Kraus

US Army Corps
of Engineers

Galveston District
Southwestern Division

Planning Assistance to States Program

SECTION 22 REPORT

Inlets Along the Texas Gulf Coast

August 1992

DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS
P.O. BOX 1229
GALVESTON, TEXAS 77553-1229

REPLY TO
ATTENTION OF:

Planning Assistance to States Program

SECTION 22 REPORT

Inlets Along the Texas Gulf Coast

U.S. Army Engineer District, Galveston
Southwestern Division
August 1992

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INTRODUCTION

This report has been prepared as part of a cooperative agreement between the State of Texas and the United States Army Corps of Engineers, Galveston District, under the Planning Assistance to States Program. The lead agencies for the State of Texas have been the Texas Water Development Board under the direction of the Executive Administrator, Mr. Craig Pedersen, and the Texas General Land Office led by Land Commissioner, Mr. Garry Mauro.

AUTHORITY

The authority for the Corps of Engineers to cooperate with States in preparing water resources related plans comes from Section 22 of Public Law 93-251. This authority was amended by Section 921 of the Water Resources Development Act of 1986, Public Law 99-662, which limits Federal expenditures to $300,000 in any one year for studies for any one State. Further policy decisions implemented cost sharing between the Federal Government and States beginning in Fiscal Year 1991 at a 90-10 ratio, changing to 70-30 in Fiscal Year 1992, then to 50-50 in Fiscal Year 1993 and beyond.

PURPOSE AND BACKGROUND

The State of Texas continues to actively pursue the development of a comprehensive coastal management plan for the State's public lands. Some of the major issues which are being addressed in this plan are coastal erosion, beach access, and wetland loss. These activities are associated with or affected by coastal inlets to some extent and thus, the continued interest of the State in the subject of inlets.

The purpose of this report has been to document historical and present actions at all of the inlets along the Texas coast to serve as a basis for the State and others in evaluating overall factors and features that affect the movement of littoral materials. This report is intended to provide decision-makers background information necessary to assess the practicability of changing current practices and procedures and the compatibility of inlet sediments for potential placement on adjacent beaches.

Scientific and technical experts are quick to advise that coastal processes, in general, are complex and dynamic. Every breaking wave generates turbulence which causes materials to become suspended in the water column and move within the littoral zone. Erosion proceeds slowly under normal wave conditions but may be as great as a few hundred feet in a matter of hours under storm conditions. There are numerous other variables that promote erosion, many of which are part of the natural system.

Erosion of the Texas Gulf shoreline is recognized as a serious problem. Sixty percent of the 367 miles of the shoreline is classified as erosional, 33 percent is in equilibrium, and 7 percent is accretionary. A generic statement as to the cause of the erosion problems along the Texas coast is that there is a deficit of materials moving to and through a particular reach of shoreline. Erosion of updrift coasts does supply materials to downdrift coasts; however, the eroded volume of material from one area may not be sufficient to offset the erosion losses at all specific segments of downdrift shorelines. Likewise, the movement of materials through inlets has a direct bearing on whether the adjoining beaches are eroding or accreting, and man's actions at several of these inlets influence the way the inlet affects littoral processes. These conditions that impact on the movement of littoral materials at the inlets, both natural and manmade, are the subject of this report.

INLETS ALONG THE TEXAS COAST

A narrow barrier chain composed of islands and peninsulas extends along the entire Texas coastline except for two relatively short reaches. These exceptions are where the mainland fronts the Gulf for about 35 miles in the area southwest of Sabine Pass and for about 30 miles in the vicinity of Freeport. Behind the barrier chain lies a vast complex of shallow bays and lagoons, broken in several locations by natural and man-made inlets or passes. These openings are avenues for the movement of marine life and the nutrients on which they depend as well as sediments from inland sources. Littoral material or sediments moving along the coast causes some of these passes to migrate, contract, and occasionally, close completely. Hurricanes often temporarily create new passes, reopen closed passes, or relocate existing passes.

The inlets addressed in this report include all natural and man-made inlets or passes, regardless of whether or not they are currently open. Even though the mouths of rivers do not meet the classical definition of an inlet, they are also included since they are the primary source of new sediments to the coastal zone. The inlets discussed, beginning on the upper Texas coast and proceeding southward, are:

- Sabine Pass
- Rollover Pass
- Galveston Harbor Channel
- San Luis Pass
- Freeport Channel
- Brazos River Diversion Channel
- San Bernard River
- Caney Fork/Mitchell Cut
- Brown Cedar Cut
- Colorado River
- Greens Bayou
- Matagorda Channel
- Pass Cavallo
- Cedar Bayou
- Aransas Pass

- Corpus Christi Water Exchange Pass
- Corpus Christi Pass, Newport Pass, and Packery Channel
- Yarborough Pass
- Mansfield Channel
- Brazos Santiago Pass
- Boca Chica Pass
- Rio Grande

A map showing the location of each inlet is shown on Figure 1. A physical description is provided for each inlet below. For those inlets that have been stabilized and maintained for commercial and recreational navigation, a maintenance dredging history, including an analysis of the sediments removed during periodic maintenance dredging, and an assessment as to the potential suitability of the dredged material for placement on adjacent beaches are also presented.

Sabine Pass

Sabine Pass is a natural inlet located at the Texas-Louisiana border, approximately 58 miles northeast of Galveston. This inlet connects Sabine Lake to the Gulf of Mexico, provides an outlet for the Sabine and Neches Rivers, and is the sole tidal inlet for Sabine Lake. The Sabine-Neches Waterway is a federally-maintained project which connects the deep-draft ports of Port Arthur, Beaumont, and Orange to the Gulf through Sabine Pass.

Prior to the navigation improvements, Sabine Pass had a natural depth of about 15 feet. However, the depth of water over the outer bar was only about 6 feet, which significantly restricted navigation. The first channel improvements at Sabine Pass were constructed in 1879 and provided a channel 12 feet deep over the outer bar. Currently, the project provides a channel 40 feet deep to Port Arthur and Beaumont, and 30 feet deep to Orange. A brief chronology of the Federal improvements at Sabine Pass is shown in Table 1.

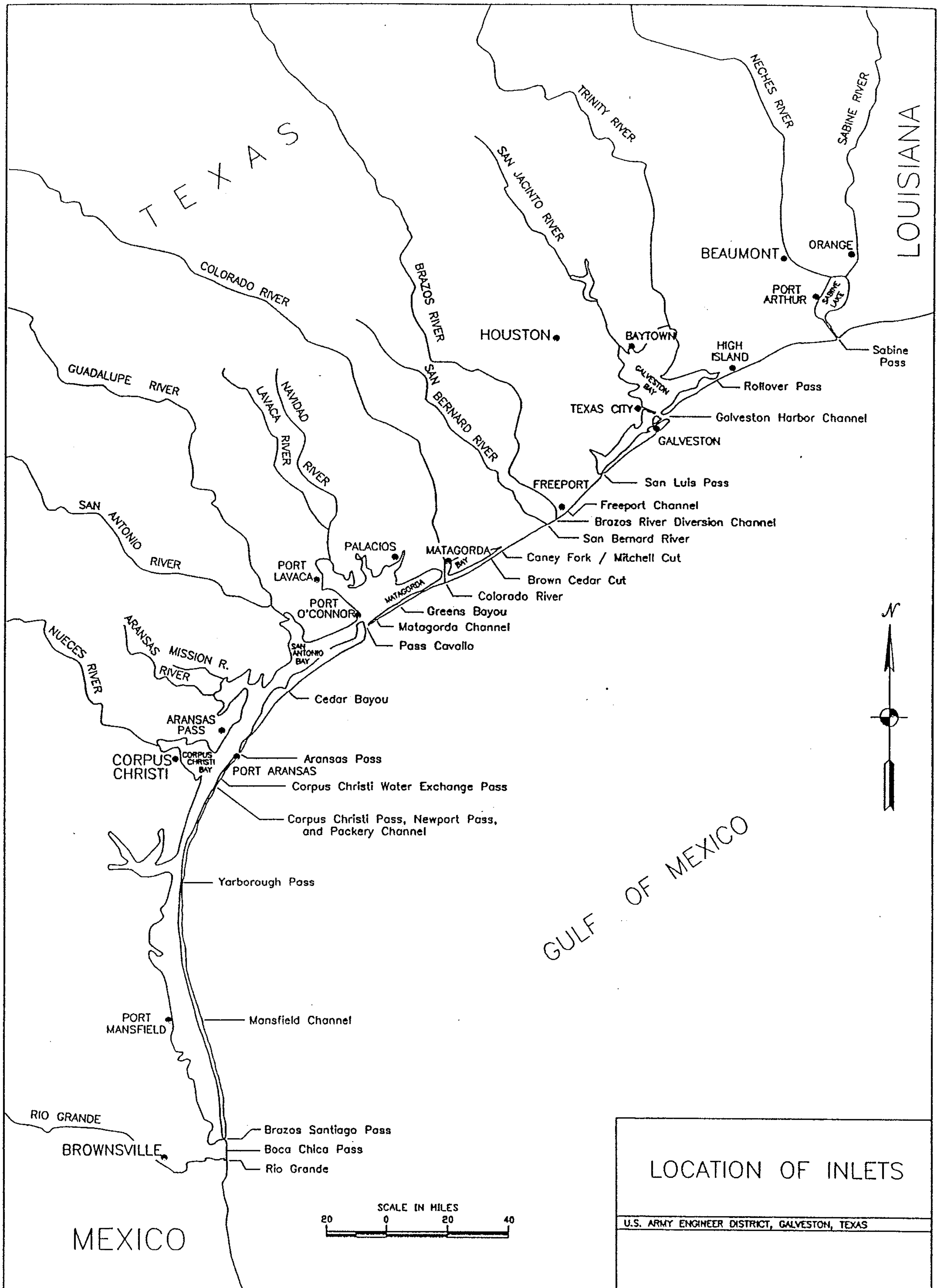

TEXAS
LOUISIANA
MEXICO
GULF OF MEXICO
COLORADO RIVER
BRAZOS RIVER
TRINITY RIVER
SAN JACINTO RIVER
NECHES RIVER
SABINE RIVER
GUADALUPE RIVER
LAVACA RIVER
NAVIDAD RIVER
SAN BERNARD RIVER
SAN ANTONIO RIVER
NUECES RIVER
ARANSAS RIVER
MISSION R.
RIO GRANDE
HOUSTON
BEAUMONT
ORANGE
PORT ARTHUR
SABINE LAKE
BAYTOWN
HIGH ISLAND
GALVESTON BAY
TEXAS CITY
GALVESTON
FREEPORT
PALACIOS
MATAGORDA
MATAGORDA BAY
PORT LAVACA
PORT O'CONNOR
SAN ANTONIO BAY
ARANSAS PASS
CORPUS CHRISTI
CORPUS CHRISTI BAY
PORT ARANSAS
PORT MANSFIELD
BROWNSVILLE
Sabine Pass
Rollover Pass
Galveston Harbor Channel
San Luis Pass
Freeport Channel
Brazos River Diversion Channel
San Bernard River
Caney Fork / Mitchell Cut
Brown Cedar Cut
Colorado River
Greens Bayou
Matagorda Channel
Pass Cavallo
Cedar Bayou
Aransas Pass
Corpus Christi Water Exchange Pass
Corpus Christi Pass, Newport Pass, and Packery Channel
Yarborough Pass
Mansfield Channel
Brazos Santiago Pass
Boca Chica Pass
Rio Grande
N
SCALE IN MILES
20 0 20 40
LOCATION OF INLETS
U.S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

FIGURE 1

TABLE 1
CHRONOLOGY OF FEDERAL IMPROVEMENTS
AT SABINE PASS

Year	Activity
1879	Construct channel over outer bar to 12-foot depth.
1896	Construct East Jetty 19,500 feet long, West Jetty 14,875 feet long, and channel 100 feet wide and 24 feet deep.
1900	Extended East Jetty to 25,270 feet, West Jetty to 21,860 feet, and deepen channel to 25 feet.
1926	Jetty Channel improved to 30 feet deep and 200 feet wide, and Outer Bar Channel improved to 33 feet deep and 450 feet wide.
1932	Sabine Pass Channel improved to 30 feet deep and 300 feet wide, Jetty Channel improved to 33 feet deep and 300 feet wide, and Outer Bar Channel deepened to 34 feet.
1943	Sabine Pass Channel improved to 34 feet deep and 500 feet wide, Jetty Channel improved to 34 feet deep and to widths varying from 500 to 800 feet, and Outer Bar Channel improved to 36 feet deep and 800 feet wide.
1949	Sabine Pass and Jetty Channels deepened to 36 feet and Outer Bar Channel deepened to 37 feet.
1967	Established East and West Jetties to present lengths of 25,310 feet and 21,905 feet, respectively.
1972	Sabine Pass and Jetty Channels deepened to 40 feet and Outer Bar Channel deepened to 42 feet.

At Sabine Pass, the Sabine-Neches Waterway project is composed of three channel segments; Sabine Bank Channel (stations 18+000 to

95+734), Sabine Pass Outer Bar Channel (stations 0+000 to 18+000), and Sabine Pass Jetty Channel (stations 0+00 to -214+88.3). The project also includes two rubble-mound jetties, the East Jetty 25,310 feet long and the West Jetty 21,905 feet long. The Sabine Bank Channel is the portion of the Entrance Channel located the farthest gulfward. It has a bottom width of 800 feet, a depth of 42 feet and an approximate length of 77,800 feet. The Sabine Pass Outer Bar Channel is 42 feet deep, 800 feet wide, and 18,000 feet long. The Sabine Pass Jetty Channel is 21,488 feet long and has a width of 500 to 800 feet and a depth of 40 feet. Figure 2 shows the entrance portion of the Sabine-Neches Waterway and its corresponding stationing.

The maintenance dredging history for the entrance to the Sabine-Neches Waterway is shown on Figure 3. This display shows that the Jetty Channel rarely requires maintenance since dredging has only been performed once since 1981, resulting in a dredging cycle of more than 11.4 years. The Sabine Bank Channel segment has been dredged three times in the past 11 years. The Outer Bar Channel, however, has been dredged eight times over the same time period. A summary of the dredging cycle and average quantity of material removed for each part of the channel is as follows:

Location	Dredging Cycle	Avg. Quantity per Cycle
Jetty Channel	>11.4 years	1.4 million cubic yards
Outer Bar Channel	1.4 years	3.6 million cubic yards
Sabine Bank Channel	3.8 years	2.4 million cubic yards

These channels are dredged by hopper dredge and the dredged materials are placed in offshore disposal sites located west of the Sabine Outer Bar and Bank Channels. The average annual shoaling rates for the Outer Bar and Bank Channels are 2.5 million cubic yards and 622,000 cubic yards, respectively.

The materials dredged from the channels at Sabine Pass are predominantly silts and clays. The majority of the grain-size distribution curves reviewed from 1960-1976 indicated a very high percentage of fines (silts and clays), generally in the 90% range. Some exceptions to this included samples with sand ranging from 60%

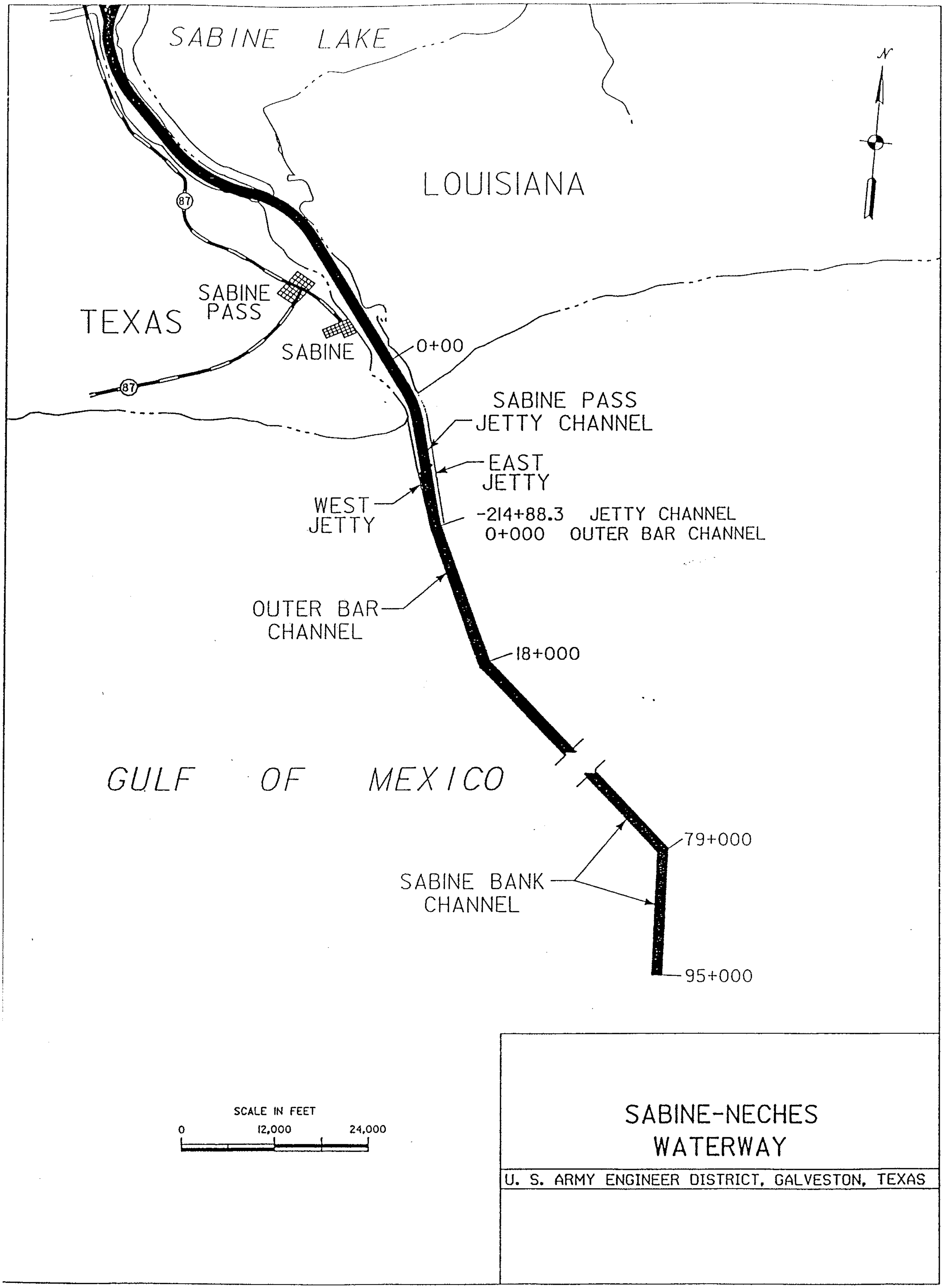
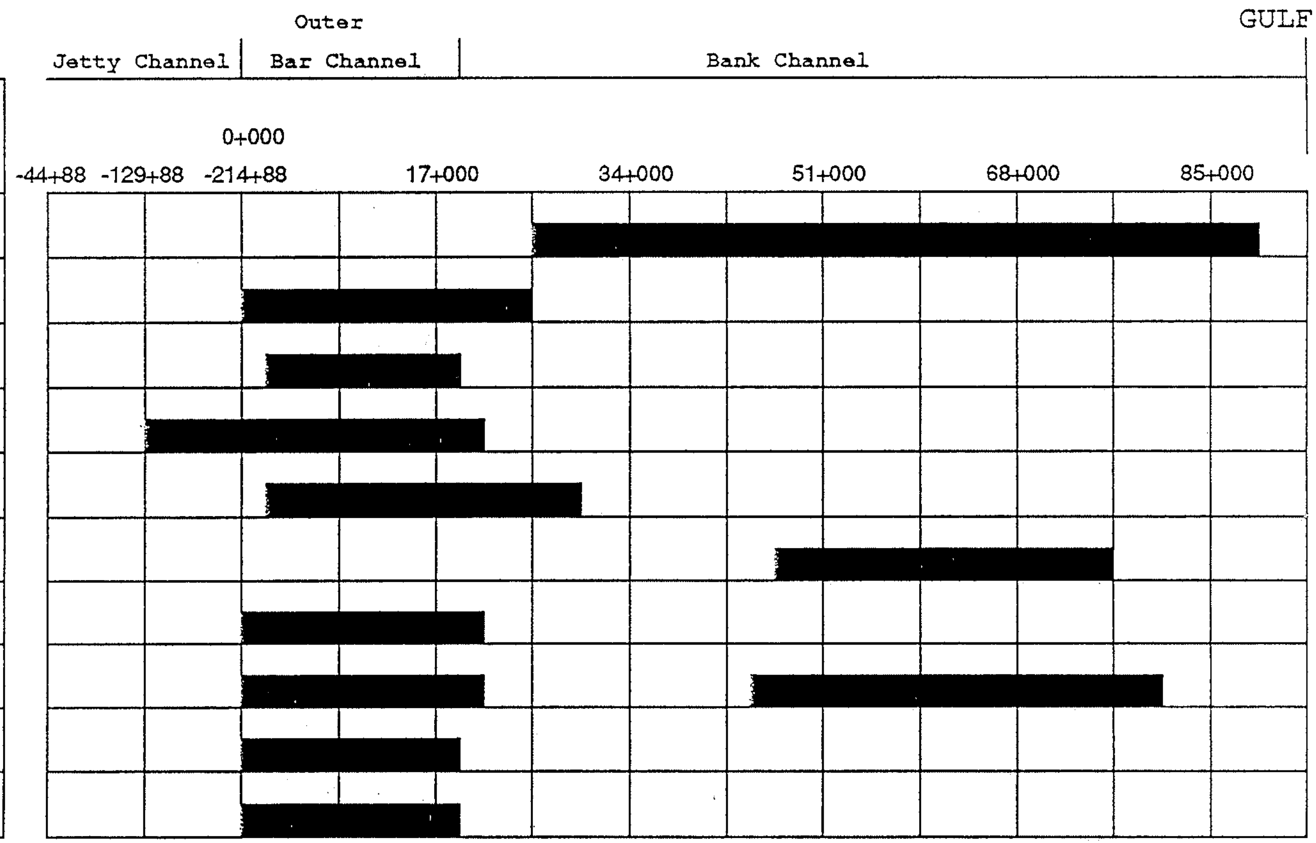

SABINE LAKE
LOUISIANA
N
TEXAS
SABINE PASS
SABINE
87
87
0+00
SABINE PASS JETTY CHANNEL
EAST JETTY
WEST JETTY
-214+88.3 JETTY CHANNEL
0+000 OUTER BAR CHANNEL
OUTER BAR CHANNEL
18+000
GULF OF MEXICO
79+000
SABINE BANK CHANNEL
95+000
SCALE IN FEET
0
12,000
24,000
SABINE-NECHES WATERWAY
U. S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

FIGURE 2

FIGURE 3
MAINTENANCE DREDGING OF THE ENTRANCE OF SABINE-NECHES WATERWAY

CONTRACT NO.	CONTRACT PERIOD	VOLUME (C.Y.)
HD91-01	AUG 91 - OCT 91	1,520,027
91-0025	APR 91	5,710,000
88-0027	SEP 88 - OCT 88	3,002,319
HD87-01	JUL 87 - SEP 87	4,572,109
86-0021	MAY 86 - JUL 86	5,626,837
HD85-01	JUL 85 - SEP 85	5,353,000
84-0023	JUL 84 - SEP 84	5,601,112
HD83-01	JUL 83 - OCT 83	378,000
82-0028	MAY 82 - JUN 82	1,693,264
81-0009	MAR 81 - MAY 81	3,589,486



and 92% at several locations and at various years between 1968 and 1972. Samples from earlier and later years in the same areas indicated a greater percentage of fines. Samples taken from the channel in 1987 showed a low percentage of sand, ranging from 1% to 46%. The 1992 samples, the latest samples taken from the channel, indicated a low percentage of sand, ranging from 8% to 58%. The conclusions which can be drawn from this data are that the maintenance material that is periodically removed from this channel contains a high percentage of silts and clays that vary significantly between dredging cycles and that the material is not suitable for placement on Gulf beaches.

Rollover Pass

Rollover Pass is located 22 miles northeast of Galveston and was constructed by the Texas Game and Fish Commission, now the Texas Parks and Wildlife Department. It is one of three inlets of the Galveston Bay complex, the others being Galveston Harbor Channel and San Luis Pass. Approximately 1 percent of the tidal flow from Galveston Bay passes through Rollover Pass. Rollover Fish Pass was initially opened between October 1954 and February 1955. Although the original design called for a channel width of about 80 feet and a depth of 8 feet, tidal currents rapidly scoured the pass to a width of 500 feet at the Gulf entrance and 30 feet deep at the State Highway 87 bridge. At the same time, the downdrift beach west of the pass was severely eroded for a distance of about one-half mile. In order to control flow through the pass and minimize scour, the Game and Fish Commission constructed a steel sheetpile bulkhead across the pass immediately south of the bridge in November 1955. The tops of alternate piles were driven to a depth of about -2 feet to permit some tidal exchange between the Gulf and bay. The Commission placed approximately 6,000 cubic yards of fill along the Gulf shore west of the pass for about 1,300 feet in February 1957. However, the fill was lost by wave erosion within about 4 months after placement. Hurricane Audrey made landfall at Cameron, Louisiana, about 80 miles northeast of Rollover on the morning of June 27, 1957. Little damage was caused in the channel itself, but the Gulf shore was eroded an average of 50 to 60 feet for about 5 miles on each side of the pass. The pass was reopened in June 1958 by driving the steel sheetpiles 5 feet below mean low water.

The pass has remained open and relatively stable since 1959. The Texas Parks and Wildlife Department constructed a concrete retaining wall behind the southwest steel bulkhead in 1966 and behind the southeast bulkhead in 1972. The Parks and Wildlife Department is currently replacing the existing bulkheads. Completion of the rehabilitation project is scheduled for November 1992.

Galveston Harbor Channel

The Galveston Harbor Channel is located at the northeast end of Galveston Island, approximately 58 miles southwest of Sabine Pass. This inlet separates Bolivar Peninsula to the northeast from Galveston Island to the south and connects Galveston Bay with the Gulf. Approximately 78 percent of the tidal flow for Galveston Bay passes through the Galveston Harbor Channel.

The Galveston Harbor Channel project is a federally-maintained channel which passes through this inlet. Corps of Engineers activities to stabilize and improve the inlet for navigation were first authorized by the Congress in 1870. Activities prior to 1874 provided for dredging operations on a small scale, and were only intended to afford temporary relief to navigation.

The original project for the permanent improvement of this harbor was adopted in 1874. This project consisted of the construction of jetties which were expected to deepen the channel on the bar to 18 feet. The method used in jetty construction proved to be unsatisfactory, and a modified project was formulated for higher and longer jetties with the expectation of creating a channel at least 25 feet deep, and with a goal of reaching 30 feet deep. The modified project was authorized in 1886 and by 1900 the channel had reached a depth of 26 feet. A chronology of Federal activities at the inlet after 1900 is shown in Table 2.

TABLE 2
CHRONOLOGY OF FEDERAL IMPROVEMENTS
TO GALVESTON CHANNEL

Year	Activity
1910	Jetties completed to present length, channel depth completed to 30 feet.
1922	Channel improved to 35 feet deep and 800 feet wide.
1950	Outer Bar Channel deepened to 38 feet and Inner Bar Channel and Bolivar Roads Channel deepened to 36 feet.
1967	Outer Bar and Inner Bar Channels relocated. Entrance and Outer Bar Channels deepened to 42 feet and Inner Bar and Bolivar Roads Channels deepened to 40 ft.

The Galveston Harbor Channel project, shown in Figure 4, allows for deep-draft navigation access to the ports of Galveston, Texas City, and Houston, as well as shallow-draft access to the Gulf Intracoastal Waterway (GIWW). The features of the project which are of interest to this study are: rubble-mound jetties extending from Galveston Island and from Bolivar Peninsula for distances of 35,900 feet and 25,907 feet, respectively; the Entrance Channel (stations 30+675 to 56+000) 42 feet deep, 800 feet wide, and over 25,000 feet long; Outer Bar Channel (stations 21+912 to 30+675) 42 feet deep, 800 feet wide, and over 8,700 feet long; Inner Bar Channel (stations 5+048 to 21+912) 40 feet deep, 800 feet wide, and over 16,800 feet long; the Bolivar Roads Channel (stations 0+000 to 5+048) 40 feet deep, 800 feet wide, and 5,048 feet long; and an anchorage area located north of the Inner Bar Channel (stations 12+000 to 23+400) which is 36 feet deep and has an average bottom width of 2,875 feet and an average length of 9,763 feet.

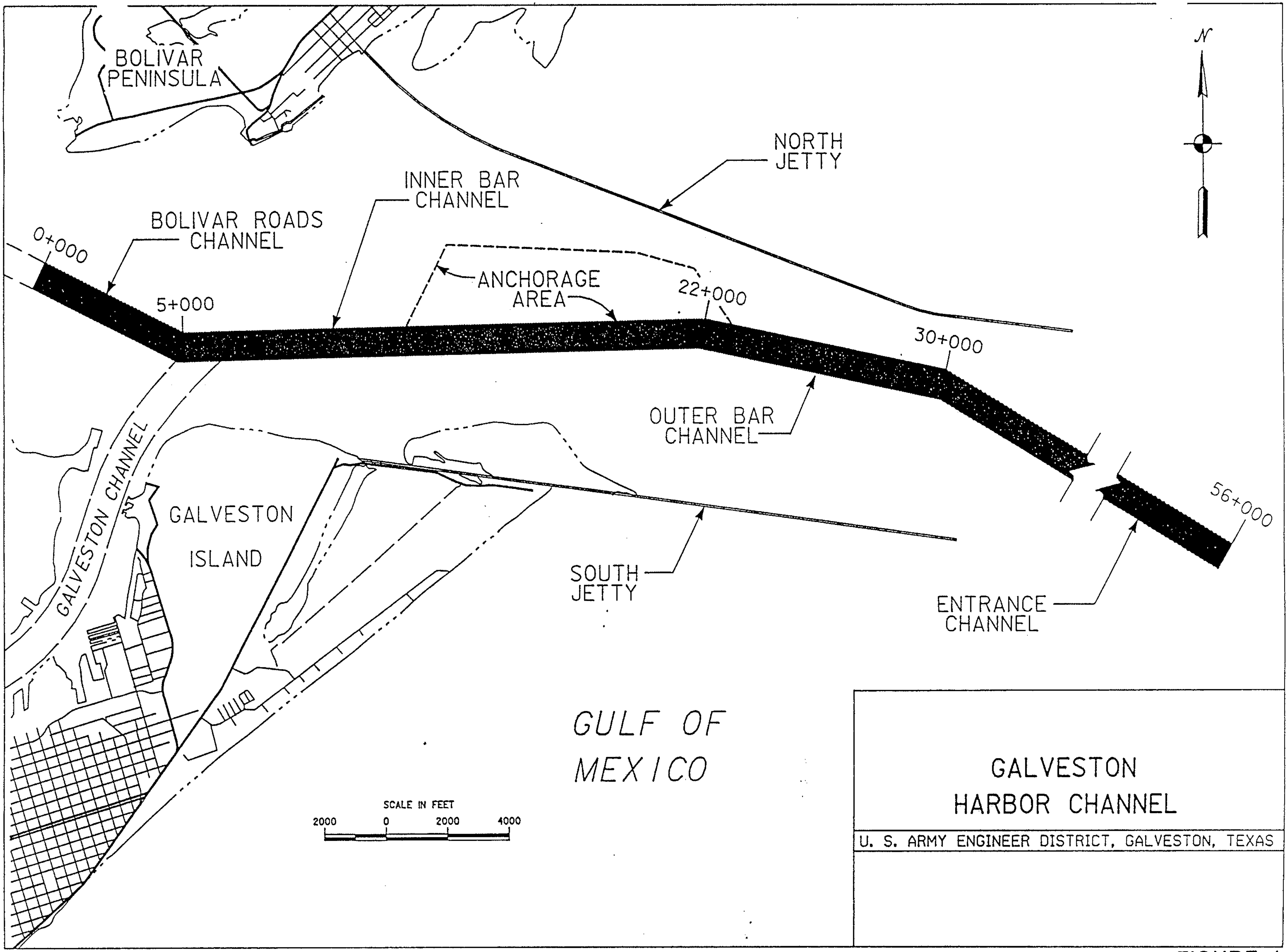

BOLIVAR PENINSULA
NORTH JETTY
INNER BAR CHANNEL
BOLIVAR ROADS CHANNEL
0+000
5+000
ANCHORAGE AREA
22+000
30+000
OUTER BAR CHANNEL
56+000
GALVESTON CHANNEL
GALVESTON ISLAND
SOUTH JETTY
ENTRANCE CHANNEL
GULF OF MEXICO
SCALE IN FEET
2000
0
2000
4000
N
GALVESTON HARBOR CHANNEL
U. S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

FIGURE 4

The maintenance dredging history for this project is presented in Figure 5. Shortly after the 1989 dredging contract was initiated, the Government hopper dredge experienced mechanical problems. Therefore, the dredging job was not completed, resulting in a low quantity of material removed and the exact stationing of dredging not known. The Galveston Entrance Channel, Galveston Outer Bar Channel, and Galveston Inner Bar Channel segments have been dredged seven times since March 1979 resulting in an average dredging cycle of about 1.9 years. The average quantity removed during a maintenance dredging cycle is 2.2 million cubic yards, and the average annual shoaling rate is 1.1 million cubic yards. This material is removed by hopper dredge and is placed in an offshore disposal site located south of the Entrance Channel.

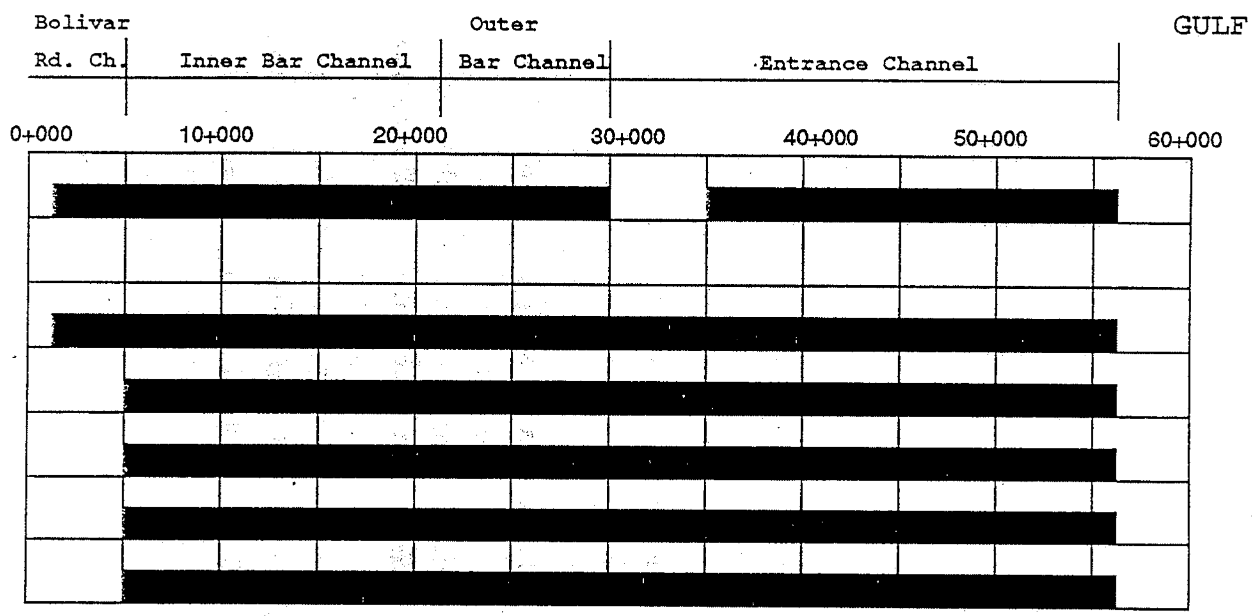
Bolivar Roads Channel has been dredged twice since March 1979, removing an average of 112,000 cubic yards of material every 6.7 years. This portion of the channel has an average annual shoaling rate of 17,000 cubic yards. The anchorage area has been dredged three times since March 1978, resulting in an average dredging cycle of about 4.8 years to remove about 786,000 cubic yards of dredged material. The average annual shoaling rate for the anchorage area is 163,000 cubic yards.

Material removed from the channel has contained some sand. From 1970 to 1977, sand percentages of samples taken from stations 8+000 to 30+000 in the Galveston Harbor Channel ranged from 88% to 97%. Samples between 1957 and 1970 for this same reach indicate a sand percentage between 9% and 97%, with the majority of samples being in the 70% to 95% range. Since 1977 samples taken from stations 0+000 to 25+000 had sand percentages ranging from 41% to 91%.

Samples taken between station 30+000 and station 38+000 from 1957 to 1977 show a sand content ranging from 40% to 88% while samples taken from station 39+000 to station 56+000 had a very low sand content. Since 1977 stations 30+000 to 56+000 have sand percentages ranging from 1% to 50% with the exception of one sample that had 79%.

FIGURE 5
MAINTENANCE DREDGING OF THE GALVESTON HARBOR CHANNEL

CONTRACT NO.	CONTRACT PERIOD	VOLUME (C.Y.)
90-0031	AUG 90 - DEC 90	2,611,873
HD89-04	SEP 89	58,938 *
HD88-01	JUL 88 - OCT 88	1,038,946
86-0026	MAY 86 - JUL 86	2,212,568
84-0012	MAR 84 - MAR 85	4,487,405
80-0023	MAY 80 - JUL 80	1,170,282
79-0017	MAR 79 - SEP 79	3,812,190



* Exact Stationing Unknown

Based on this analysis, the project segment from station 0+000 to station 25+000 has the best potential source of sand for beach nourishment. This reach, which includes Bolivar Roads Channel, the Inner Bar Channel, and a portion of the Outer Bar Channel, accumulates 819,000 cubic yards of material about every 1.9 years for an average annual shoaling rate of 427,000 cubic yards.

San Luis Pass

San Luis Pass is an unjettied, natural inlet located at the southwest end of Galveston Island. It extends between the Gulf and West Galveston Bay, separating Galveston and Follets Islands with a tidal channel approximately 1 mile wide. It connects Christmas, Bastrop, and West Bays with the Gulf of Mexico. Approximately 21 percent of the tidal flow to Galveston Bay occurs through San Luis Pass. Although the first chart survey of San Luis Pass was made in 1853, there are historical records of the pass dating back to 1834. From 1853 to 1933 volume changes within the inlet were minor with some erosion of the ebb tidal delta. Historically, the deepest part of the pass has been the southwest side of the inlet. The inlet began to widen in the 1950's and the ebb tidal delta moved toward the southwest. Major changes were a result of hurricanes. The hurricane of 1959 passed directly over the pass and Carla in 1961 struck Pass Cavallo 95 miles to the southwest, producing large waves and strong currents at San Luis Pass. By 1965 the inlet width had increased to more than 4,000 feet. In 1983, the center of Hurricane Alicia moved inland directly over San Luis Pass. Although some erosion occurred on adjacent shorelines and in the pass, the overall impacts were minor. Since that time the inlet width has remained almost constant. Typical inlet changes have occurred, the ebb and flood tidal deltas have changed in volume, migration has taken place, new channels have been cut, and adjacent shorelines have eroded and accreted. Beaches southwest of the pass have accreted while those to the northeast have eroded, emphasizing the downdrift offset typical of many Texas inlets.

Freeport Channel

The Federal project known as Freeport Harbor is located on the upper Texas coast, approximately 60 miles south of Houston. The project is an improvement of the original mouth of the Brazos River and provides for a deep-draft waterway from the Gulf of Mexico to the city of Freeport. In 1929 the Brazos River was diverted from the Freeport Channel to a new outlet about 6.5 miles southwest of the original mouth by the Corps of Engineers. The diversion made Freeport Harbor entirely tidal. The project has an overall length of about 8.6 miles.

The Brazos River, the longest river in the state, sustained considerable commerce as early as the 1830's. It differs from most other Texas rivers by emptying directly into the Gulf without an intermediary tidal basin. The Brazos was not, however, an ideal candidate for dependable navigation, impeded by many rocks, shoals, bars, snags, bends, rapids, and variable water levels. A further hindrance lay in the shifting bar, fluctuating in depth from 4 to 10 feet, where the mouth of the river flowed into the Gulf.

The original project for Federal improvement at this locality was authorized by the River and Harbor Act approved June 14, 1880, which provided for construction of jetties for controlling and improving the channel over the bar at the mouth of the Brazos River. The work was started in 1881 and continued until 1886, when operations were suspended for lack of funds. Partial construction of the jetties was accomplished, but the work was not successful in obtaining an adequate depth over the bar. On March 28, 1899, the Brazos River Channel and Dock Company, under authority granted by the River and Harbor Act of August 21, 1888, started work to provide a navigable channel from the mouth of the Brazos River inland. The company was unable to finance completion of the work, and on April 25, 1899, in accordance with requirements of the River and Harbor Act of March 3, 1899, transferred all its works, rights, and privileges to the United States. A chronology of the Federal improvements made after taking over the project is shown in Table 3.

TABLE 3

CHRONOLOGY OF FEDERAL IMPROVEMENTS AT FREEPORT CHANNEL

Year	Activity
1908	Repaired jetties constructed by the Brazos River Channel and Dock Company. The jetties were 560 feet apart; the length of the North Jetty was 4,708 feet and the South Jetty 5,018 feet.
1911	Dredged 18- by 150-foot channel from outer end of jetties to railway wharf.
1919	Channel deepened to 22 feet.
1929	Dredging of Diversion Channel to relocate mouth of the Brazos River completed.
1931	Outer Bar and Jetty Channels improved to 25 feet deep and 150 feet wide.
1936	Outer Bar Channel improved to 32 feet deep and 300 feet wide, and Jetty Channel improved to 32 feet deep and 200 feet wide.
1958	Realigned Outer Bar Channel on straight alignment with Jetty Channel.
1961	Outer Bar Channel deepened to 38 feet; Jetty Channel deepened to 36 feet.
1990	Outer Bar Channel improved to 47 feet deep and 400 feet wide.
1991	North Jetty relocated 640 feet to the northeast, increasing the distance between the jetties to 1,200 feet.
1992	Jetty Channel improved to 45 feet deep by 400 feet wide.

The most recent improvements at Freeport Harbor were authorized by the River and Harbor Act of December 1970 which provided for the relocation and deepening of the Entrance Channel to 47 feet, relocation and deepening of the Jetty Channel to 45 feet, deepening and/or enlarging of inside channels and turning basins, relocation of the North Jetty, and rehabilitation of the South Jetty. This report focuses on the entrance area of this project, as shown in Figure 6.

Deepening of the Entrance Channel was completed in November 1990. The North Jetty was relocated 640 feet to the northeast in March 1991, increasing the distance between the jetties to 1,200 feet. The Jetty Channel was widened and deepened in April 1992 with work on the inner channels and basins completed in June 1992. Rehabilitation of the South Jetty and the 500-foot extension of the North Jetty is ongoing with completion scheduled for October 1993. Upon completion, total length of the North and South Jetties will be 4,200 feet and 4,600 feet, respectively. The North and South Jetties also have inshore shore protection sections of 3,500 feet and 1,460 feet, respectively. The Outer Bar Channel (station 0+00 to station -270+00) is 400 feet wide and 47 feet deep. The Jetty Channel (stations 0+00 to 60+00) has dimensions of 400 feet wide and 45 feet deep.

The maintenance dredging records shown in Figure 7 show that the entrance to Freeport Harbor has been maintained numerous times from 1970 until 1990. The maintenance record was interrupted in 1990 and 1991 when the channel was widened and deepened. The new work material removed in 1990 during the deepening project was removed by hopper and bucket dredges, whereas the new work material removed in 1991 was by a pipeline dredge.

Prior to channel modification, the average dredging cycle for the entrance at Freeport was 1.2 years to remove 1.2 million cubic yards of material. Maintenance dredging of the Freeport Outer Bar and Jetty Channels has been performed by hopper dredge and the material placed in an offshore disposal area located southwest of the Outer Bar Channel. An average shoaling rate of 960,000 cubic yards per year was calculated for this channel. The improved

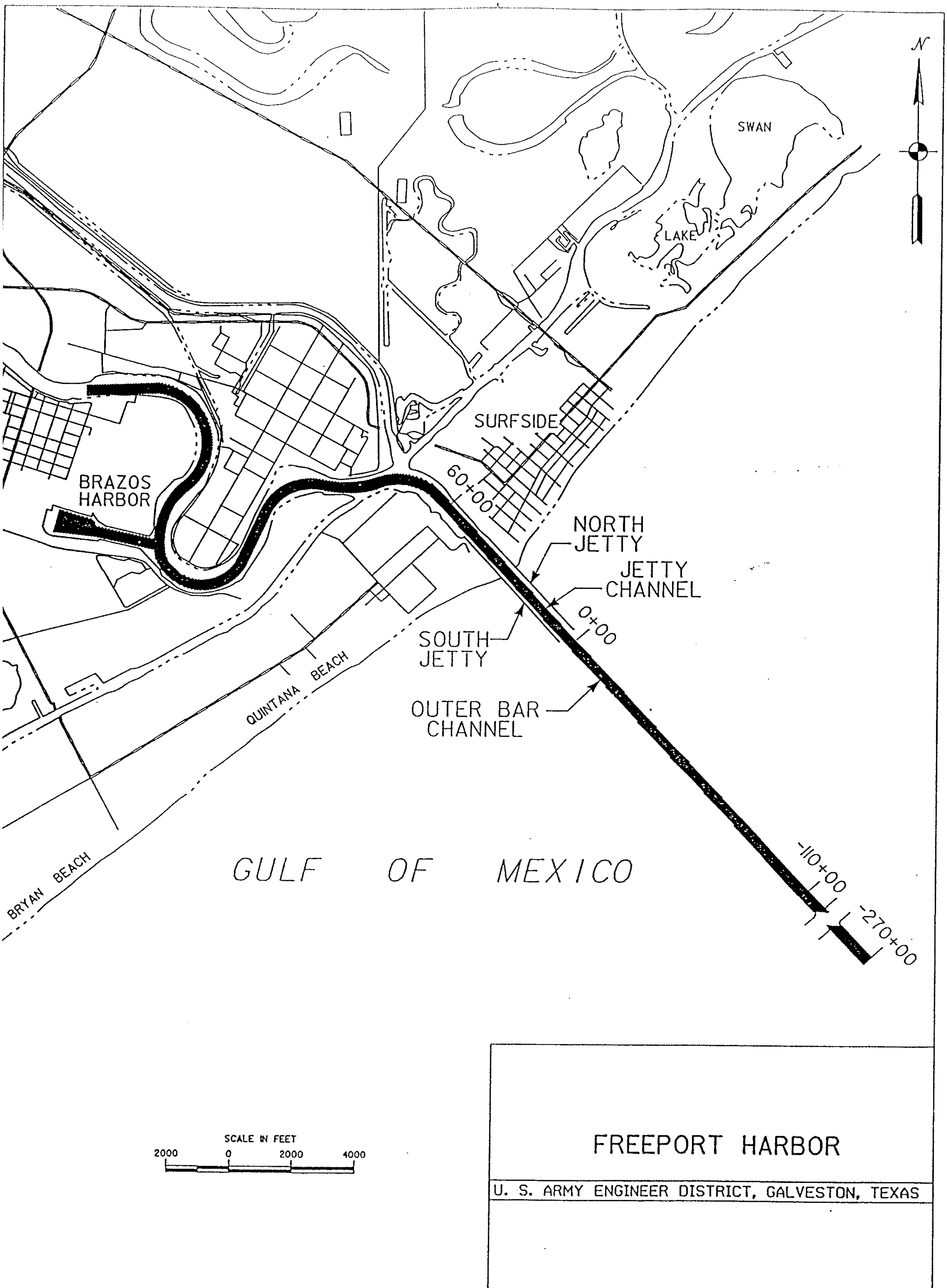
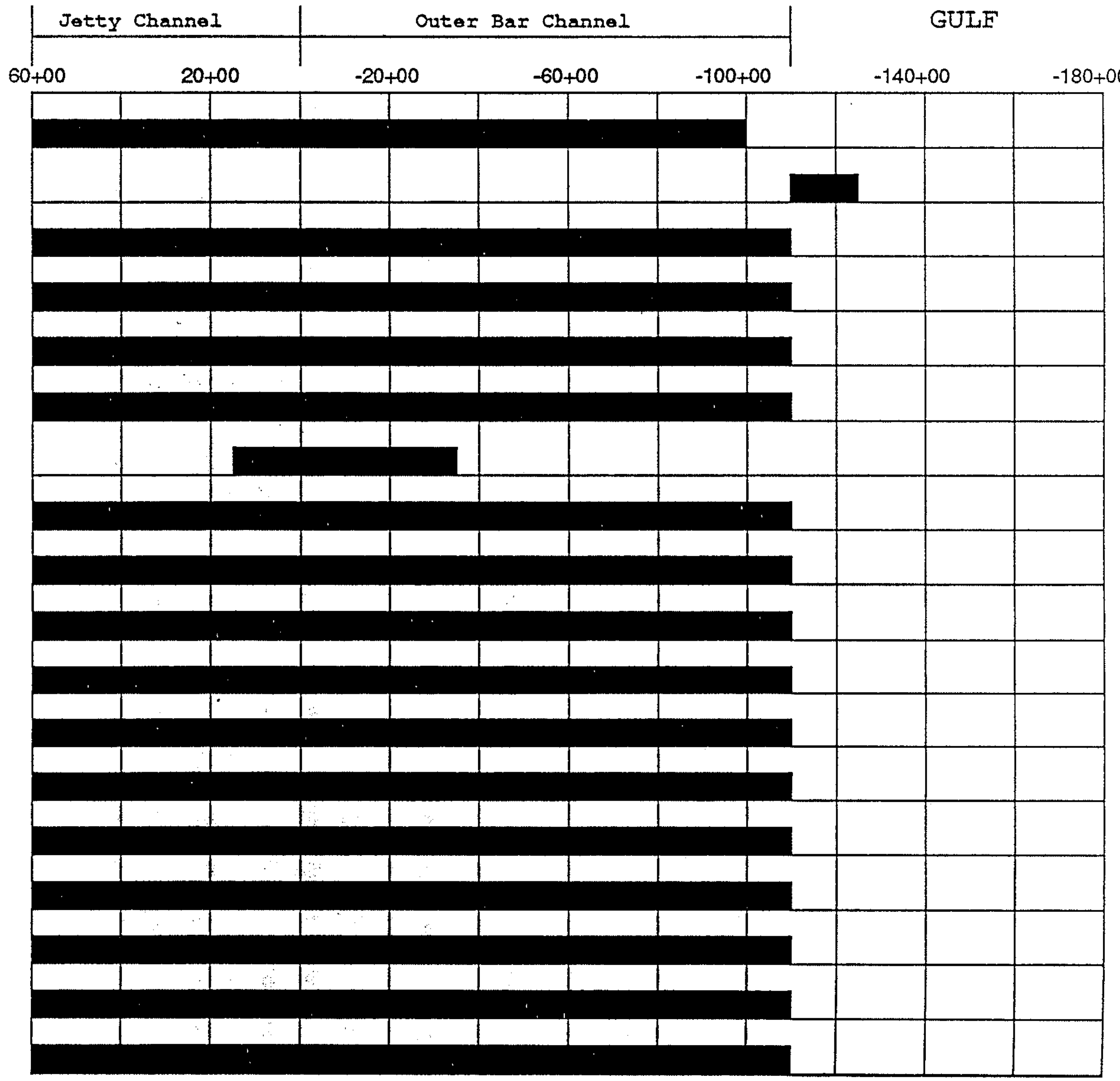

N
SWAN
LAKE
SURFSIDE
BRAZOS
HARBOR
60+00
NORTH
JETTY
JETTY
CHANNEL
0+00
SOUTH
JETTY
OUTER BAR
CHANNEL
QUINTANA BEACH
-110+00
-270+00
GULF OF MEXICO
BRYAN BEACH
SCALE IN FEET
2000 0 2000 4000
FREEPORT HARBOR
U. S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

FIGURE 6

FIGURE 7
MAINTENANCE DREDGING OF THE ENTRANCE OF FREEPORT HARBOR

CONTRACT NO.	CONTRACT PERIOD	VOLUME (C.Y.)
88-0026	AUG 88 - SEP 88	843,940
HD87-02	SEP 87	213,773
87-0023	MAY 87 - JUL 87	1,016,286
86-0033	JUL 86 - AUG 86	925,709
85-0029	AUG 85 - SEP 85	903,748
84-0033	OCT 84 - NOV 84	1,186,135
HD84-01	OCT 84 - NOV 84	212,799
83-0016	JUN 83 - OCT 83	1,109,789
82-0027	JUN 82 - AUG 82	1,387,826
HD80-04	AUG 80 - JAN 81	1,098,920
HD80-02	DEC 79 - FEB 80	1,101,208
HD78-03	AUG 78 - OCT 78	966,648
HD76-01	SEP 75 - DEC 75	2,095,572
HD75-01	NOV 74 - DEC 74	1,010,361
-	SEP 73 - JAN 74	1,089,540
-	NOV 72 - MAY 73	868,540
-	OCT 71 - MAY 72	1,161,215
-	NOV 70 - MAY 71	1,614,436



channel has not required maintenance since its construction.

Historical records showing grain size of the material removed from the channel indicate a very low percentage of sand at all stations from 1957 through 1976, generally less than 20%. Samples taken in December 1976 had sand percentages ranging from 0% to 50% with the exception of one sample showing 71% sand at station 0+000. Samples taken in the channel from 1983 to 1989 between stations -100+000 to 50+000 show the sand content to range from 3% to 52%. From this data it was concluded that dredged material from the Freeport Outer Bar and Jetty Channels is not considered suitable for placement on beaches.

Brazos River Diversion Channel

The lower 5 miles of the Brazos River is known as the Brazos River Diversion Channel. It was completed in 1929 by the Federal Government in an effort to divert the sediment-laden waters of the Brazos River away from the deep-draft navigation facilities located at Freeport along the lower portion of the river. This was accomplished by damming the river about 7.5 miles upstream of the original mouth and rerouting the river flows through the Brazos River Diversion Channel to discharge into the Gulf of Mexico at a point approximately 6.5 miles southwest of the original mouth.

From the time the Freeport Jetties were constructed in the late 1800's, the areas adjacent to the jetties accumulated material forming a delta into the Gulf on both sides of the jetties. When the river was diverted in 1929 to its present location, the delta near the jetties began to erode, and a delta at the relocated mouth began to form. Since 1949 the new delta has been eroding because of a reduction in sediment loads on the river.

San Bernard River

Federal improvements on the San Bernard River consist of a 9-foot deep by 100-foot wide channel from the GIWW to a point 28 miles upstream authorized by the River and Harbor Act of June 20, 1938. Original plans considered for the project provided for an improved deepwater channel with jetty protection at the mouth; however, this proposal was abandoned. Federal improvements on the San Bernard River currently terminate at its intersection with the GIWW. The 1-mile reach of the river between the GIWW and the Gulf is not maintained by the Federal Government. There is not any delta building ongoing at the mouth of the river.

Caney Fork/Mitchell Cut

In May 1989 the Matagorda County Drainage District opened an inlet, Caney Fork/Mitchell Cut, between the GIWW and the Gulf through the eastern end of East Matagorda Bay. This inlet replaced McCabe Cut which was opened in 1983 to allow a direct outlet for floodwaters from the Caney Creek watershed. McCabe Cut was subsequently closed in 1989 because natural processes expanded this channel. This enlarged channel allowed strong currents to develop between the GIWW and the Gulf and became a hazard to navigation, particularly to eastbound traffic on the GIWW. This new inlet has an 80-foot bottom width and -8 foot depth. Since the Caney Fork/Mitchell Cut was constructed, the inlet has been laterally stable.

Brown Cedar Cut

The natural formation of Brown Cedar Cut near the eastern end of Matagorda Peninsula probably occurred in 1929 and has been open intermittently since that time. Historically, tidal flows and flushing through the inlet have been ineffective in keeping it open for substantial periods of time. A constantly changing inlet resulted until deposition completely closed it. It now opens during hurricanes because of storm surges from the Gulf to East Matagorda Bay or because of interior rainfall accumulations flowing from East Matagorda Bay to the Gulf.

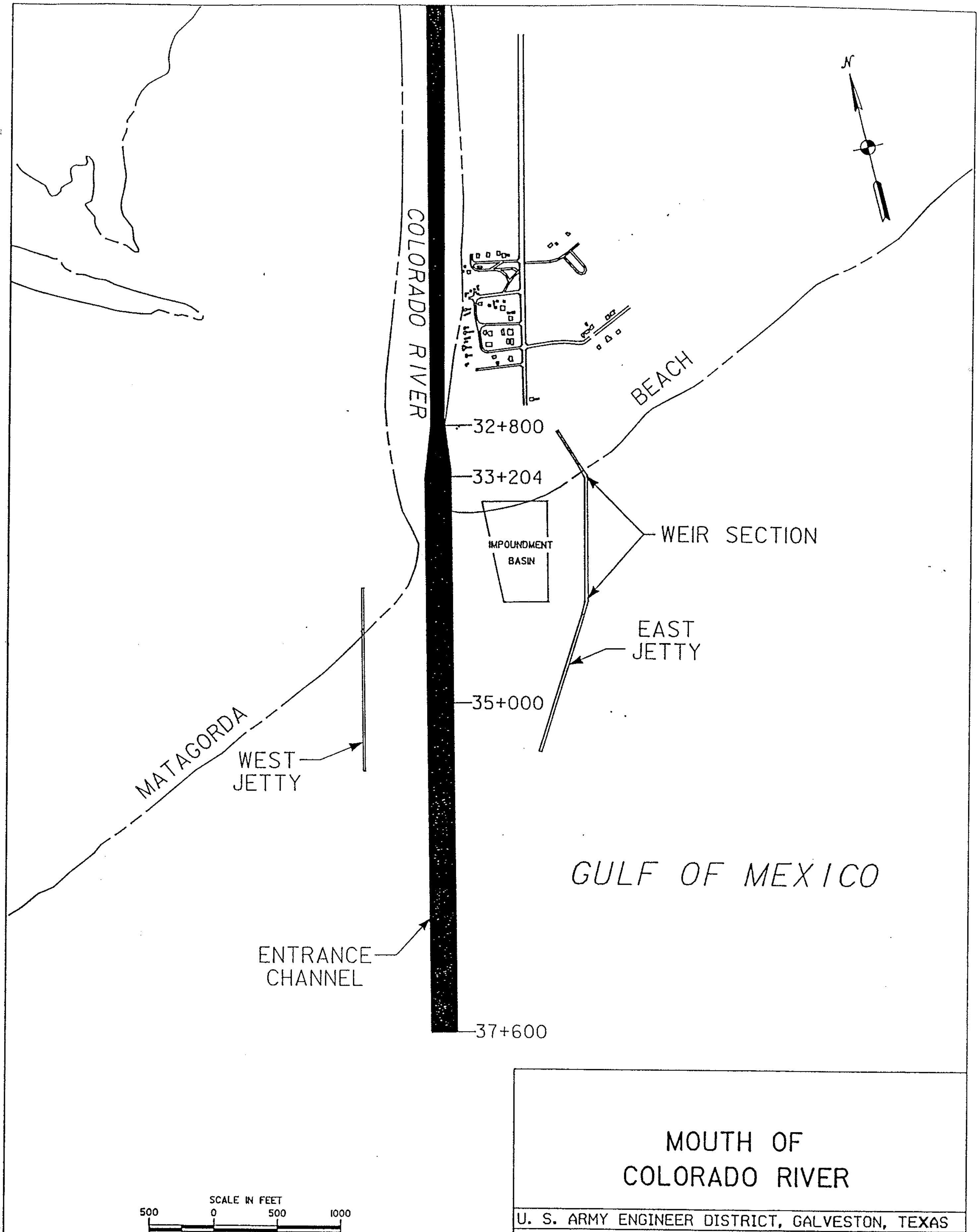
Colorado River

The Colorado River discharges into the Gulf of Mexico about 80 miles southwest of Galveston. The Mouth of Colorado River project is located in the delta portion of the Colorado River and extends from the river's mouth to the town of Matagorda. The existing project to divert the Colorado River flows into Matagorda Bay is an effort to reestablish historical flows of the river into the bay.

Sediment transported by the Colorado River was hindered in the mid and late 1800's by a log raft. It is uncertain when this particular raft originated as log jams were characteristic of the lower Colorado River. References have been made to a raft in 1824, 1831, 1837, and 1875. By 1926 the raft extended 46 miles upstream from Matagorda and formed a lake which also impounded coarse sediment.

Dredging of a pilot channel through the raft was initiated in March 1925 and completed in 1929. Growth rate of the delta changed little until June 1929 when a major flood carried large quantities of sediment and logs into Matagorda Bay. Additional sediment was also contributed by bank erosion and adjustment of the river channel after the log raft was removed. After 1929, the delta grew rapidly and by 1935 had prograded across Matagorda Bay.

The navigation features of the project include dual jetties into the Gulf with the East Jetty consisting of a weir to allow sediments to accumulate in a constructed impoundment basin between the jetties; the Entrance Channel (stations 33+200 to 37+600) 15 feet deep and 200 feet wide; a 12-foot deep by 100-foot wide navigation channel from the Entrance Channel to the GIWW which generally follows the Colorado River Channel, and a harbor and turning basin. The Impoundment Basin is located between stations 33+404 and 34+204. The project also includes recreational facilities adjacent to the East Jetty and features to restore the Colorado River outfall to Matagorda Bay. This project is shown in Figure 8. Construction of the Jetty and Entrance Channel was completed in April 1990. The remaining project features are scheduled for completion in mid-1994.



MOUTH OF
COLORADO RIVER

U. S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

FIGURE 8

Maintenance dredging records are shown in Figure 9. In April 1991, the Entrance Channel from stations 30+600 to 36+600 was dredged. Approximately 62,000 cubic yards of material removed from the impoundment basin was used to construct a dam in Tiger Island Channel, closing the cut between Matagorda Bay and the Colorado River. This material was not analyzed to determine the percentage of sand.

Because of the short length of time since the channel and impoundment basin were completed, an average maintenance cycle and quantity could not be developed. However, the impoundment basin is scheduled to be maintained again in 1992. This material will be dredged by a pipeline dredge and pumped to the downdrift shore beyond the South Jetty to avoid interrupting the littoral transport downcoast. This procedure is incorporated into the project's Environmental Impact Statement.

Dredging of the channel to divert the Colorado River into Matagorda Bay was completed in May 1990. After the dam is completed in the Colorado River downstream of the diversion channel, the Colorado River will no longer discharge into the Gulf of Mexico.

Greens Bayou

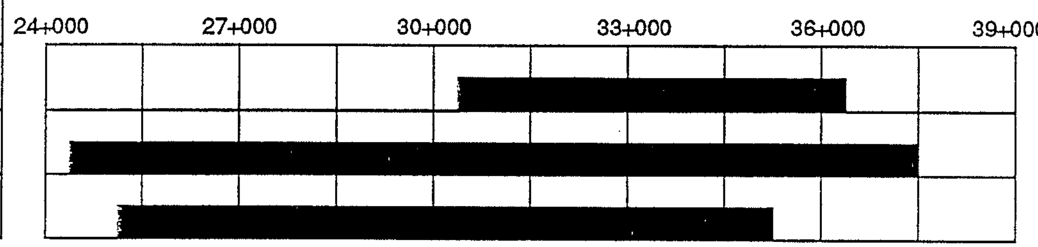
Greens Bayou is a natural hurricane washover channel located on Matagorda Peninsula between the Colorado River and the Matagorda Ship Channel. When open, this channel connects Matagorda Bay and the Gulf. It is opened by hurricanes and closed by natural processes.

Matagorda Channel

The Matagorda Ship Channel is a federally-maintained channel located 80 miles northeast of Corpus Christi. The channel extends across Matagorda Peninsula, connecting Matagorda Bay to the open Gulf. Approximately 44 percent of the tidal flow between the bay

FIGURE 9
MAINTENANCE DREDGING OF THE
MOUTH OF COLORADO RIVER

CONTRACT NO.	CONTRACT PERIOD	VOLUME (C.Y.)
91-0022	APR 92 - MAY 91	62,077
89-0038	SEP 89	New Work
73-0133	JUL 73 - NOV 73	781,668



and the Gulf passes through the Matagorda Entrance Channel. The remaining 56 percent passes through Pass Cavallo.

In 1958, Congress authorized the construction of a deep-draft navigation channel from the Gulf of Mexico through Pass Cavallo, 38 feet deep, 300 feet wide and about 6 miles long; an inner channel 36 feet deep, 200 feet wide and about 22 miles long across Matagorda and Lavaca Bays; a turning basin at Point Comfort 36 feet deep and 1,000 feet square; and dual jetties at the channel entrance. The authorization also provided for enlargement of the shallow-draft channels near Port Lavaca. During preconstruction project design, a fixed-bed hydraulic model was constructed as an aid in developing sound engineering design of the project. The results of the model tests showed that the location of the Entrance Channel should be moved from Pass Cavallo to a man-made cut across Matagorda Peninsula. The relocated Entrance Channel would provide a shorter and straighter entrance, shorter jetties, a lesser length of channel in which current velocities would be relatively high, and the probability that periodic maintenance dredging would be less.

Dredging was initiated in July 1962, and construction of the jetties began early in 1963. The channel across Matagorda Peninsula was completed in September 1963. Dredging of the inner portion of the Entrance Channel and construction of the South Jetty were completed early in 1966; however, dredging on the outer portion of the Entrance Channel and construction of the North Jetty were not completed until October 1966.

This report focuses on the Entrance Channel (stations 0+000 to -20+000) and the North and South Jetties which are 5,900 feet and 6,000 feet long, respectively. The project is shown in Figure 10.

The maintenance dredging history for the entrance of the Matagorda Ship Channel is shown on Figure 11. Maintenance dredging records indicate that the Matagorda Jetty Channel is dredged by hopper dredge and the material is placed in an offshore disposal site located southwest of the channel. Portions of the Jetty Channel have been dredged ten times since October 1970, resulting in a 2.2-

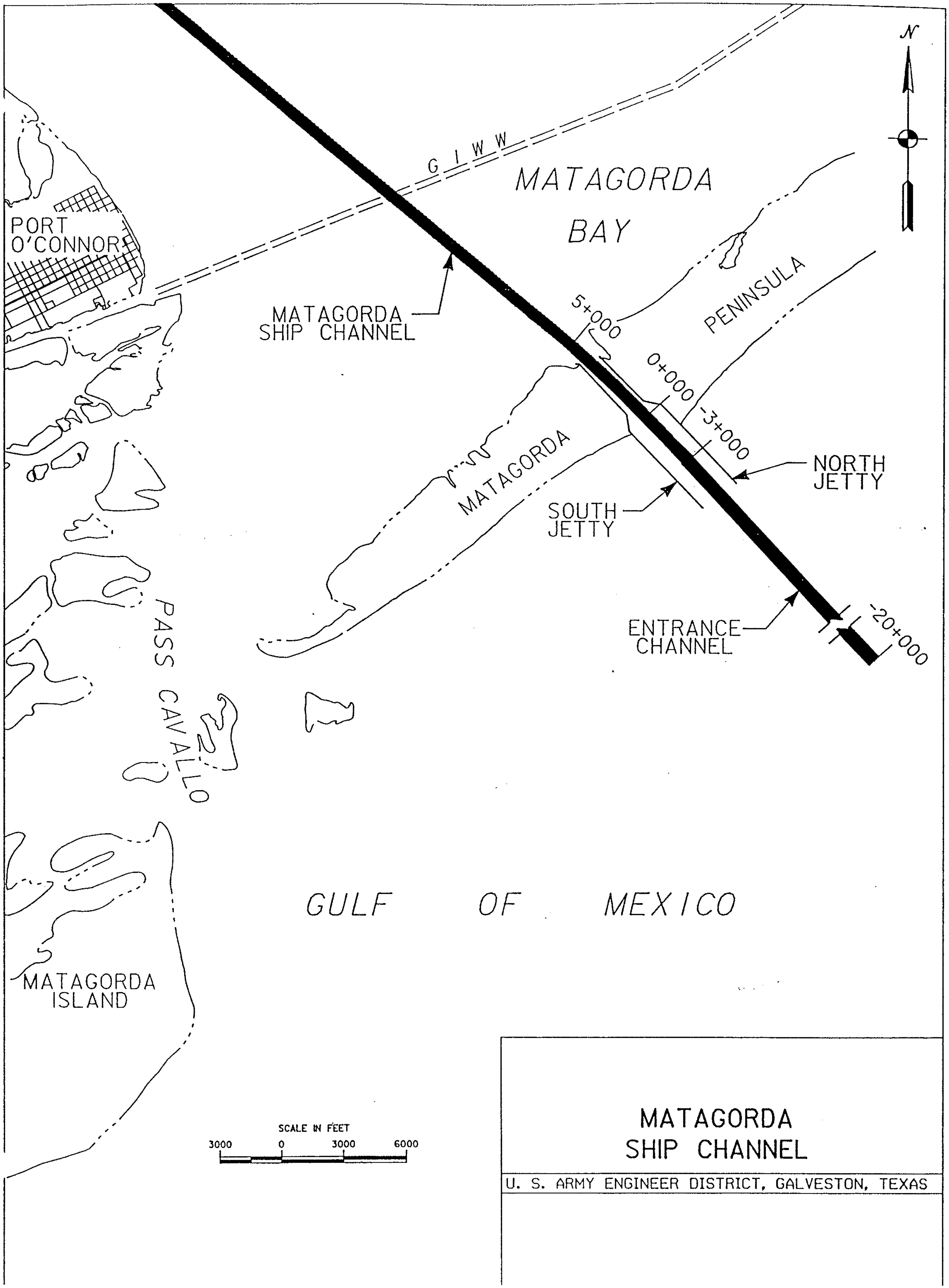
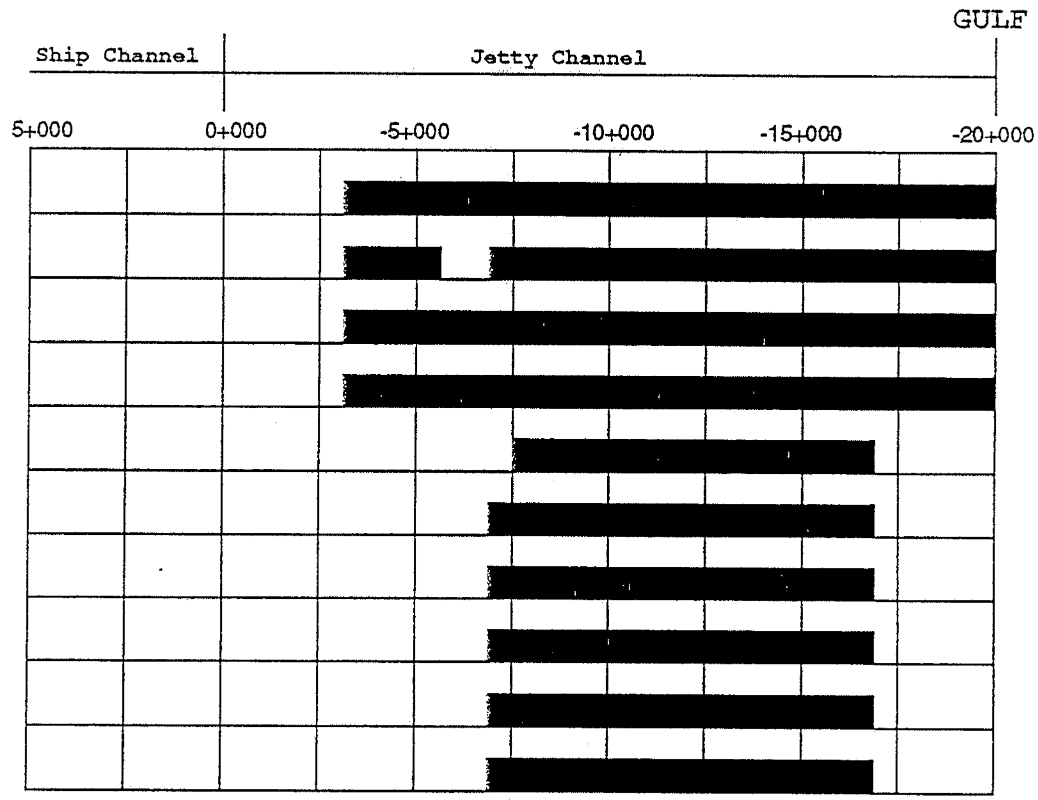

MATAGORDA BAY
G I W W
PORT O'CONNOR
MATAGORDA SHIP CHANNEL
5+000
0+000
-3+000
-20+000
PENINSULA
MATAGORDA
NORTH JETTY
SOUTH JETTY
ENTRANCE CHANNEL
PASS CAVALLO
GULF OF MEXICO
MATAGORDA ISLAND
SCALE IN FEET
3000 0 3000 6000
N
MATAGORDA SHIP CHANNEL
U. S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

FIGURE 11
MAINTENANCE DREDGING OF THE
ENTRANCE OF MATAGORDA SHIP CHANNEL

CONTRACT NO.	CONTRACT PERIOD	VOLUME (C.Y.)
89-0015	JAN 89 - FEB 89	498,040
84-0009	JAN 84 - MAR 84	908,933
80-0056	AUG 80 - DEC 80	1,790,548
79-0034	AUG 79	539,891
HD78-02	DEC 77 - JAN 78	290,000
HD76-02	JAN 76 - FEB 76	943,112
HD75-02	DEC 74 - MAY 75	1,463,473
HD73-02	MAR 73 - APR 73	547,000
HD72-02	MAR 72 - APR 72	484,560
HD71-02	OCT 70 - AUG 71	1,135,825



year average dredging cycle. The average quantity removed per cycle is 860,000 cubic yards. The average annual shoaling rate for this channel is 395,000 cubic yards.

For the period 1963 through 1976 sand percentages of dredged material ranged from 18% to 99%. Samples taken between stations -3+000 and -11+000 indicated a high sand content varying from 64% to 99%. Samples taken in 1977, 1979, and 1983 indicated a percentage of sand ranging from 7% to 94% from stations 0+000 to -20+000. The most recent samples taken in December 1988 also indicated a high sand content. Stations -10+000 to -20+000 had a sand percentage ranging from 81% to 98%. Based on this analysis, dredged materials from stations -3+000 to -20+000 are considered a potential source of sand for beach nourishment.

Pass Cavallo

Pass Cavallo is a natural inlet located between Matagorda Peninsula to the northeast and Matagorda Island to the southwest. It provides continuous, significant tidal flow between Matagorda Bay and the Gulf, accounting for 56 percent of the tidal exchange.

Among the first to be used for navigation in Texas, Pass Cavallo at the entrance into Matagorda Bay was the last to be successfully improved. According to shipping interests in the 1800's, Pass Cavallo was the second best natural pass on the Texas coast; Galveston was ranked first. To secure a 12-foot channel depth across the bar, a single jetty was begun in 1881 at the south side of the pass, designed to extend 7,600 feet from Matagorda Island. Construction proceeded over the next 5 years, marked by the usual problems of inadequate funds and work suspensions. In 1888 the attempt to improve Pass Cavallo was abandoned.

After abandonment of the project, no improvement was attempted between the Gulf and Matagorda Bay for many years. Pass Cavallo served in its natural state to accommodate the shallow-draft vessels using its channel. The pass had remained in a stable position for more than 200 years and the channel depth between the inner and outer bars ranged from 20 to 42 feet. Opening of the Colorado River Flood Discharge Channel across Matagorda Peninsula in the mid-1930's reduced the flow through Pass Cavallo and, gradually, its navigability.

By 1949, the outer bar posed a drastic problem, even for the small fishing and oil exploration vessels that needed to cross it. Navigation required calm weather and was limited to boats drawing less than 6 feet. As an emergency measure to relieve this restricted situation, the Corps of Engineers cut a 3,000-foot long channel, 17 feet deep by 135 feet wide. Completed in September 1949, the channel shoaled rapidly to a depth of 10 feet within 2 months, largely because of a hurricane in November 1949, and by March of 1952 had deteriorated to 8 feet. No further attempts were made to dredge Pass Cavallo.

Cedar Bayou

Cedar Bayou is a natural tidal inlet which connects the Gulf with Mesquite Bay and separates Matagorda Island and San Jose (formerly St. Joseph) Island. It is located about 40 miles northeast of Corpus Christi.

Cedar Bayou is the smallest of the natural inlets along the Texas coast that stays open on a regular basis. It is approximately 3 miles long and has maximum depths of 10 to 12 feet. When open, the depth of the pass at the Gulf is about 2 feet. Cedar Bayou is a relatively undisturbed natural pass, mainly because of its accessibility only by boat and its distance to major population centers.

Cedar Bayou is alternately opened and closed according to dominating tidal and shoreline processes. When open, it is the only tidal connection through the barrier island system for about 76 miles of coastline from Pass Cavallo at Matagorda Bay to Aransas Pass at Corpus Christi Bay. Its orientation is north-northeast by south-southwest which is the stable configuration for the inlet. Based on a comparison between the earliest available hydrographic chart (1860) and more recent aerial photography, the pass's position has not changed. This orientation is controlled in part by the strong ebb tidal currents operating during northers that scour the channel and transport sediment seaward.

A study, conducted by Turner, Collie & Braden, Inc., dated 1967, of the feasibility of reopening Corpus Christi Pass provided pertinent information on historical openings and closures of Cedar Bayou. Records dating back to 1906 indicate the pass was closed by hurricanes in 1915, 1929, and 1934. The pass was opened by a hurricane in 1919, and opened naturally in 1930. In 1939, the pass was opened artificially by dredging and remained open for 16 years, closing naturally in 1955. In 1959, the pass was again opened artificially and remained open until 1979 when the pass was closed with sand to prevent spilled oil from the IXTOC offshore oil platform from entering the bays. At the time of the oil spill, the pass appeared to be in the process of closing itself naturally. The pass remaining open for this 20-year period (1950-1979) can probably be attributed to the large number of hurricanes affecting the area (Carla, 1961; Beulah, 1967; Celia, 1970; and Fern, 1971). The force of Hurricane Allen in 1980 reopened the sand-filled pass.

The Texas Parks and Wildlife Department led efforts to improve the mouth of Cedar Bayou to provide a migration route for fish as well as to help moderate salinity levels in Mesquite Bay in the mid-1980's. The 80- to 100-foot wide by 6- to 8-foot deep channel was completed in October 1988, and the inlet remains open at this time.

Aransas Pass

Aransas Pass is a natural inlet located approximately 20 miles east of Corpus Christi between San Jose and Mustang Islands, connecting Corpus Christi Bay and Redfish Bay with the open Gulf. The entrance to the federally-maintained Corpus Christi Ship Channel project traverses the pass. This channel, in addition to providing deep-draft access to the port of Corpus Christi, allows shallow-draft access through the Channel to Aransas Pass and the Lydia Ann Channel.

Prior to channel improvements, Aransas Pass had depths over the outer bar which varied from 7 to 9 feet and a shifting channel 100 to 500 feet wide. Aransas Pass was extremely unstable during the middle to late 1800's. Relocation of the channel axis, changes in channel depth of several feet, and shifting of the inlet-mouth bars accompanied southerly migration of the inlet. Frequent changes caused navigation problems for trade vessels traveling over the outer bars and through the inlet. Because of the importance of Aransas Pass as a route for commercial vessels and because of the continuous changes in channel position and depth, numerous efforts were made by governmental and private interests to stabilize the channel and maintain navigable depths.

The first attempt at improvement was made in 1868 when a 600-foot dike was constructed on the southern end of San Jose Island; however, this dike was destroyed by storms within 3 years.

The first Federal improvements were completed in 1885. A chronology of activities at Aransas Pass since 1885 is shown in Table 4.

TABLE 4
CHRONOLOGY OF IMPROVEMENTS
AT ARANSAS PASS

Year	Activity
1885	In April, the Federal Government completed improvements including seven groin jetties on south side of pass, breakwater, mattress revetment along channel face of Mustang Island, and sand fences on the heads of both islands to reduce erosion. Also included jetty known as Mansfield Jetty or Old Government Jetty 5,500 feet long on south side of pass, constructed of brush mattresses and stone and portions capped with piles and stones. Jetty damaged seriously in September storm.
1889	Completion of riprap protection 2,725 feet long from high water to the bottom of the channel along Mustang Island.

TABLE 4 (cont'd)

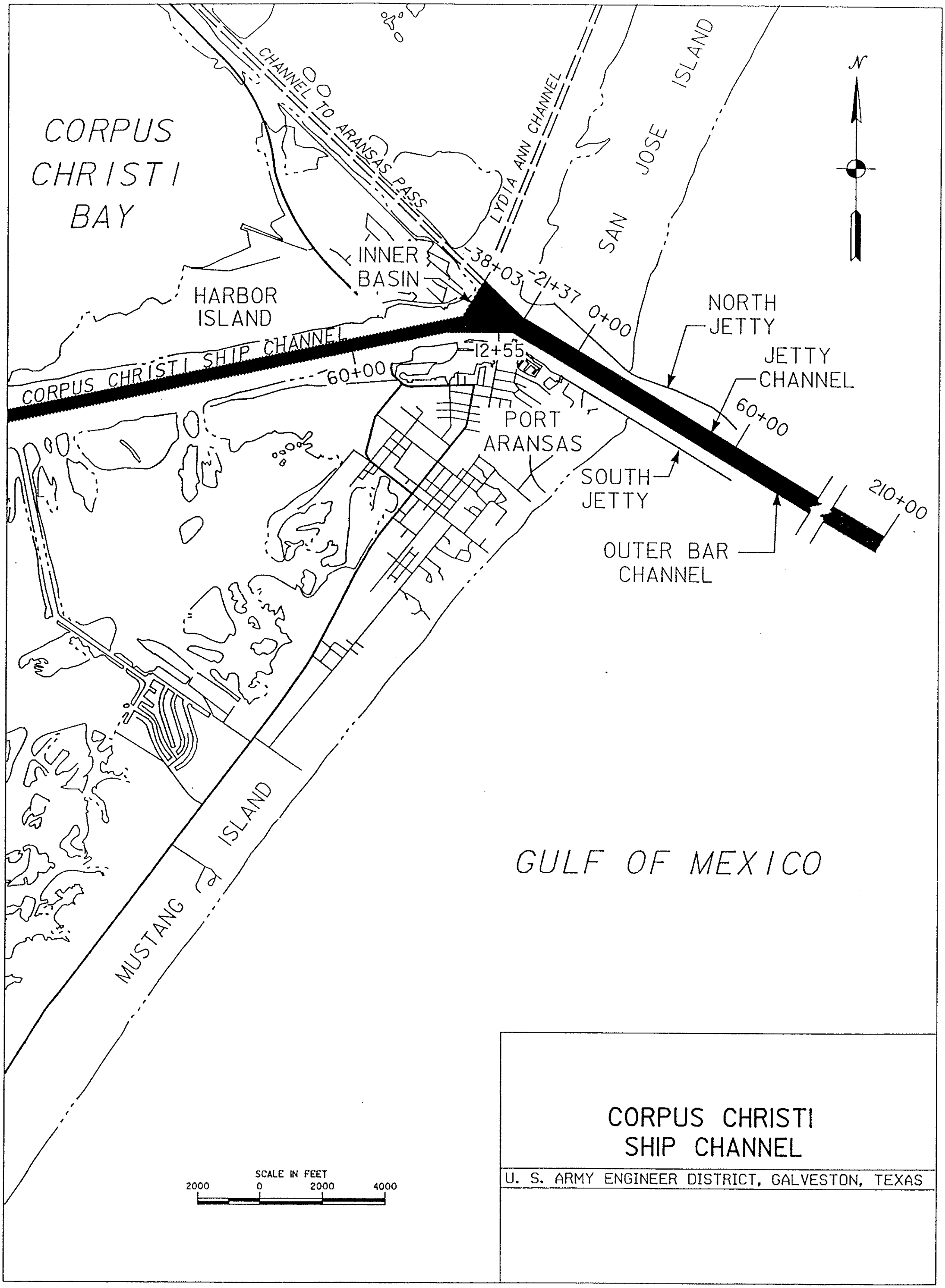
Year	Activity
1892	Since no Federal funding was available, Aransas Pass Harbor Company built South or Nelson Jetty 600 to 1,000 feet nearer the channel than the Mansfield Jetty.
1896	Aransas Pass Harbor Company completed about three-quarters of work on construction of North or Haupt Jetty. This effort failed to create anticipated depth.
1899	Responsibility of North Jetty transferred to Federal Government.
1906	Completion of Haupt Jetty in accordance with original plans and specifications.
1911	Completion of South Jetty to 6,400 feet long and North Jetty to 9,241 feet long with channel between jetties naturally deepened to 20 feet.
1912	Channel through jetties dredged to 20 feet deep and 150 feet wide. Completion of stone dike 10,000 feet long on San Jose Island.
1916	Channel between jetties dredged to 23 feet deep and 100 to 400 feet wide. Extended stone dike to a total length of 20,991 feet. South Jetty constructed to length of 7,385 feet.
1922	Four spurs projecting right angles from the North Jetty into Aransas Pass constructed in order to straighten the channel and move it southward away from jetty.
1931	Inner and Outer Bar Channels dredged to 30 and 33 feet, respectively.
1935	Channel deepened to 35 feet between jetties and 37 feet over outer bar.

TABLE 4 (cont'd)

Year	Activity
1956	Channel deepened to 36 feet between jetties and 38 feet over outer bar.
1966	Completion of project consisting of Jetty Channel 40 feet deep and Outer Bar Channel 42 feet deep.
1970	Present lengths of North and South Jetty established to 11,190 feet and 8,610 feet, respectively.
1975	Completion of channel to 45 feet between jetties and 47 feet over the bar.

For the purposes of this study, the project consists of two stone jetties, a stone dike, and the entrance portion of the Corpus Christi Ship Channel. The jetties extend into the Gulf from San Jose and Mustang Islands for distances of 11,190 and 8,610 feet, respectively, and a 20,991-foot long stone dike on San Jose Island extends from the North Jetty in a northeasterly direction along the centerline of the island. The Outer Bar Channel (stations 60+00 to 210+00) is 47 feet deep, 15,000 feet long, and has a bottom width of 700 feet. The Jetty Channel (stations 60+00 to -21+37) has dimensions of 45-foot depth, 600-foot bottom width, and 8,137-foot length. The Inner Basin extends from station -21+37 to station -38+03 (the beginning of the Channel to Aransas Pass) and has a width of 730 to 1,720 feet and a depth of 45 feet. The portion of the Corpus Christi Ship Channel which has been analyzed begins at station 12+55, the intersection of the Inner Basin, and extends to station 60+00. It has a width which varies from 400 to 600 feet and a depth of 45 feet. This project is shown in Figure 12.

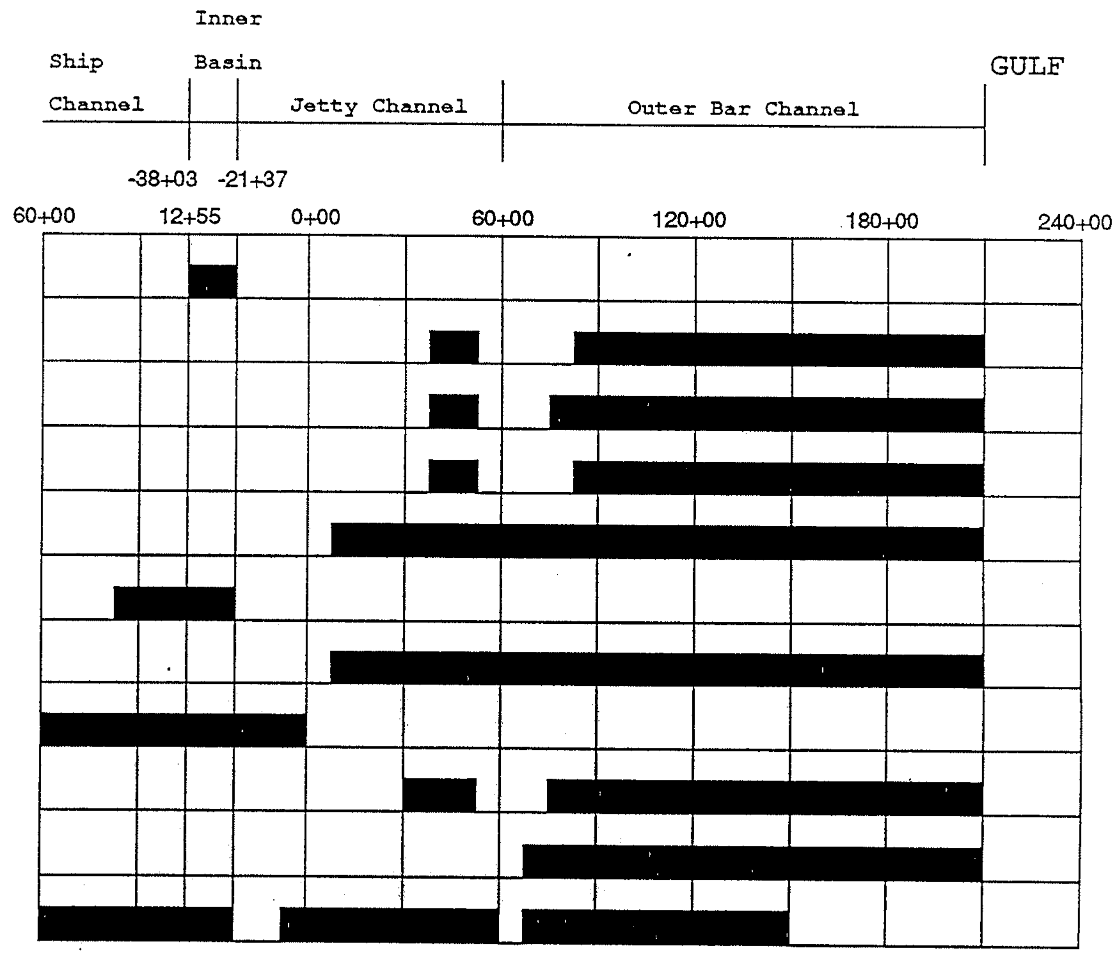
The maintenance dredging history for the entrance of the Corpus Christi Ship Channel is shown in Figure 13. The Jetty Channel has required maintenance dredging eight times since 1976, resulting in an average dredging cycle of 2.1 years removing 335,000 cubic yards of material. The Outer Bar Channel was also dredged a total of


CORPUS CHRISTI BAY
HARBOR ISLAND
INNER BASIN
CHANNEL TO ARANSAS PASS
LYDIA ANN CHANNEL
SAN JOSE ISLAND
N
38+03
21+37
0+00
12+55
60+00
CORPUS CHRISTI SHIP CHANNEL
NORTH JETTY
JETTY CHANNEL
60+00
PORT ARANSAS
SOUTH JETTY
210+00
OUTER BAR CHANNEL
MUSTANG ISLAND
GULF OF MEXICO
SCALE IN FEET
2000 0 2000 4000
CORPUS CHRISTI
SHIP CHANNEL
U. S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

4-AUG-1992

FIGURE 13
MAINTENANCE DREDGING OF THE ENTRANCE OF CORPUS CHRISTI SHIP CHANNEL

CONTRACT NO.	CONTRACT PERIOD	VOLUME (C.Y.)
89-0018	APR 89	201,671
HD89-01	OCT 88	261,343
HD86-01	JUL 86 - SEP 86	1,340,540
HD84-02	AUG 84 - OCT 84	1,208,800
82-0036	AUG 82 - OCT 82	1,748,754
81-0051	OCT 81 - APR 82	310,784
HD80-03	AUG 80 - MAR 81	4,223,334
78-0034	MAY 78 - AUG 78	561,475
HD78-04	APR 78 - AUG 78	337,704
HD77-04	APR 77 - MAY 77	671,622
HD76-02	OCT 75 - OCT 76	2,071,293



eight times from 1976 to the present. This portion of the channel has a dredging cycle frequency of 2.1 years and on average has 1.1 million cubic yards of material removed. The average annual shoaling rates for the Jetty Channel and the Outer Bar Channel are 159,000 cubic yards and 520,000 cubic yards, respectively. The Inner Basin (station -21+37 to station - 38+03) and the Ship Channel (station 12+55 to station 60+00) required maintenance dredging four times since 1976, resulting in an average dredging cycle of every 4.2 years and removal of about 375,000 cubic yards. This section of the channel has an average annual shoaling rate of 89,000 cubic yards.

The Outer Bar Channel and Jetty Channel are normally dredged by hopper dredge and the material placed in an offshore disposal site located southwest of the channel. The Inner Basin and Ship Channel are dredged by pipeline dredge and the material is placed in disposal areas adjacent to the North Jetty on San Jose Island or immediately north of the Ship Channel. An exception to this was the maintenance of the Inner Basin and Ship Channel in 1976 which was performed by hopper dredge. In 1978 a portion of the Jetty Channel was dredged at the same time as the Inner Basin and Ship Channel and, therefore, was dredged by pipeline.

The dredged material samples taken from 1957 to 1975 from stations 0+00 to 210+00 in the Jetty Channel contained high percentages of sand. The sand content varied from 60% in the vicinity of station 210+00 to 90% in the vicinity of station 30+00. The dredged material samples taken in 1982 and 1984 in the Jetty Channel from stations 0+00 to 150+00 ranged from 71% to 90% sand. Samples from the Corpus Christi Ship Channel (station 0+00 to station 60+00) showed approximately 96% sand from 1965 to 1975. In 1988 samples from stations -32+00 to -36+00 (the Inner Basin) had sand content ranging between 81% and 97%. From these data, the Entrance Channel, Inner Basin, and the portion of the Corpus Christi Ship Channel from station 12+55 to station 60+00 are potential sources of sand for beach nourishment.

Corpus Christi Water Exchange Pass

The Corpus Christi Water Exchange Pass is a manmade inlet located about 10 miles east of Corpus Christi. Motivated by the intermittent opening and closing of Corpus Christi Pass, Newport Pass, and Packery Channel as discussed below, this jettied fish and water exchange pass across Mustang Island was opened by the Texas Parks and Wildlife Department in August 1972, connecting Corpus Christi Bay with the open Gulf. Its purpose was to control the high salinities in Corpus Christi Bay and the Laguna Madre and to allow for greater fish migration. The inlet was 150 to 300 feet wide and 10,000 feet long from the bay mouth to the tips of the jetties, extending 875 feet into the Gulf. The original depth was 8 feet. This project was never maintained and closed from natural processes by 1979.

Corpus Christi Pass, Newport Pass, and Packery Channel

These three passes are natural tidal inlets located within a 4-mile segment of southern Mustang Island. Documentation of the historical migration and closures of these channels is difficult because Corpus Christi Pass, identified on an 1881-1882 topographic chart, was later referred to as Packery Channel.

Corpus Christi Pass is the most northern of the three passes, approximately 2 miles south of the Corpus Christi Water Exchange Pass. In 1928 a 1-foot deep, 20-foot wide channel was dredged through Corpus Christi Pass. This channel was dredged three times during that summer but shoaled in within a few days after each dredging. The pass was dredged again in 1938 and a bulkhead was built on the south side of the pass. The pass remained opened until 1943 when it once again shoaled closed. All three inlets are periodically opened by hurricanes but close shortly thereafter from natural processes.

In 1965 the Corps of Engineers conducted an experiment on dune growth at these three inlets. These experiments utilized junk cars and picket fences to trap sand and initiate dune formation to develop a natural barrier against hurricane surges. These experimental dunes were destroyed by Hurricane Beulah in 1967.

Yarborough Pass

Yarborough Pass is a manmade inlet located along Padre Island 30 miles downcoast of Corpus Christi Pass. Initial dredging of Yarborough Pass, also called Murdoch's Landing Pass, was completed in 1941 to improve water circulation in the Laguna Madre. It was closed by littoral processes within 5 months of its opening. Between 1942 and 1952 several unsuccessful attempts were made to reopen the pass. Since that time, the pass has remained closed and the dunes have reestablished themselves, approaching conditions that existed prior to dredging.

Mansfield Channel

The Channel to Port Mansfield project is a federally-maintained, man-made inlet located along the south Texas coast about 93 miles south of Corpus Christi. It crosses Padre Island and connects the Laguna Madre with the Gulf. The tributary channel connecting the GIWW with the community of Port Mansfield, completed in 1949, preceded other developments at that location. Around the middle 1950's, Willacy County dredged an outlet to the Gulf 10 feet deep by 100 feet wide across Padre Island and a 16-foot deep by 250-foot wide channel from the gulfside of Padre Island to the 16-foot depth contour and constructed dual jetties. A brief chronology of the improvements at Mansfield Channel since 1957 is shown in Table 5.

TABLE 5
CHRONOLOGY OF IMPROVEMENTS
AT MANSFIELD CHANNEL

Year	Activity
1957	Local interests completed construction of tetrapod jetties in September. Jetties destroyed by storms in November.
1961	Extensive subsidence of tetrapods permitted complete closure of channel entrance by shoaling.
1962	Federal maintenance of locally dredged Jetty Channel 16 by 250 feet and construction of two new parallel jetties, the North Jetty 2,300 feet long and South Jetty 2,270 feet long. Reach from Entrance Channel to hopper dredge turning basin initially dredged to 26 feet deep to accommodate government hopper dredge. Channel presently maintained to 14-foot depth.

The Channel to Port Mansfield project is shown in Figure 14 and has a jettied entrance with a 2,300-foot long North Jetty and a 2,270-foot long South Jetty. The Entrance Channel (stations 0+000 to -3+500) has dimensions of 16 feet deep by 250 feet wide and is 3,500 feet long. The Approach Channel (station 0+000 to station 2+000) is 14 feet deep and 100 feet wide.

The maintenance dredging history for the entrance of the Channel to Port Mansfield is shown in Figure 15. The Port Mansfield Jetty Channel has been dredged 12 times since 1971 resulting in a 1.8-year dredging cycle and 175,000 cubic yards of material removed on average. The average shoaling rate is 97,000 cubic yards per year. The Approach Channel has been dredged 10 times since 1970 with an average dredging cycle of 2.2 years, an average quantity of material removed of 73,000 cubic yards, and an average annual shoaling rate of 34,000 cubic yards. All of these dredging contracts were performed by pipeline dredge with the exception of two contracts for the Jetty Channel and one contract for the Jetty and Approach Channels. In 1983 and 1986, the maintenance material

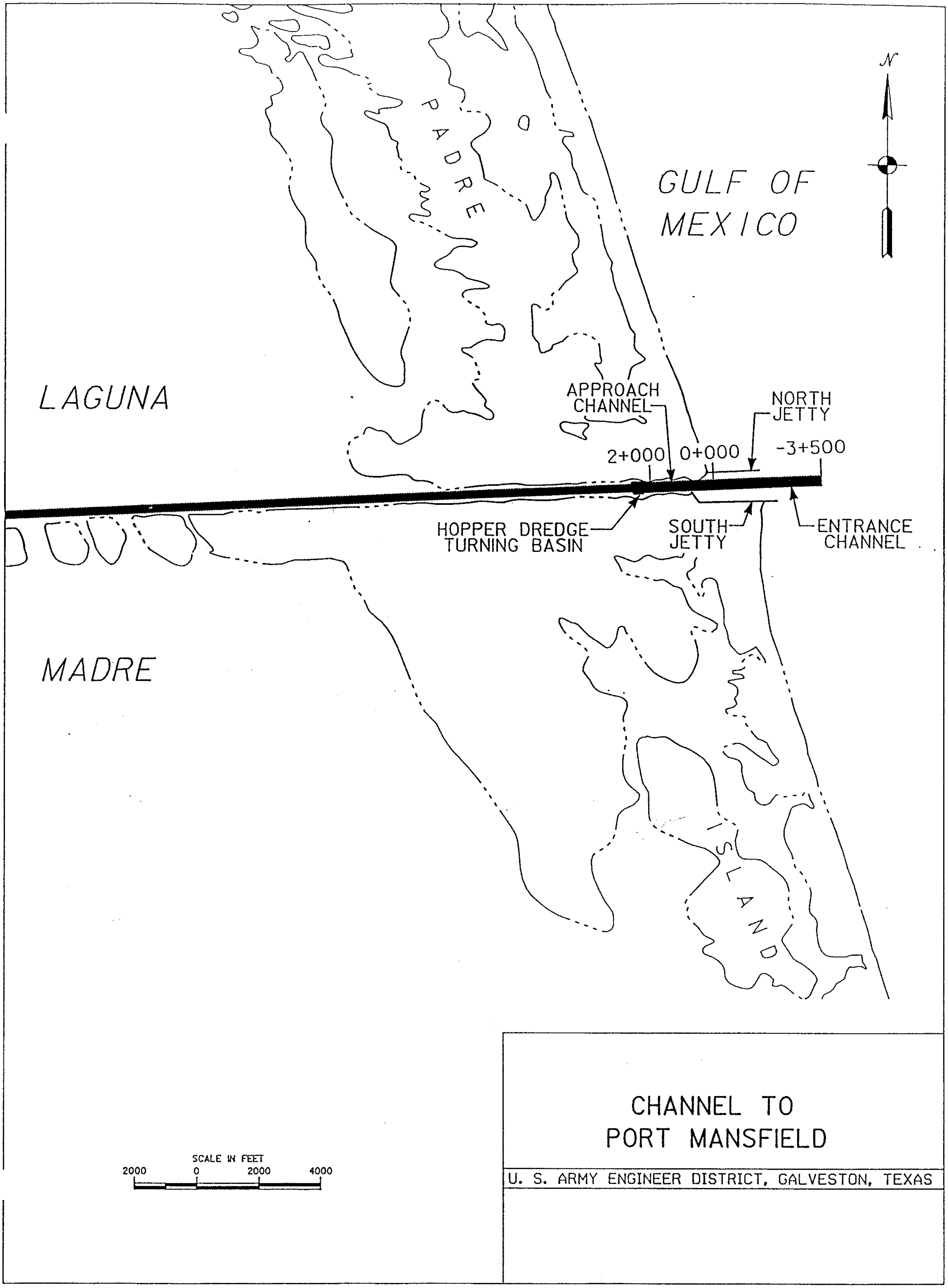
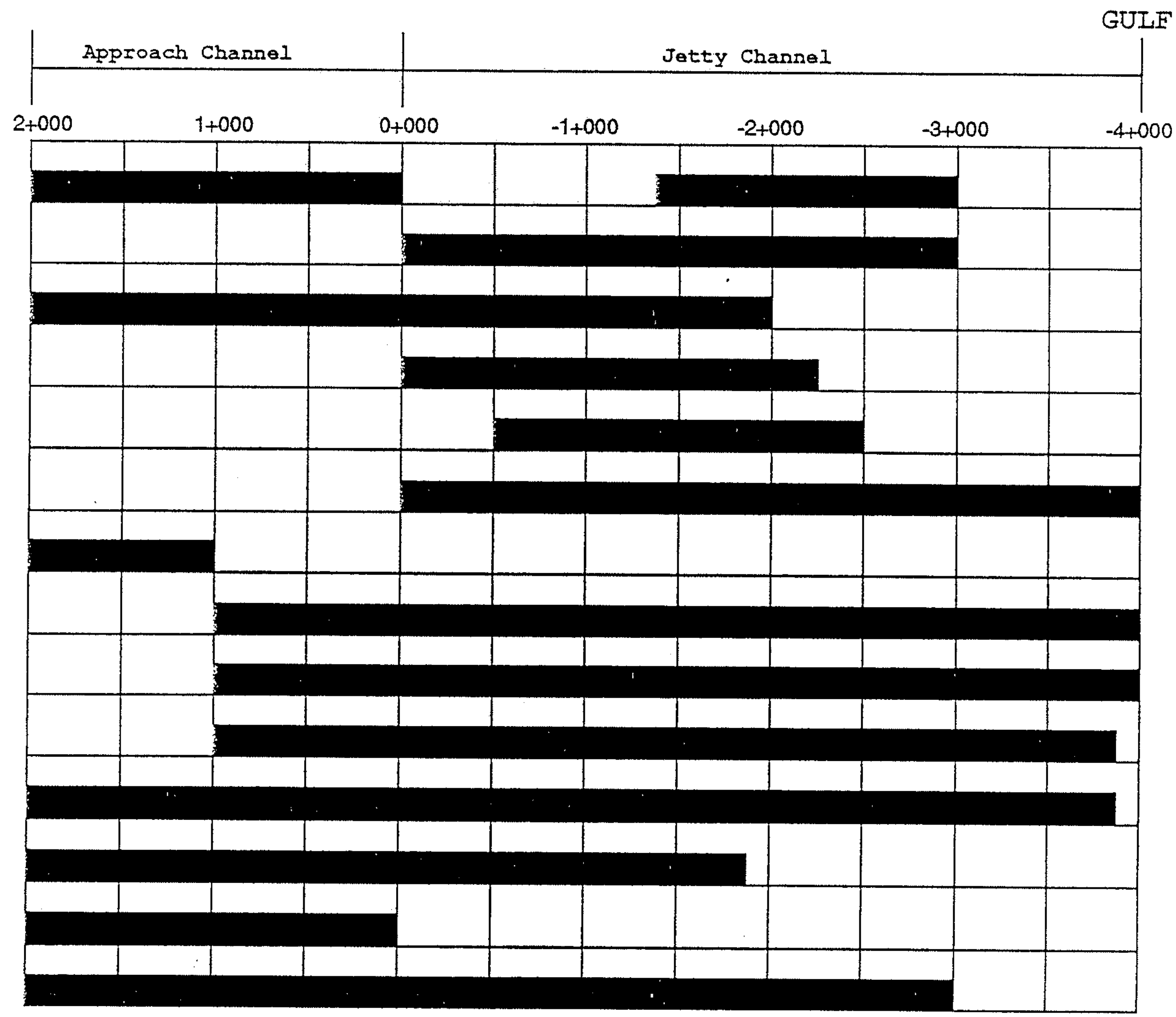

GULF OF MEXICO
N
LAGUNA
MADRE
PADRE
ISLAND
APPROACH CHANNEL
NORTH JETTY
2+000
0+000
-3+500
HOPPER DREDGE TURNING BASIN
SOUTH JETTY
ENTRANCE CHANNEL
SCALE IN FEET
2000
0
2000
4000
CHANNEL TO PORT MANSFIELD
U. S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

FIGURE 14

FIGURE 15
MAINTENANCE DREDGING OF THE
CHANNEL TO PORT MANSFIELD

CONTRACT NO.	CONTRACT PERIOD	VOLUME (C.Y.)
91-0031	AUG 91 - SEP 91	192,271
90-0016	MAR 90 - MAR 91	128,700
89-0005	NOV 88 - DEC 88	138,438
88-0014	MAR 88 - JUN 88	132,937
86-0013	APR 86 - MAY 86	104,196
83-0009	MAY 83 - JUL 83	372,765
81-0007	NOV 80 - MAY 81	62,232
80-0020	NOV 80 - DEC 80	302,181
79-0049	JUL 79 - AUG 79	369,116
HD78-01	AUG 78 - SEP 78	226,296
77-0070	SEP 77 - OCT 77	509,307
74-0073	MAR 74 - SEP 74	26,382
71-0142	APR 71 - JUN 71	44,565
71-0160	JAN 71 - AUG 71	223,232



in the Jetty Channel was removed by hopper dredge and placed in an offshore disposal site located north of the channel. The Jetty and Approach Channels were dredged by hopper dredge in 1978. When maintained by pipeline dredge, the material is generally placed on the beach adjacent to the North Jetty as a beneficial use of dredged material and to prevent flanking of the jetty.

Analysis of dredged material samples for the period 1962 through 1973 from the Port Mansfield Jetty Channel reveals a very high sand content for dredged material in the entire Jetty Channel. June 1979 samples showed 85% to 87% sand at stations -2+500 and 0+000, respectively. The most recent samples, taken in January 1983, show an 86% sand content at station -2+500 and a 19% sand content at station 0+000. Although 19% sand content is too low for beach fill, the potential for using material as beach nourishment should not be based on one sample. The material has been placed on the beach during previous dredging projects although no monitoring of these projects was performed. Therefore, the dredged materials from stations -3+500 to 2+000 of this channel are still considered a possible sand source for beach nourishment.

Brazos Santiago Pass

Brazos Santiago Pass is a natural inlet between Padre Island and Brazos Island which connects Laguna Madre with the Gulf. The entrance to the federally-maintained Brazos Island Harbor project is located approximately 20 miles east of Brownsville and 118 miles south of Corpus Christi. It passes through Brazos Santiago Pass and allows access to the ports of Port Isabel and Brownsville.

Prior to navigation improvements, Brazos Santiago Pass had a natural depth over the bar which varied from 6.5 to 11 feet at mean low tide and a narrow shifting channel. There also existed a small deep-water anchorage with a maximum depth varying from 27.5 to 40 feet at the throat of the pass. Laguna Madre had a natural depth of about 5 feet.

Existence of Brazos Santiago Pass was first documented by Alonso Alvarez de Pineda in 1519. The first Federal improvement of the pass was initiated in 1878 with the removal of a shipwreck from the channel. In 1882 construction was begun on the South Jetty which consisted of brush mattresses weighted down with clay bricks. This work was halted in 1884 because of lack of funds and the South Jetty was destroyed by storms in 1887.

The first channel improvements at Brazos Santiago Pass were constructed in 1927 and provided a 18-foot by 400-foot Entrance Channel through the pass. Currently, the project provides channels 36 feet deep to Brownsville and Port Isabel; however, construction is underway to deepen the project to 42 feet. A brief chronology of the Federal improvements at Brazos Santiago Pass since 1927 is shown in Table 6.

TABLE 6
CHRONOLOGY OF FEDERAL IMPROVEMENTS
AT BRAZOS SANTIAGO PASS

Year	Activity
1927	Completion of experimental project to dredge channel 18 by 400 feet through pass and a 16-foot by 100-foot channel from pass to turning basin at Port Isabel. Project included two short stone dikes extending into Gulf (north side 1,700 feet, south side 1,400 feet). Experimental project discontinued in 1928 because of rapid reshoaling.
1935	As authorized in 1930, completion of North Jetty to 5,600 feet long, South Jetty to 3,600 feet long, and construction of rock groins to protect inner end of jetties.
1936	Channel dredged to 25 feet deep by 300 feet wide through Brazos Santiago Pass and 25 feet deep by 100 feet wide inland of the pass.

TABLE 6 (cont'd)

Year	Activity
1940	Jetty Channel deepened to 31 feet and inner channel and turning basins to 28 feet.
1947	Completion of channel through pass to 35 feet deep and Channel to Brownsville and turning basins to 32 feet deep.
1960	Completion of channel through pass to 38 feet deep and 300 feet wide (in 1957) and all other channels and basins to 36 feet deep.
1961	Construction of erosion protection of North Jetty.
1966	Completion of major rehabilitation of North and South Jetties.
1978	Extended shore protection of North Jetty resulting in total length of 6,770 feet.
1986	Deauthorization of 1,000-foot extension of North Jetty, authorization of enlargement of the Entrance Channel to 44 feet deep and 400 feet wide.
1992	Dredging of Entrance Channel to 44 feet deep completed in March.

The project consists of a dual jettied entrance with the North Jetty being 6,770 feet long and the South Jetty 4,917 feet long, including shore protection sections. The Entrance Channel (stations 0+000 to -12+000) has depths varying from 36 to 38 feet MLT, a 300-foot bottom width, and 12,000-foot length. Figure 16 shows the Brazos Island Harbor project.

The maintenance dredging history for the entrance of the Brazos Island Harbor project is shown in Figure 17. The Brazos Island

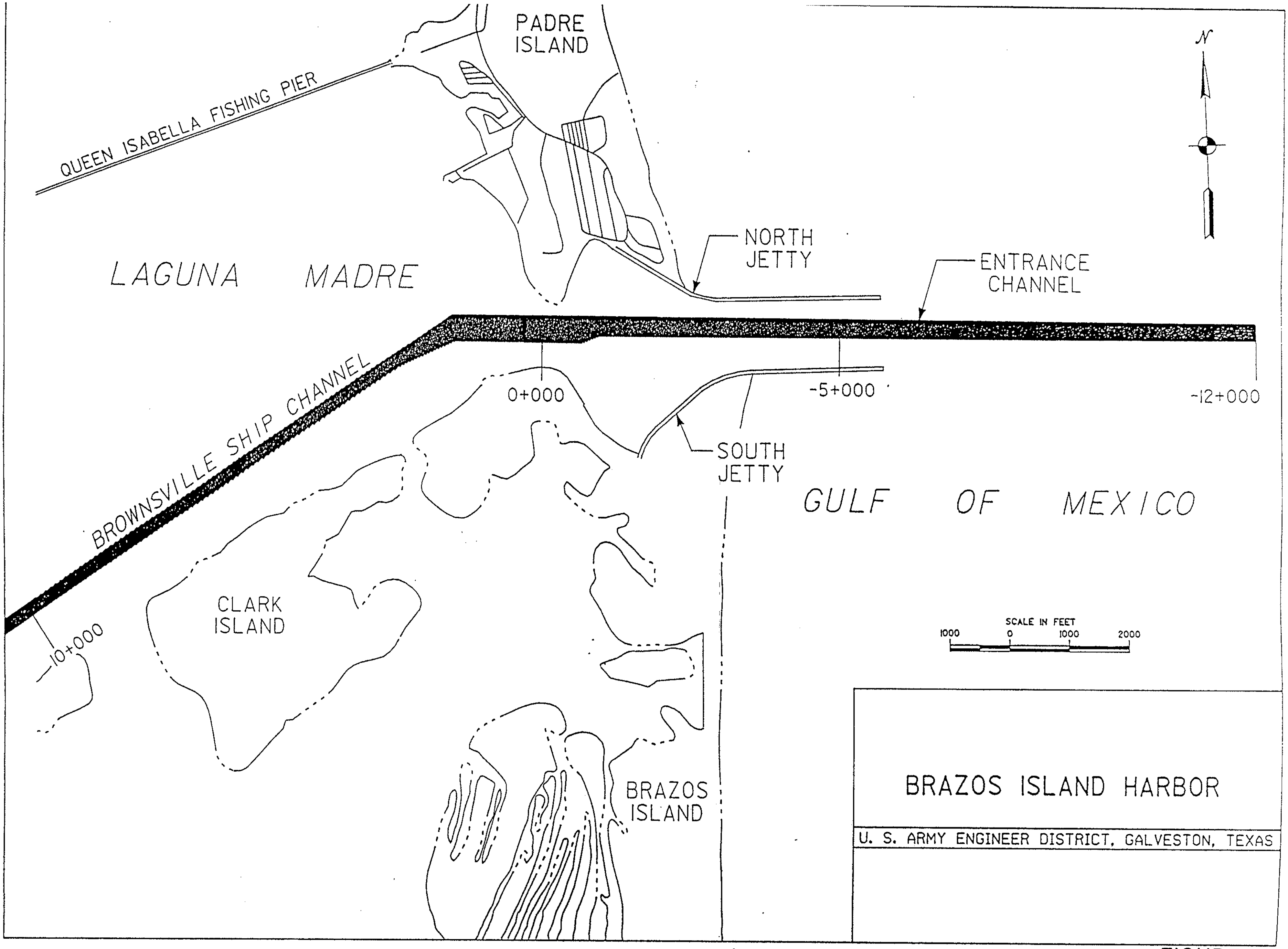

PADRE ISLAND
QUEEN ISABELLA FISHING PIER
NORTH JETTY
ENTRANCE CHANNEL
LAGUNA MADRE
BROWNSVILLE SHIP CHANNEL
0+000
-5+000
-12+000
SOUTH JETTY
GULF OF MEXICO
CLARK ISLAND
10+000
SCALE IN FEET
1000 0 1000 2000
BRAZOS ISLAND
BRAZOS ISLAND HARBOR
U. S. ARMY ENGINEER DISTRICT, GALVESTON, TEXAS

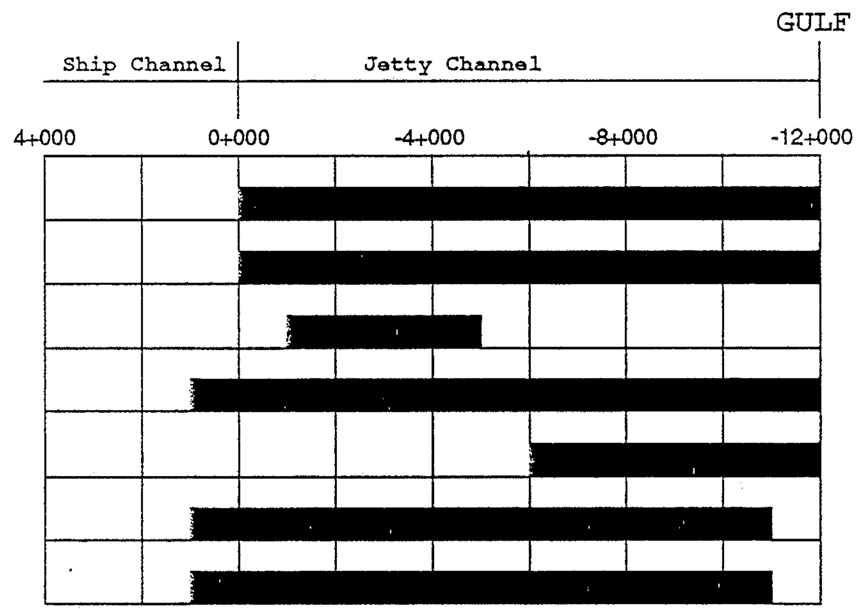
FIGURE 16

FIGURE 17

MAINTENANCE DREDGING OF THE

ENTRANCE TO BRAZOS ISLAND HARBOR

CONTRACT NO.	CONTRACT PERIOD	VOLUME (C.Y.)
91-0016	MAR 91 - APR 91	576,931
88-0035	NOV 88- JAN 89	731,545
86-0013	APR 86 - MAY 86	333,693
83-0030	AUG 83 - SEP 83	886,343
HD82-01	OCT 81 - FEB 82	1,016,000
HD80-01	OCT 79 - DEC 79	847,000
HD78-01	NOV 77 - DEC 77	761,523



Harbor Jetty and Outer Bar Channel has been dredged seven times since 1977. The average maintenance calculations were based on data from 1977 until January 1992 (the beginning of the new work to deepen the channel). The dredging cycle is 2.0 years and the average quantity of material removed is 736,000 cubic yards. The average annual shoaling rate is 364,000 cubic yards. The material is removed by hopper dredge and placed in an offshore disposal area located north of the channel.

A high percentage of sand was noted in the Brazos Island Harbor Jetty Channel samples from station -10+500 to station 1+000 during the years 1971 to 1976. In fact, all samples except for one contained more than 80% sand and the exception contained 61% sand. Samples taken in 1979 showed stations 0+000 to -10+000 with a sand content higher than 51% with the exception of one sample at station 0+000 with 8% sand content. In 1988 and 1990, samples taken from stations 0+000 to -18+000 (beyond the end of the channel) had a sand content higher than 63% and at some stations the sand content was higher than 90%. Therefore, the dredged material between stations 0+000 and -12+000 is considered a potential sand source for beach nourishment.

Boca Chica Pass

Boca Chica Pass is a hurricane washover channel located approximately 5 miles south of Brazos Santiago Pass. It crosses Brazos Island and connects the South Bay of Laguna Madre with the open Gulf. Historic records show the pass was open in the mid 1800's and required a bridge over it for access to an army depot on Brazos Island. It remained opened until the pass was dammed in 1868. Since that time Boca Chica Pass has infrequently opened during storms only to close through natural processes shortly thereafter.

Rio Grande

The mouth of the Rio Grande is the southernmost of the Texas inlets and the river forms the border between Texas and Mexico. From 1854 until 1958 the mouth of the Rio Grande migrated northward, reaching its northernmost position in 1958. From 1958 until 1962 the mouth of the river then moved southward. During Hurricane Carla in 1961, the river made a new course, shifting approximately 4,000 feet south. Beginning in 1962 the mouth again migrated to the north. During Hurricane Beulah in 1967 the river again shifted its course to the south.

SUMMARY

Of the 24 inlets along the Texas coast discussed in this report, eight are federally maintained, five are manmade and either maintained by others or not maintained at all, and the remaining eleven are natural. Other than the maintained inlets, the fate of littoral materials moving along the coast is virtually controlled by natural processes. If the natural processes are accepted as the base condition with no consideration to change, then the opportunities to modify the overall system lies solely with those channels which are undergoing periodic modification through dredging operations.

For the federally-maintained channels, the dredging frequency, average quantity of material removed per cycle, and type of dredge routinely used are shown in Table 7. These data were developed from historical records which ranged in length from 11 to 22 years, and included the most recent maintenance dredging cycle.

Prior to dredging contracts, sediment samples are taken along the channel and analyzed for various pollutants as well as to determine the physical characteristics of the material to be removed. These physical tests include a determination of the grain size distribution of the particles within the sample. The percentages of clay, silt, and sand particles and the sample's location are recorded. From these test results, a preliminary assessment as to the potential that specific reaches of a channel would be suitable for placement on nearby beaches was made and the reach identified.

Of the eight federally-maintained channels, only the material being removed from two channels, the entrance to the Sabine-Neches Waterway and the entrance to Freeport Harbor, is considered unsuitable for placement on adjacent beaches. The reason being their high silt and clay content. The remaining six channels contain various length reaches which are potential sources suitable for beach replenishment.

It is a long-standing policy of the Corps of Engineers to secure the maximum practicable benefits through the use of dredged

TABLE 7
SUMMARY OF MAINTENANCE
FEDERALLY-MAINTAINED CHANNELS

	STATIONING	DREDGING FREQUENCY (years)	AVERAGE QUANTITY PER CYCLE (cubic yards)	TYPE OF DREDGE	POTENTIAL FOR NOURISHMENT	STATION	AVERAGE ANNUAL SHOALING RATE (cy/yr)
Sabine-Neches Waterway							
Jetty Channel	0+00 to -214+88.3	>11.4	1,362,260	Hopper	no		
Outer Bar Channel	0+000 to 18+000	1.4	3,571,290	Hopper	no		
Bank Channel	18+000 to 95+734	3.8	2,371,191	Hopper	no		
Galveston Harbor Channel							
Bolivar Roads Channel	0+000 to 5+048	6.7	111,967	Hopper	yes	0+000 to 5+048	17,000
Anchorage Area	12+000 to 23+400	4.8	785,640	Hopper	yes		163,000
Inner Bar Channel	5+048 to 21+912						
Outer Bar Channel	21+912 to 30+675	1.9	2,166,895	Hopper	yes	5+048 to 25+000	427,000
Entrance Channel	30+675 to 56+000						
Freeport Harbor							
Jetty Channel	0+00 to 60+00	1.2	1,175,403	Hopper	no		
Outer Bar Channel	0+00 to -270+00						
Mouth of Colorado River *							
Entrance Channel	33+204 to 37+600	----	------	Pipeline	yes	------	------
Impoundment Basin	33+404 to 34+204						
Matagorda Ship Channel							
Entrance Channel	0+000 to -20+000	2.2	860,138	Hopper	yes	-3+000 to -20+000	395,000
Corpus Christi Ship Channel							
Ship Channel	12+55 to 60+00	4.2	374,682	Pipeline	yes	12+55 to 60+00	89,000
Inner Basin	-21+37 to -38+03					-21+37 to -38+03	
Jetty Channel	-21+37 to 60+00	2.1	335,393	Hopper	yes	-21+37 to 60+00	159,000
Outer Bar Channel	60+00 to 210+00	2.1	1,094,424	Hopper	yes	60+00 to 210+00	520,000
Channel to Port Mansfield							
Approach Channel	0+000 to 2+000	2.2	72,974	Pipeline	yes	0+000 to 2+000	34,000
Entrance Channel	0+000 to -3+500	1.8	175,240	Pipeline/Hopper	yes	0+000 to -3+500	97,000
Brazos Island Harbor							
Entrance Channel	0+000 to -12+000	2.0	736,148	Hopper	yes	0+000 to -12+000	364,000

* This material is currently being placed on the beach as a part of the project. No average dredging frequencies and quantities could be developed because of the short time since implementation of the project.

material from authorized navigation channels provided extra cost is not incurred. Placement of beach quality sand on adjacent beaches is consistent with this policy objective. The initial step in this process is a request from the State to place the material on the beach.

The channel reach that shows the potential for yielding significant quantities of beach quality material would then be more intensely sampled and tested to confirm the quality of the material as well as defining the extent and location of the most suitable material. This channel material would then be compared to the native beach material to be able to approximate the expected life of the fill material on the beach. If the material to be placed on the beach is substantially finer than the existing beach materials, rapid erosion could be anticipated.

If additional costs would be required to place the material on a nearby beach over the least costly alternative of material disposal, a non-Federal sponsor would have to be identified to provide the difference in costs. Under special circumstances where the material may be used to provide storm reduction benefits, the Federal Government can provide half of the increased costs after approval from the Assistant Secretary of the Army for Civil Works.

CONCLUSIONS

It is evident that there is diversity of shoreline conditions which exist along the Texas coast. These conditions vary from erosional, to accretional, to stable. The erosional and accretional shorelines vary considerably in degree, from gradual to extreme. The usual approach when addressing coastal shorelines is to focus on a problem area, which usually means that erosion is affecting manmade improvements or some other economic loss is involved. However, the entire system must be evaluated including the stable areas, but particularly the areas that are accreting. One cannot just accept the gain (accretion) and concentrate on the loss (erosion). Gains and losses will occur at any interruption of the shoreline whether it is a natural inlet, river, or a modified and controlled inlet.

There are numerous factors which affect shoreline response other than inlets. Many of which are meteorological, such as storms, others are global or regional, such as sea level rise, and neither of which can be controlled, but must be considered. Inlets are only one shoreline feature which affect updrift and downdrift beaches. The affects of inlets with structures, such as jetties, are often much more pronounced than inlets without structures.

Opportunities exist to alter shoreline impacts at inlets, particularly where there are ongoing and periodic modifications through dredging operations. Various bypassing alternatives are available although most would require significant initial capital outlays as well as costs for future operation and maintenance of the facility. Direct bypassing typically is limited to those inlets where beach quality sand is accumulating on the updrift side of the inlet and can be collected and deposited on the downdrift beaches. Implementation of these opportunities is driven by economics, regardless of whether the initiative is at the local, State, or Federal level. Under any circumstances the costs for such an investment would have to be offset by the benefits derived.

The current dredging practices at the eight inlets that are Federally maintained for navigation purposes employ an indirect form of bypassing by placement of material in offshore placement areas located on the predominant downdrift side of the channel. These areas are generally located in deep water to allow full loading and unloading of the larger hopper dredges. Incorporation of new techniques, some of which are in the experimental stages, for beneficial uses of dredged material are also being tried. Other changes are being implemented as the base of knowledge increases in the coastal processes and coastal engineering fields. No authority is presently available to address bypassing at rivers and other inlets where there is no Federal project.

On the Texas coast, most of the material that accumulates in the inlet channels has high percentages of silts and clays. Placement of this type of material in offshore areas allows the underwater currents to separate the sand particles from the remaining material. Some portion of this material becomes part of the active littoral system although there is no specific information available as to what portion of the sand materials ultimately reach the nearshore area for each of the several offshore sites.

To summarize, the results of these investigations show that potential opportunities exist to use channel maintenance material from six of the eight federally-maintained channels. They are Galveston Harbor Channel, Mouth of Colorado River, Matagorda Ship Channel, Corpus Christi Ship Channel, Channel to Port Mansfield, and Brazos Island Harbor. Through further examination of current practices at these respective inlets and other inlets, a more comprehensive strategy can be developed to utilize available maintenance material more effectively to address coastal erosion losses. The next step would entail undertaking development of a more comprehensive plan. The information provided herein is intended to aid the State and other involved agencies in such an undertaking.