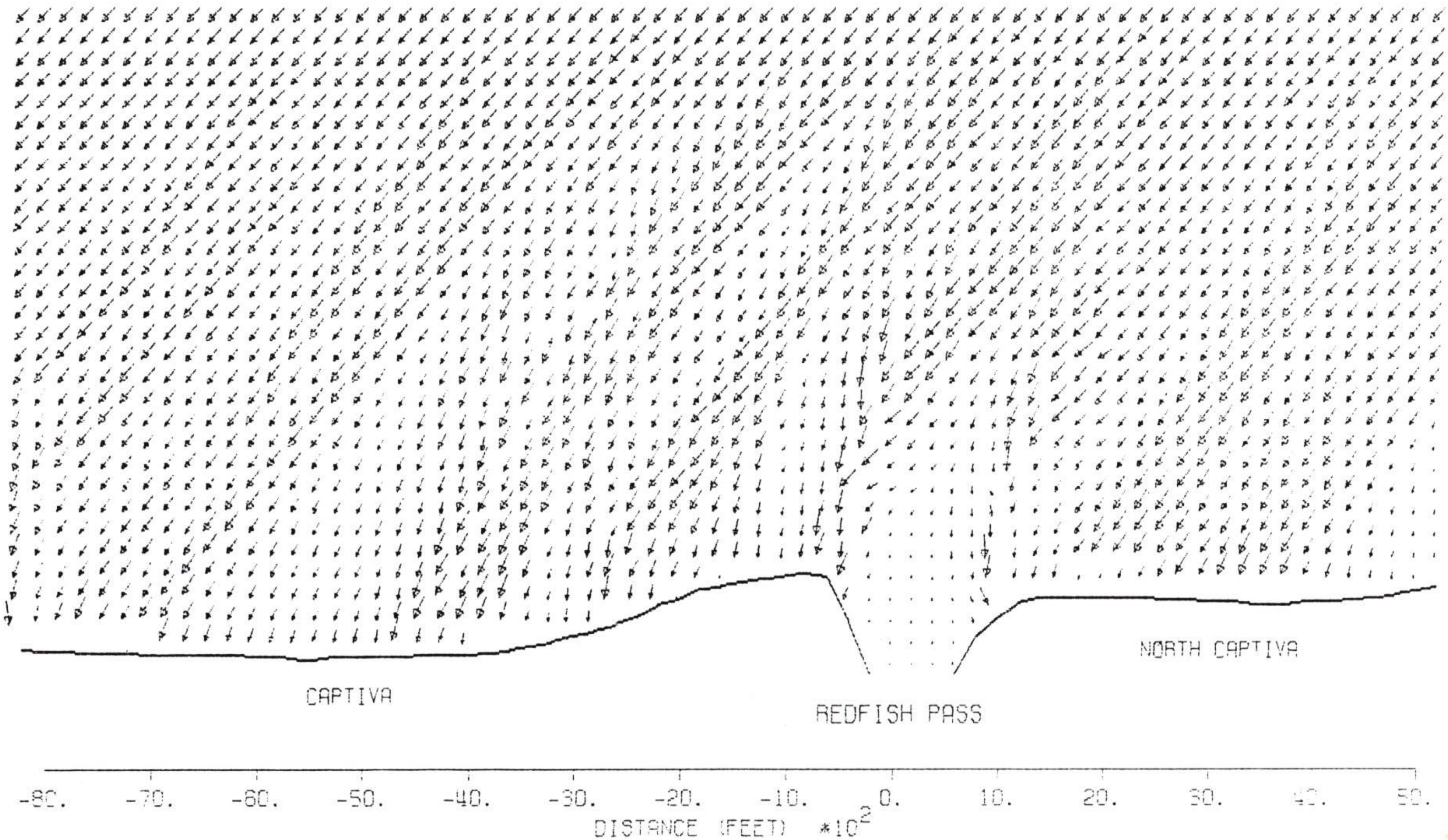
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.6 FEET
WAVE PERIOD = 4.9 SECONDS
WAVE DIRECTION = -27.2 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



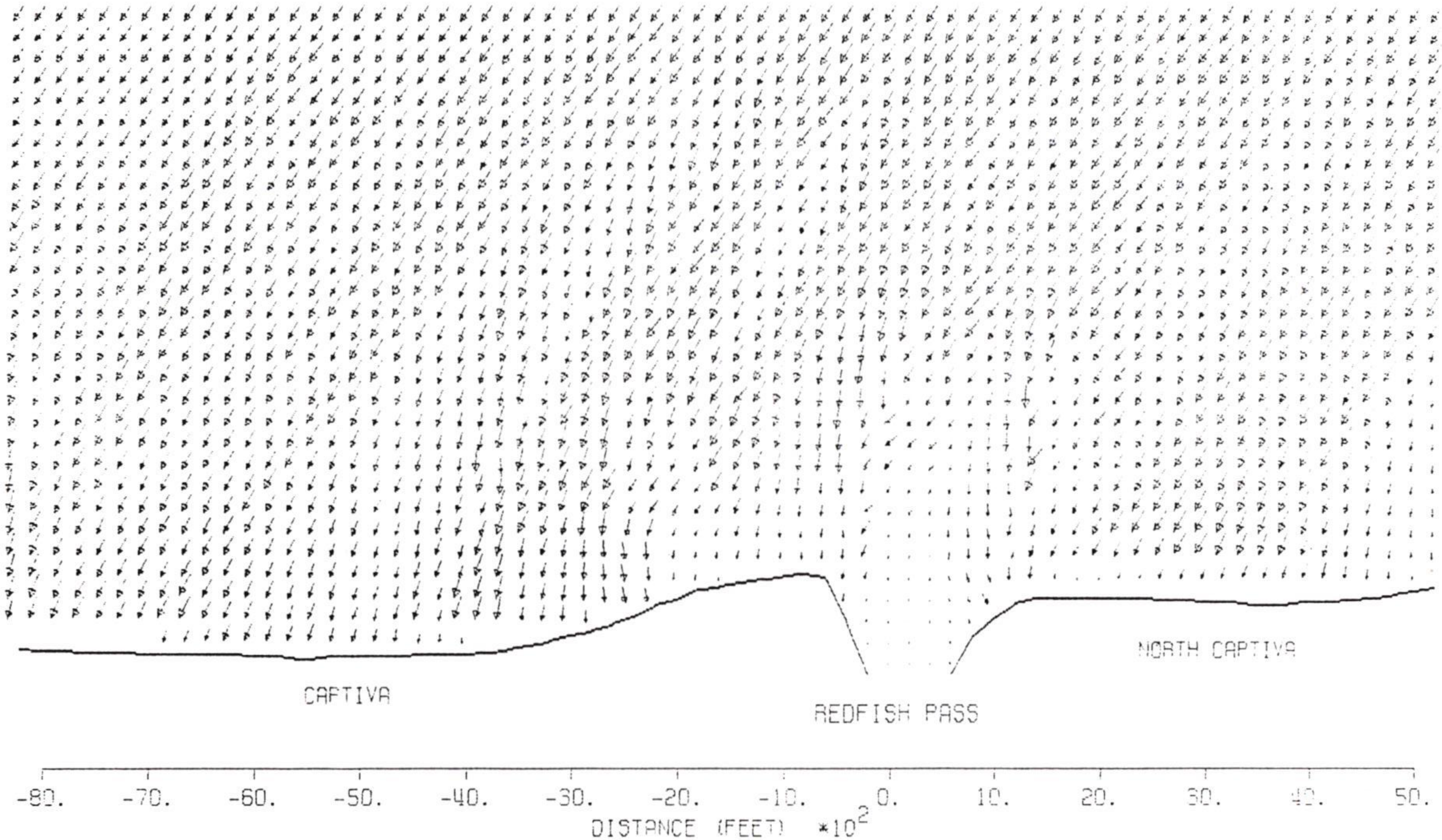
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 4.9 FEET
WAVE PERIOD = 7.5 SECONDS
WAVE DIRECTION = -21.3 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.9 FEET
WAVE PERIOD = 5.1 SECONDS
WAVE DIRECTION = -42.9 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 5.2 FEET
WAVE PERIOD = 7.1 SECONDS
WAVE DIRECTION = -34.5 DEGREES

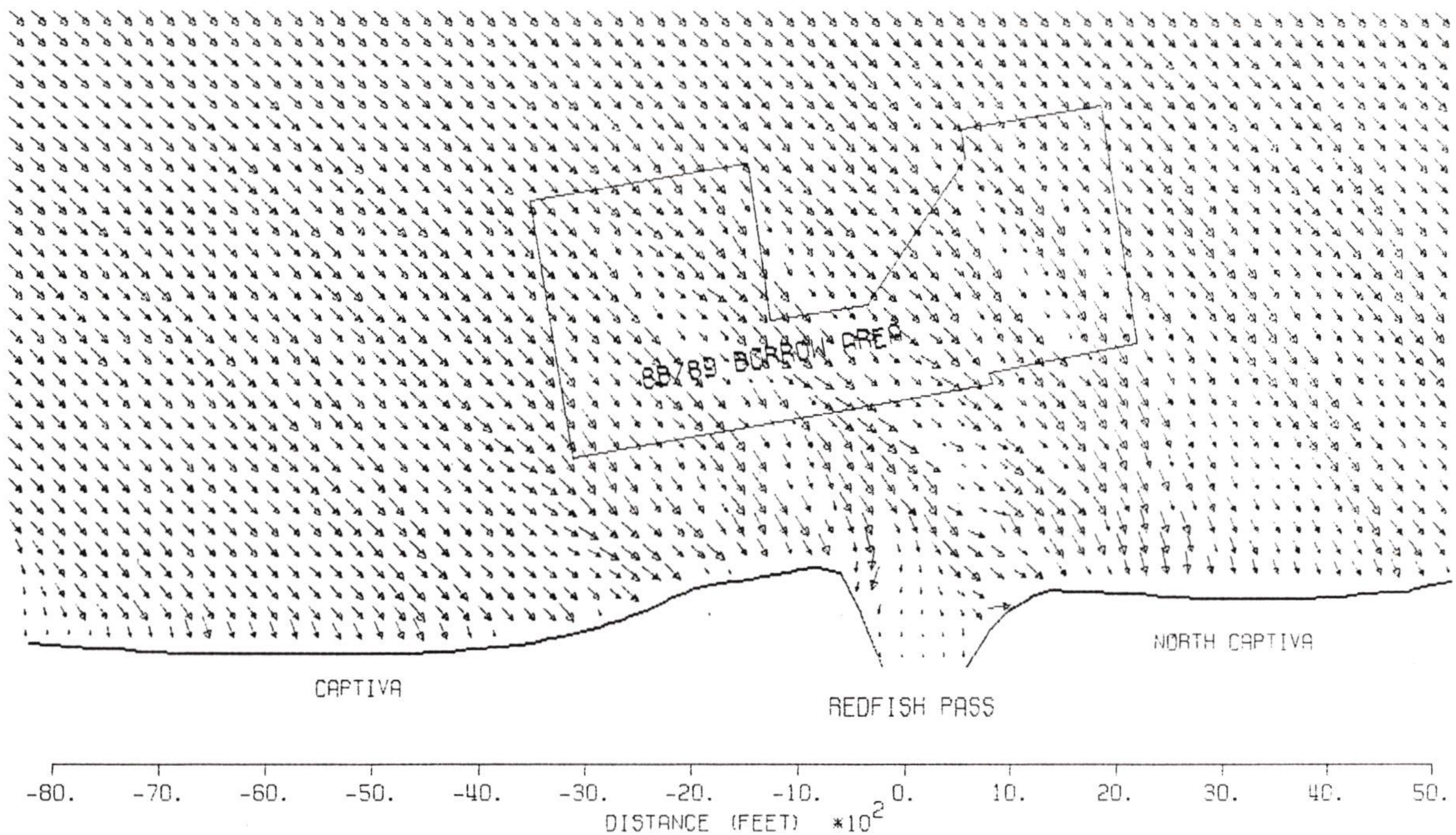
N

REDFISH PASS EBB SHOAL BORROW AREA (PRE-DREDGE) CONDITION

APPENDIX G-2

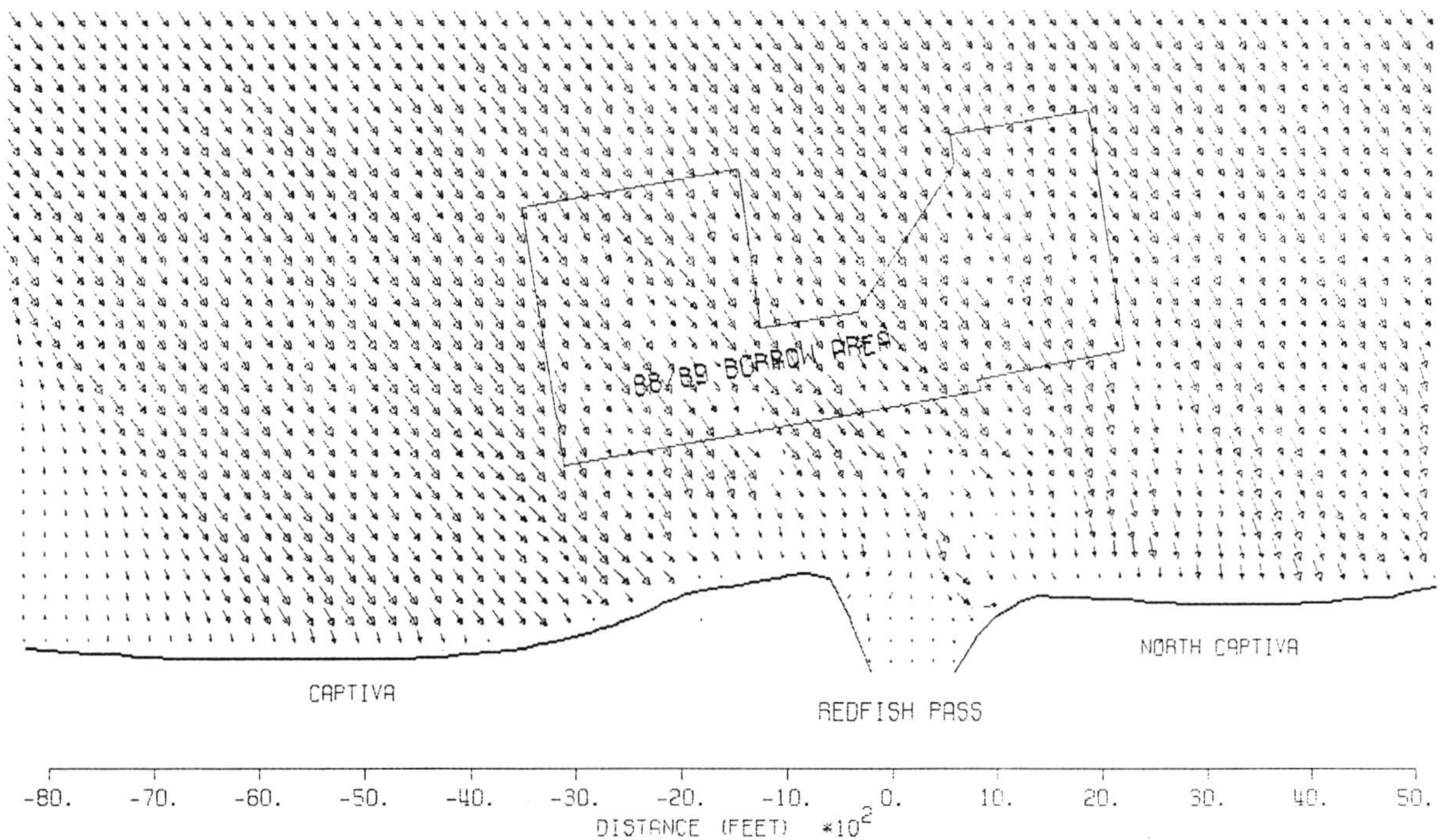
REDFISH PASS WAVE REFRACTION PATTERNS

POST-DREDGING CONDITIONS



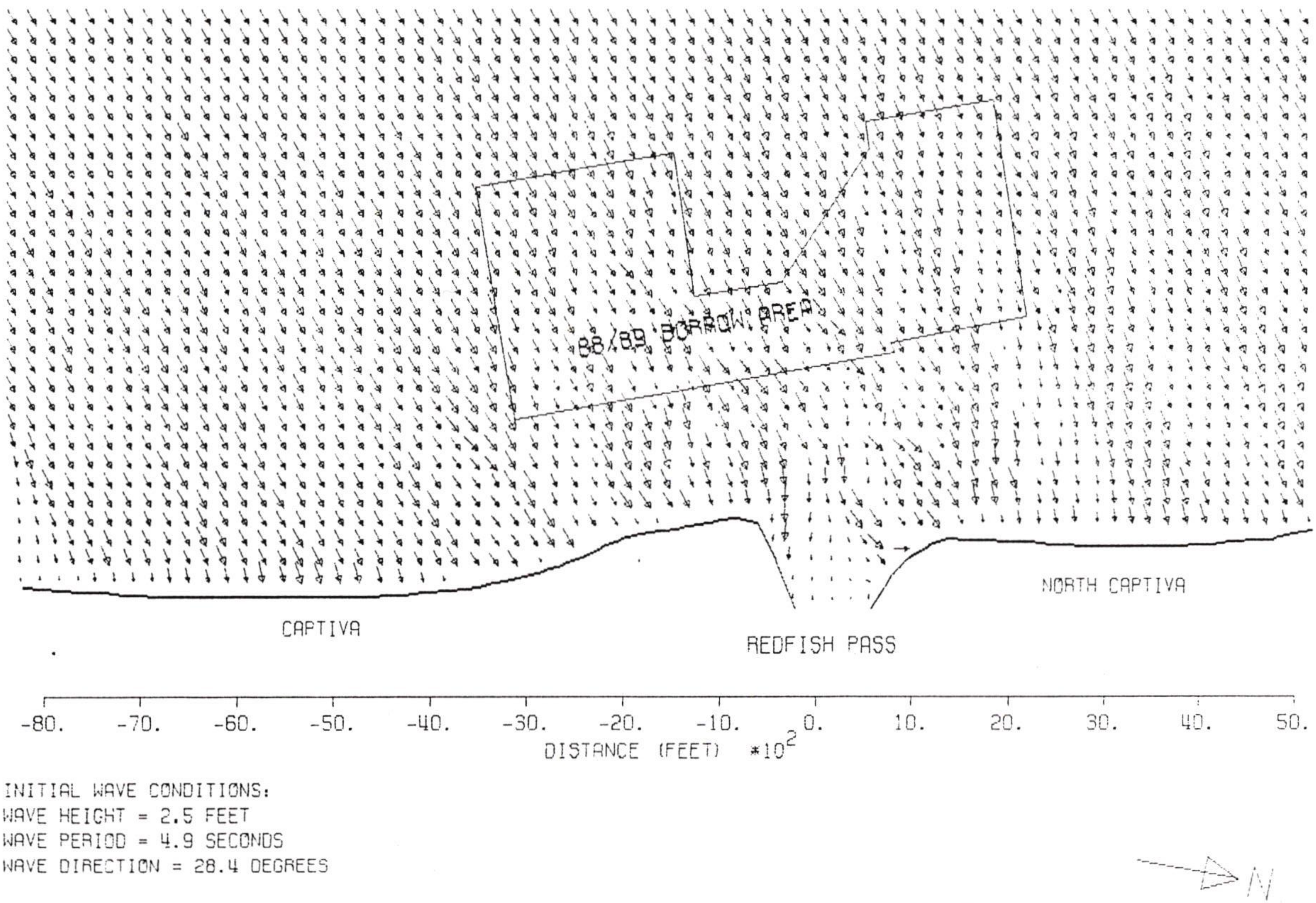
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.3 FEET
WAVE PERIOD = 4.8 SECONDS
WAVE DIRECTION = 45.4 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



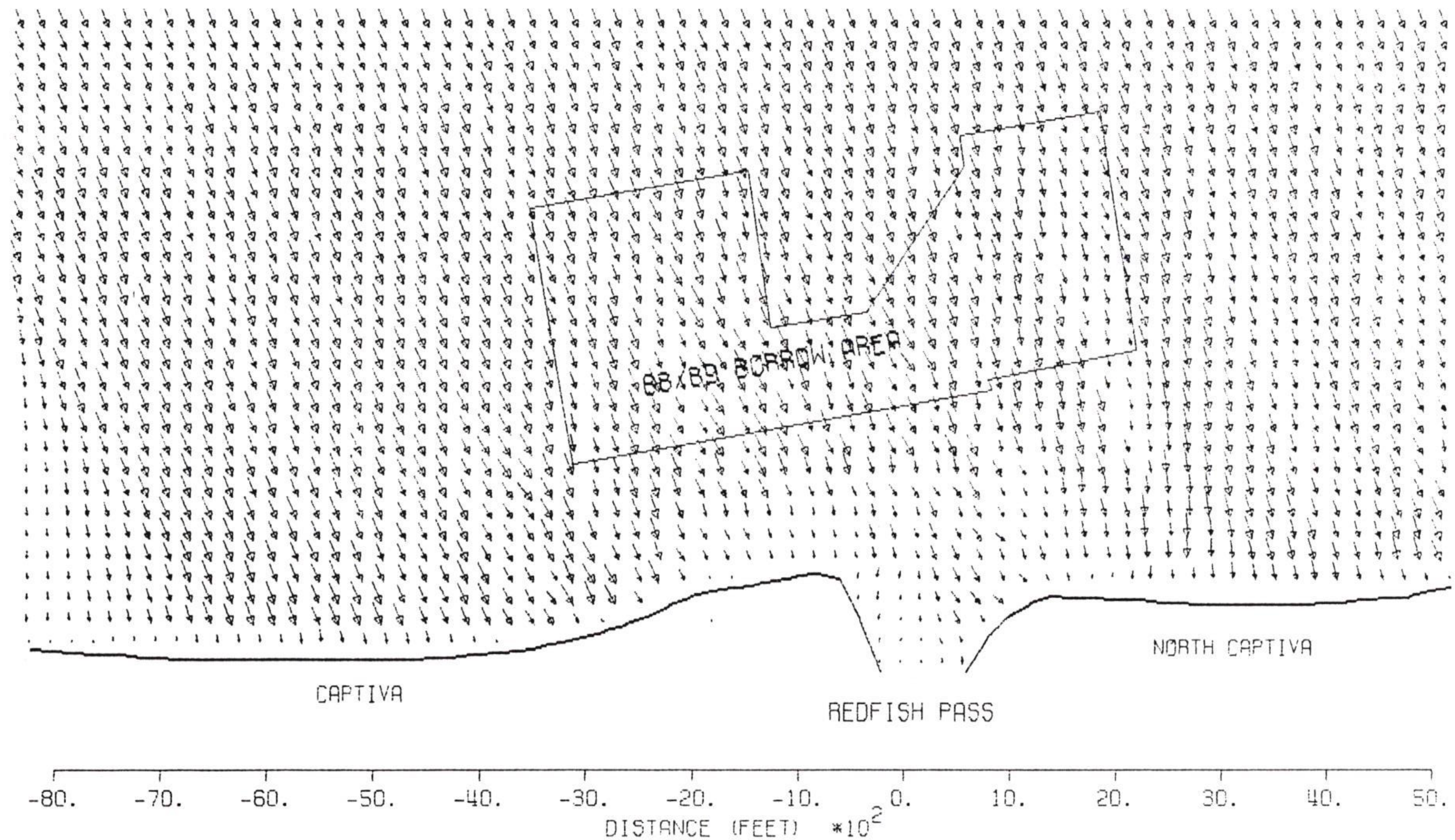
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 4.7 FEET
WAVE PERIOD = 7.0 SECONDS
WAVE DIRECTION = 35.3 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.5 FEET
WAVE PERIOD = 4.9 SECONDS
WAVE DIRECTION = 28.4 DEGREES

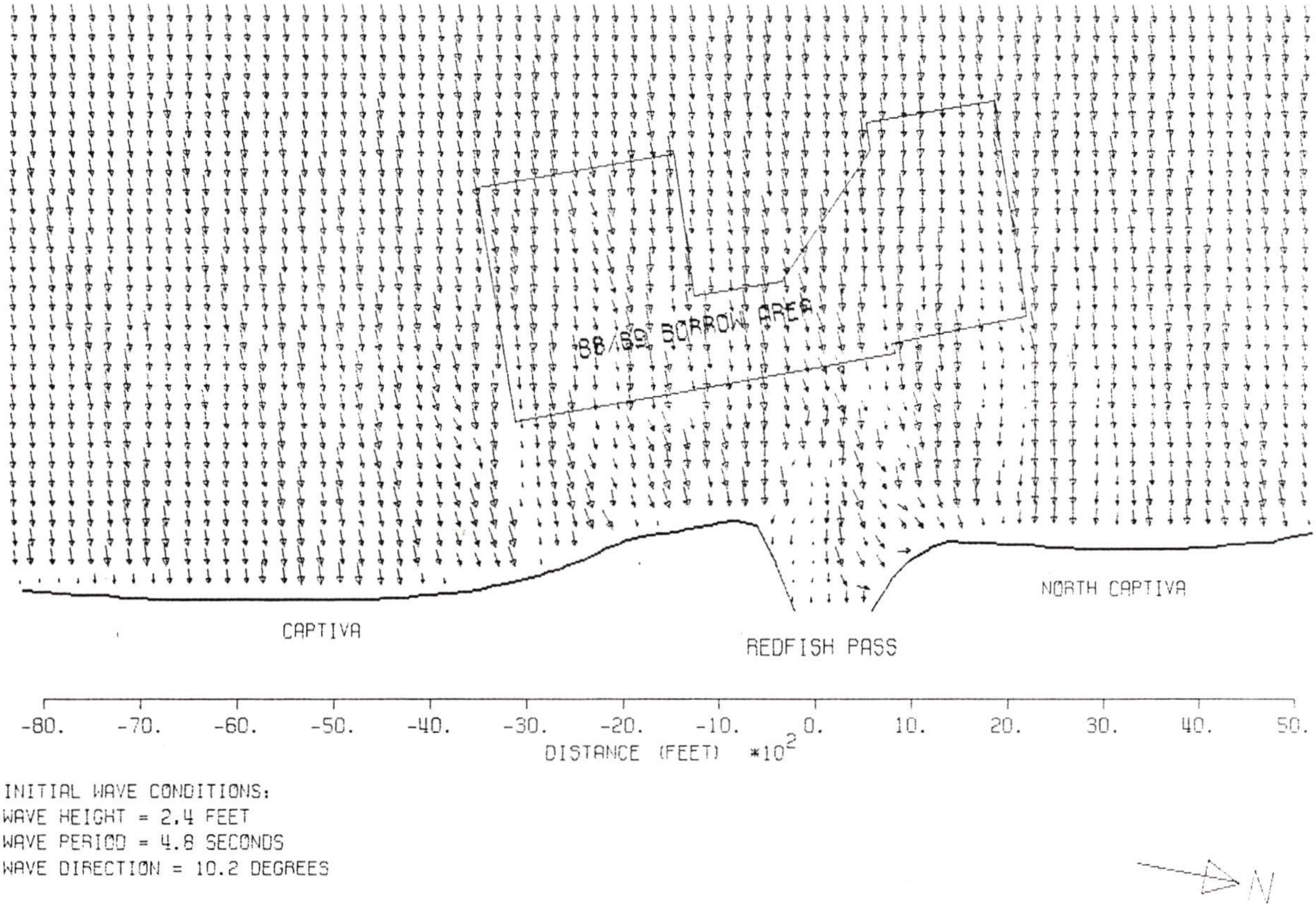
REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 5.1 FEET
WAVE PERIOD = 7.2 SECONDS
WAVE DIRECTION = 22.3 DEGREES

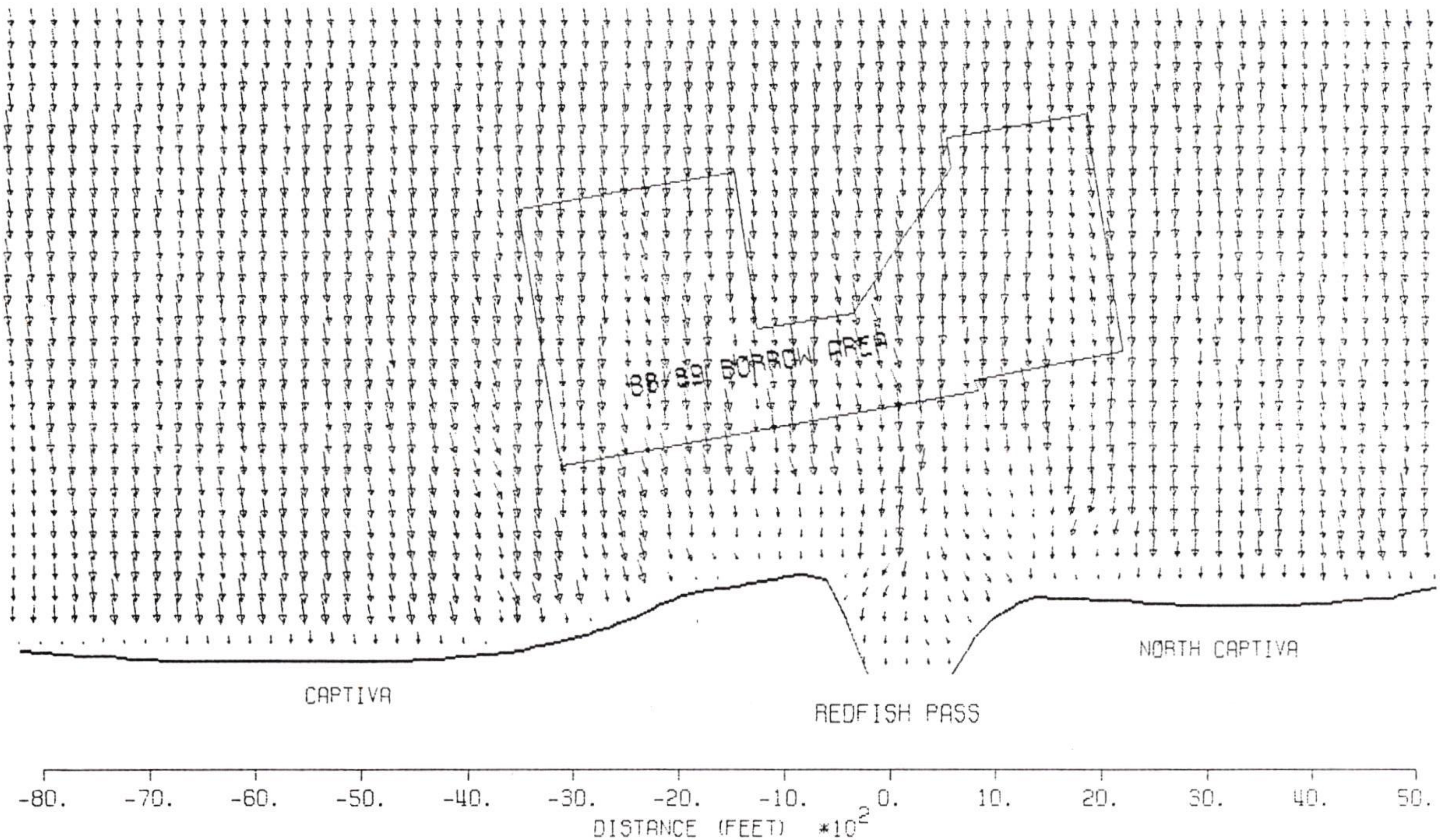
N

REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.4 FEET
WAVE PERIOD = 4.8 SECONDS
WAVE DIRECTION = 10.2 DEGREES

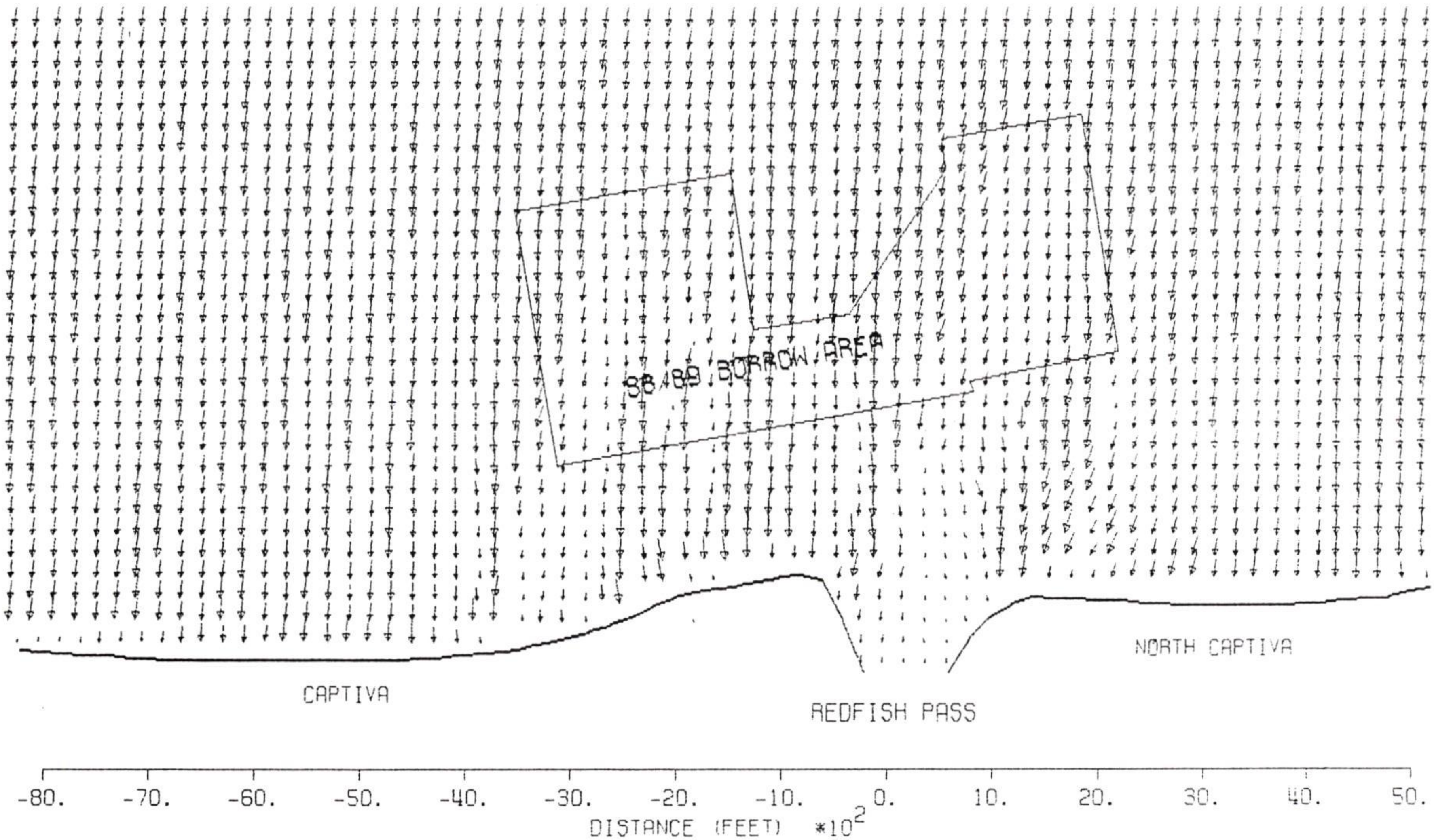
REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 5.4 FEET
WAVE PERIOD = 7.6 SECONDS
WAVE DIRECTION = 7.9 DEGREES

N

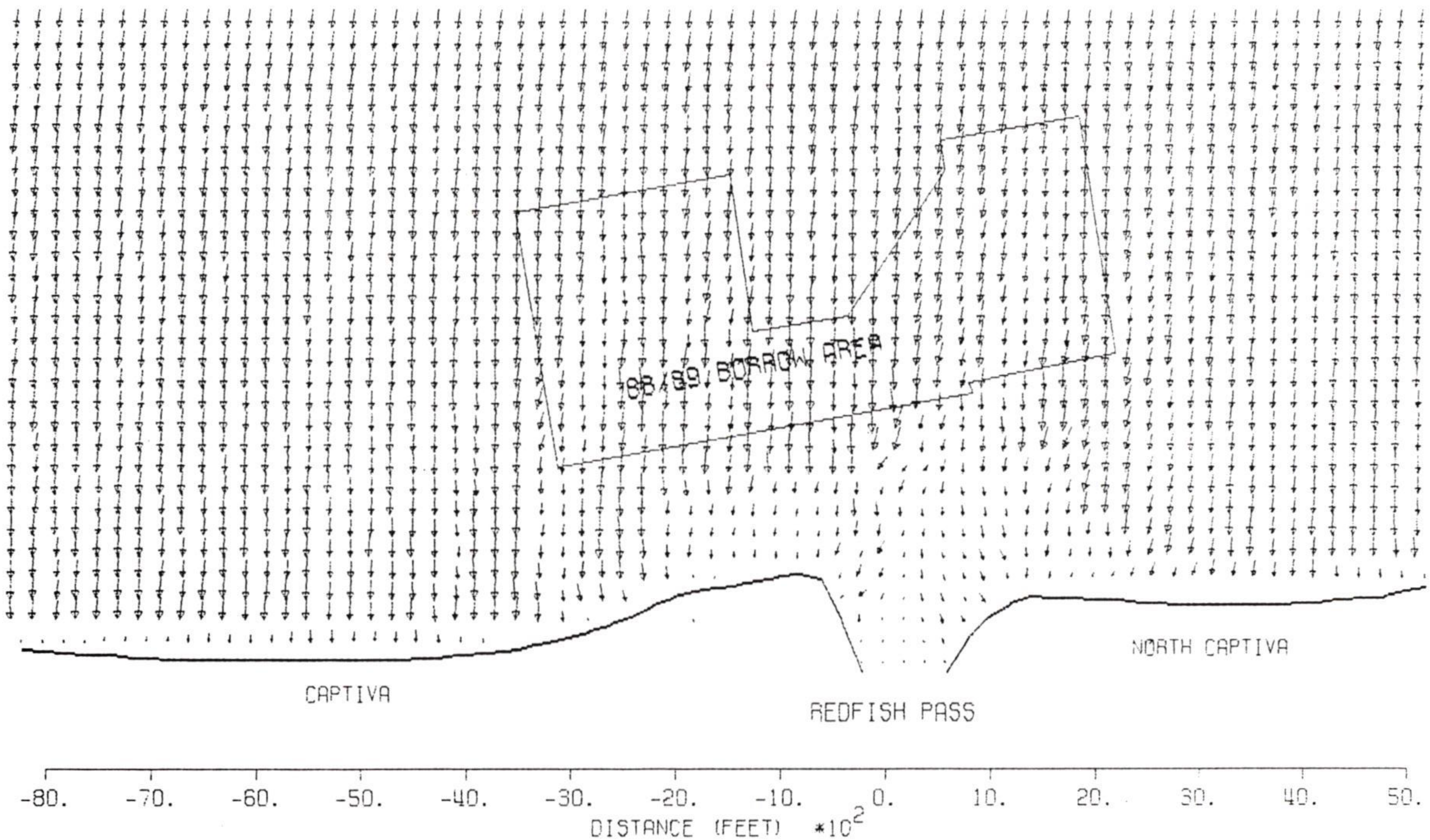
REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



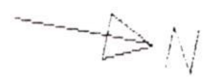
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.4 FEET
WAVE PERIOD = 4.9 SECONDS
WAVE DIRECTION = -9.2 DEGREES

N

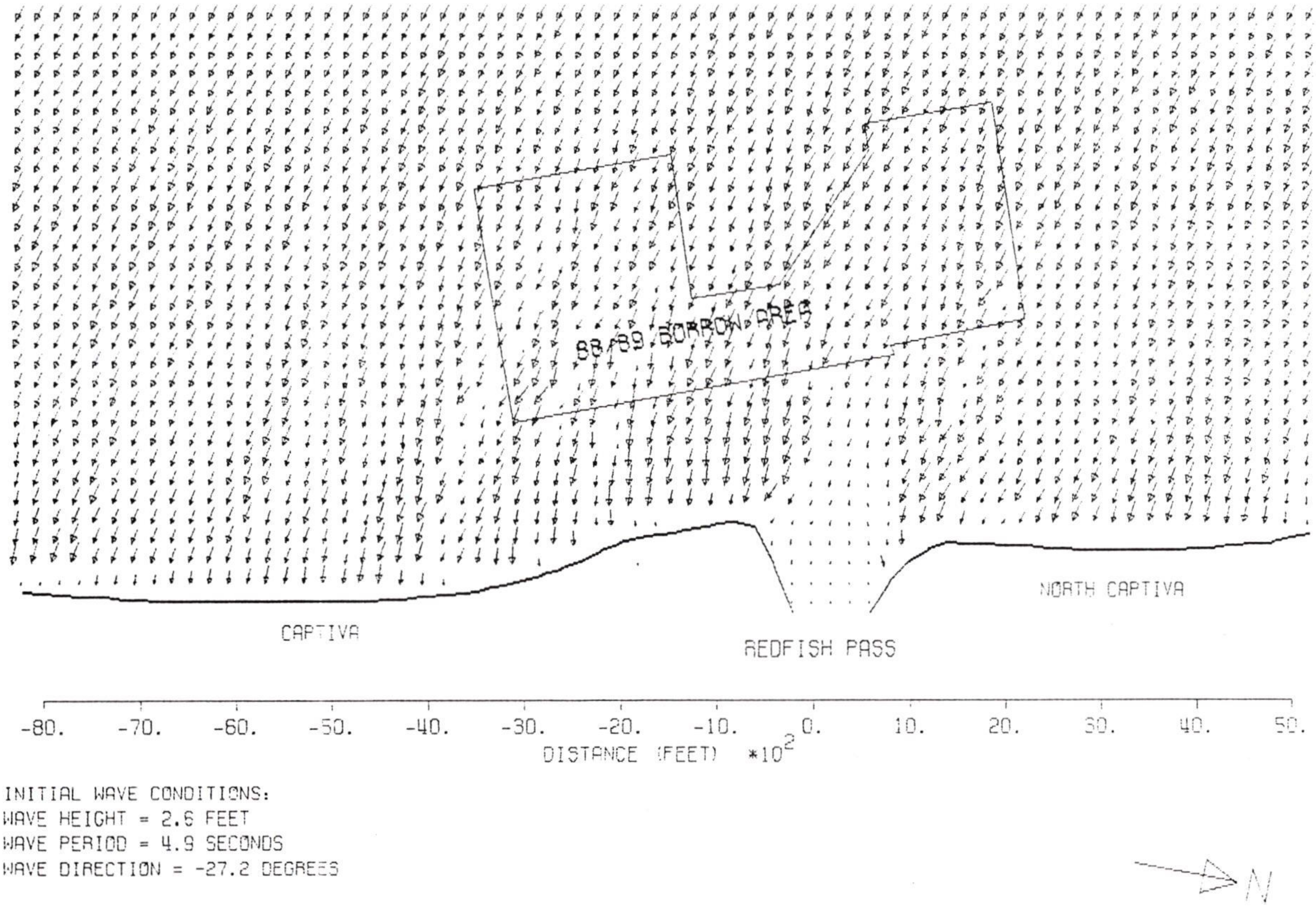
REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 5.1 FEET
WAVE PERIOD = 7.6 SECONDS
WAVE DIRECTION = -7.3 DEGREES

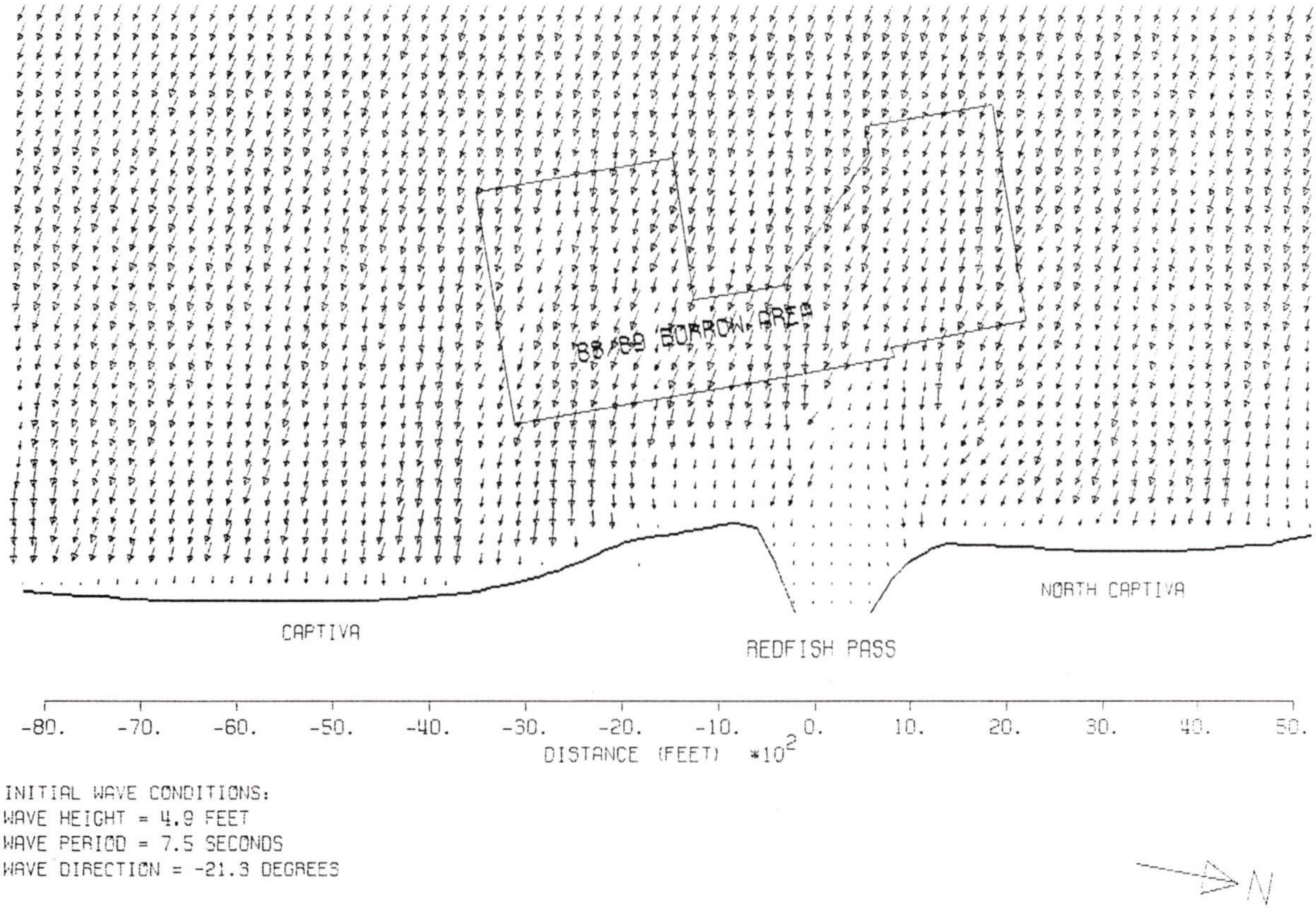


REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



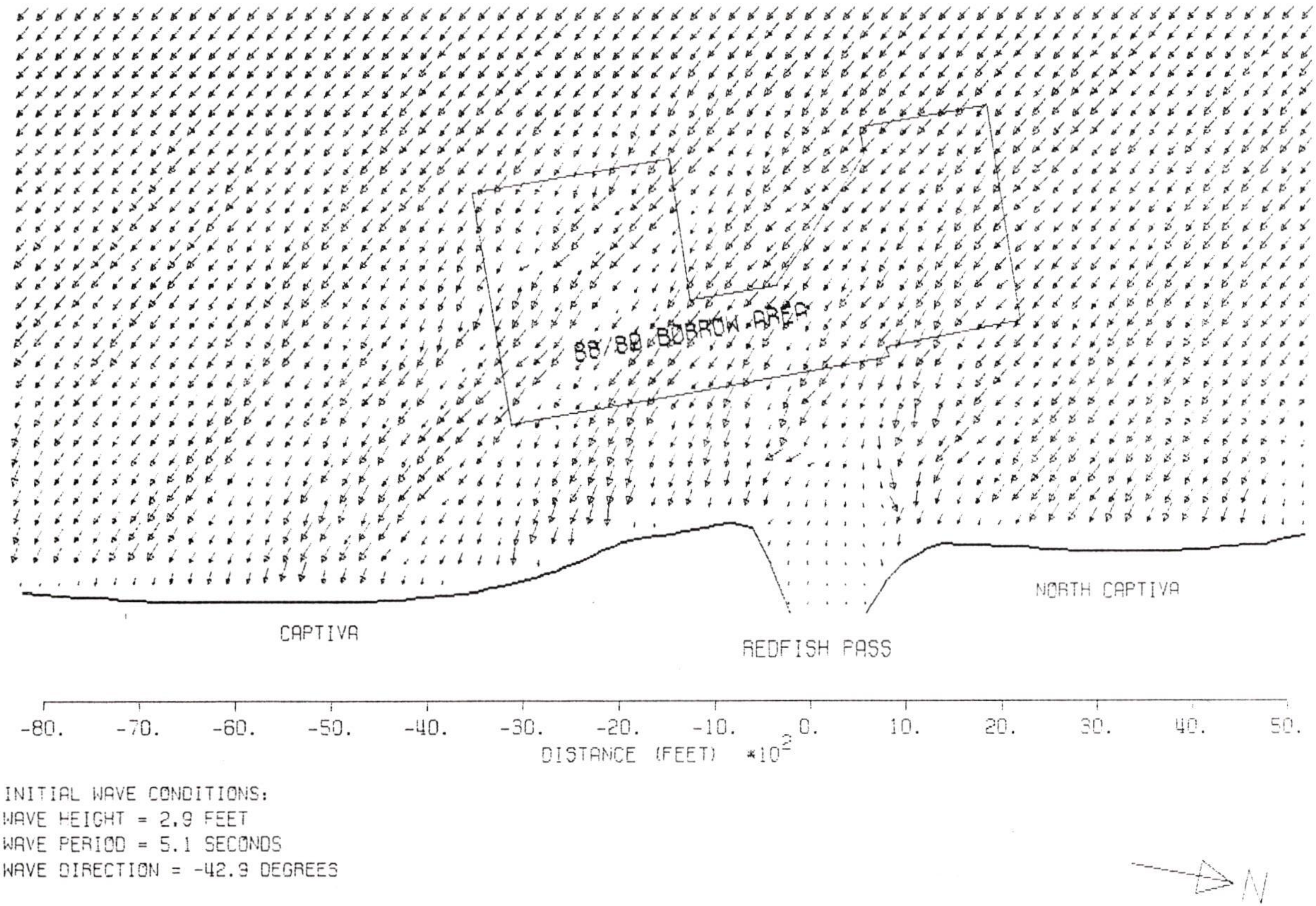
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.6 FEET
WAVE PERIOD = 4.9 SECONDS
WAVE DIRECTION = -27.2 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



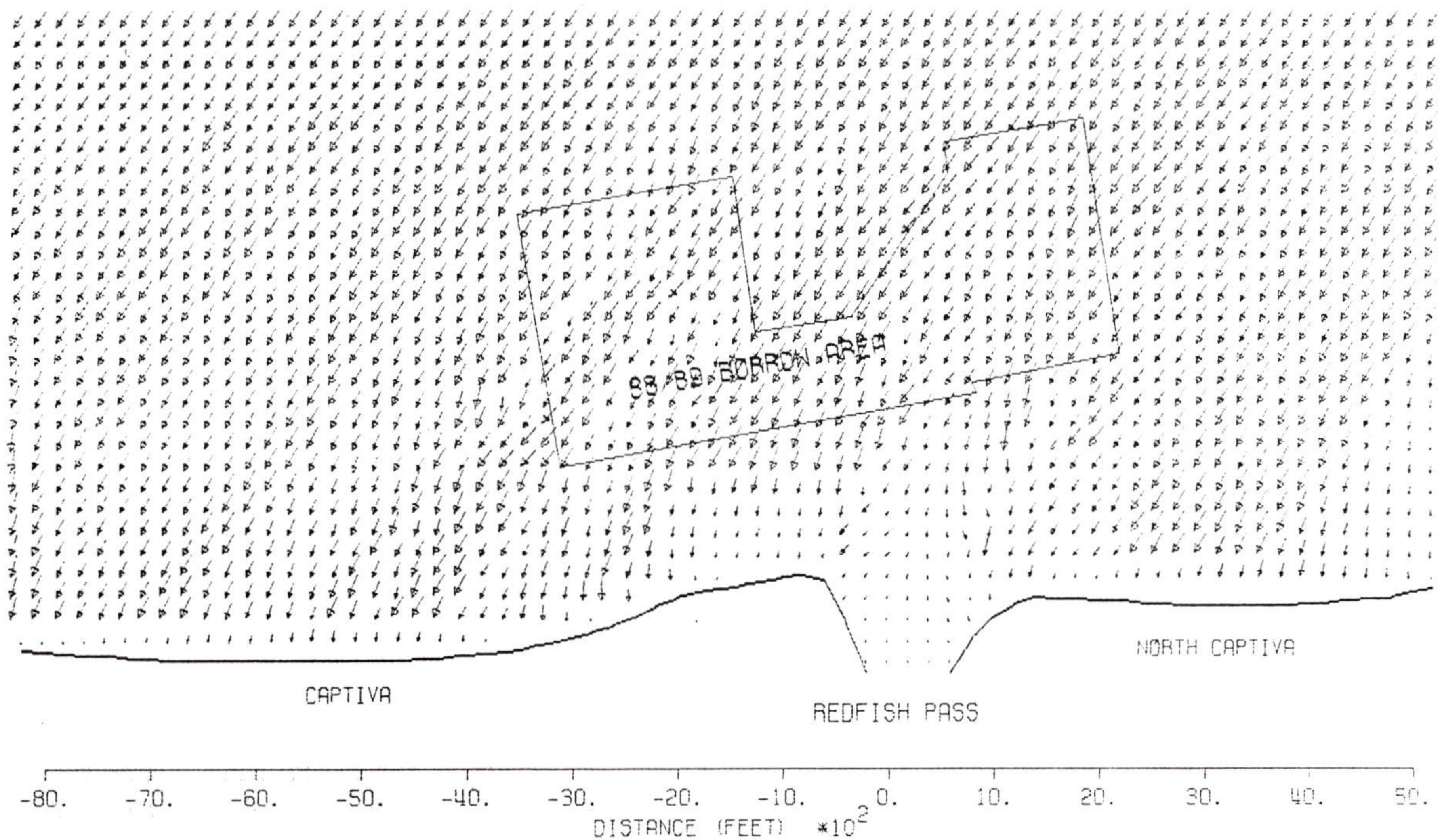
INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 4.9 FEET
WAVE PERIOD = 7.5 SECONDS
WAVE DIRECTION = -21.3 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 2.9 FEET
WAVE PERIOD = 5.1 SECONDS
WAVE DIRECTION = -42.9 DEGREES

REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION



INITIAL WAVE CONDITIONS:
WAVE HEIGHT = 5.2 FEET
WAVE PERIOD = 7.1 SECONDS
WAVE DIRECTION = -34.5 DEGREES

N

REDFISH PASS EBB SHOAL BORROW AREA (POST-DREDGE) CONDITION