MOBILE COUNTY, ALABAMA
(Including Dauphin Island)

FEASIBILITY REPORT FOR

BEACH EROSION CONTROL AND HURRICANE PROTECTION

SEPTEMBER 1978

2

SYLLABUS

This study was undertaken to investigate the feasibility of erosion control and hurricane protection for Mobile County, Alabama, including Dauphin Island. Information presented herein addresses these related problems for various sections of the study area. Possible solutions and the desires of local interests have also been assessed. Analyses indicate that essentially all practical nonstructural measures offering potential benefits have been implemented in the study area. These analyses also indicate that, except for utilizing maintenance material dredged from the Mobile Bay entrance channel to reduce erosion on Dauphin Island, structural alternatives are either unacceptable to local interests or not economically feasible.

Accordingly, the study discloses that the only economically feasible plan which has not been implemented provides for nourishment of the gulf nearshore of Dauphin Island with material removed from the Mobile Bay entrance channel as part of the ongoing maintenance program for the Federal Navigation Project for Mobile Harbor. About 396,000 cubic yards are removed from the entrance channel every 1½ years. The selected plan provides for placing this material in an area about 2 miles long and 900 feet wide at about the 28-foot depth in the Gulf of Mexico south of Dauphin Island. Only those costs over and above those for present maintenance operations would be charged against this plan. The average annual costs are estimated to increase from the present $573,000 to about $789,000 or an increase of $216,000. Annual savings in loss of land are estimated to be $261,000.

The selected plan can be accomplished under the existing authority of the Chief of Engineers for maintenance of Mobile Harbor. Therefore, the District Engineer recommends that no additional improvements for beach erosion control and hurricane protection for Mobile County be authorized by the Congress at this time. However, it is recommended that the Chief of Engineers modify the present maintenance dredging practice for the entrance channel to Mobile Harbor to conform to the procedures outlined herein for the selected plan as soon as practical.

MOBILE COUNTY, ALABAMA
(INCLUDING DAUPHIN ISLAND)

FEASIBILITY REPORT FOR
BEACH EROSION CONTROL
AND
HURRICANE PROTECTION

TABLE OF CONTENTS

Item	Page
THE STUDY AND REPORT	1
PURPOSE AND AUTHORITY	1
SCOPE OF THE STUDY	1
STUDY OBJECTIVES	2
STUDY PARTICIPANTS AND COORDINATION	3
THE REPORT	4
PRIOR STUDIES AND REPORTS	4
NATURAL RESOURCES	6
PHYSICAL SETTING	6
MORPHOMETRY	7
CLIMATE	10
GEOMORPHOLOGY	10
HYDROLOGIC FEATURES	11
SHORE PROCESSES - GULF SHORE	16
TERRESTRIAL ENVIRONMENT	18
AQUATIC ENVIRONMENT	19
THREATENED FISH AND WILDLIFE	22
AESTHETIC AND HUMAN INTEREST AREA	23
SALT WATER RELATED RECREATIONAL DEMANDS	24
RESOURCE PRODUCTS	25
AIR POLLUTION	29
NOISE POLLUTION	29
HUMAN RESOURCES	29

TABLE OF CONTENTS (Cont'd)

Item	Page
COMMUNITY COHESION	29
DEMOGRAPHIC SKETCH	30
EDUCATION	31
HOUSING	32
ECONOMY AND DEVELOPMENT	32
EXISTING FEDERAL WATER RESOURCE PROJECTS	33
PORT USE	35
ECONOMIC DEVELOPMENT	35
INCOME	35
COVERED WAGES BY MAJOR INDUSTRY SECTOR	36
EMPLOYMENT	36
AREA FINANCIAL RESOURCES	41
TRANSPORTATION	41
PROBLEMS AND NEEDS	42
THE STORM PROBLEM	42
STORMS OF RECORD	42
27 SEPTEMBER 1906	47
5 JULY 1916	48
20 SEPTEMBER 1926	49
17 AUGUST 1969	51
FLOOD DAMAGE PROBLEMS	52
THE EROSION PROBLEM	55
SEA LEVEL RISE	55
HISTORIC SHORELINE CHANGES	56
MOBILE HARBOR REGION	56
WESTERN SHORE REGION	59
NORTH SHORE MISSISSIPPI SOUND	59
DAUPHIN ISLAND	63
MAIN ENTRANCE CHANNEL	73

TABLE OF CONTENTS (Cont'd)

Item	Page
VOLUMETRIC CHANGES	80
EFFECT OF MAINTENANCE DREDGING - OUTER BAR	83
THE SALINITY PROBLEM	84
SALT WATER RELATED RECREATION PROBLEMS	95
EXISTING PLANS FOR IMPROVEMENTS	95
IMPROVEMENTS DESIRED	96
FORMULATION OF PLANS	98
FORMULATION AND EVALUATION CRITERIA	98
TECHNICAL CRITERIA	99
ECONOMIC CRITERIA	99
SOCIOECONOMIC AND ENVIRONMENTAL CRITERIA	100
FORMULATION METHODOLOGY	101
PROFILE OF EXISTING CONDITIONS	101
INITIAL ALTERNATIVES CONSIDERED	101
INTERMEDIATE ALTERNATIVES CONSIDERED	106
EROSION CONTROL ALTERNATIVES	106
ALTERNATIVE FOR THE CONTROL AND STABILIZATION OF PETIT BOIS PASS	108
EXPANDED RECREATION FACILITIES	109
FLOOD CONTROL ALTERNATIVES	109
AREA 1 - BAYOU LA BATRE	110
AREA 2 - HERON BAY	111
AREA 3 - DAUPHIN ISLAND	111
AREA 4 - BELLE FONTAINE	112
AREA 5 - HOLLINGERS ISLAND	113
AREA 6 - MOBILE	113
AREA 7 - SATSUMA	115
NONSTRUCTURAL MEASURES	115
ALTERNATIVES CONSIDERED FOR FURTHER ANALYSIS	116

TABLE OF CONTENTS (Cont'd)

Item	Page
DEVELOPMENT AND EVALUATION OF DETAILED PLANS	118
NO ACTION	119
BEACH NOURISHMENT	119
NEARSHORE NOURISHMENT	123
EFFECT ASSESSMENT	124
SELECTING A PLAN	128
THE SELECTED PLAN	129
PLAN DESCRIPTION	129
DESIGN	130
DUMPING PROCEDURE	132
ECONOMICS OF SELECTED PLAN	134
COST	134
BENEFITS	134
SUMMARY OF ECONOMICS	135
DIVISION OF PLAN RESPONSIBILITIES	135
PLAN IMPLEMENTATION	135
COORDINATION	137
CONCLUSIONS	138
RECOMMENDATIONS	140
FOR THE CONGRESS	140
FOR THE CHIEF OF ENGINEERS	140
MOBILE COUNTY REFERENCES	141

LIST OF FIGURES

Title		Page
FIGURE 1	CIRCULATION PATTERNS - MOBILE BAY	13
FIGURE 2	40-FT NAVIGATION CANAL - EBB TIDE	14
FIGURE 3	40-FT NAVIGATION CANAL - FLOOD TIDE	15
FIGURE 4	MOBILE COUNTY STAGE FREQUENCY STORM TIDE	17
FIGURE 5	SURVEY REPORT ON MOBILE COUNTY, ALABAMA OIL & GAS FIELD MAP	27
FIGURE 6	STUDY AREAS FOR FLOOD DAMAGE SURVEY	54
FIGURE 7	SHORELINE CHANGES - MOBILE HARBOR AREA 1917 - 1953	57
FIGURE 8	SHORELINE CHANGES - MOBILE HARBOR AREA 1953 - 1974	58
FIGURE 9	HISTORIC TRENDS OF SHORELINE CHANGES ALABAMA COASTAL AREA 1917-1974	60
FIGURE 10	BATHYMETRIC CONTOUR CHANGES - PETIT BOIS PASS 1917 & 1933	64
FIGURE 11	BATHYMETRIC CONTOUR CHANGES - PETIT BOIS PASS 1961 & 1973	65
FIGURE 12	CROSS SECTION PETIT BOIS PASS - 1973	66
FIGURE 13	SHORELINE CHANGES DAUPHIN ISLAND BETWEEN 1917 & 1942	68
FIGURE 14	SHORELINE CHANGES DAUPHIN ISLAND BETWEEN 1942 & 1974	69
FIGURE 15	RATE OF EROSION AT SELECTED LOCATIONS - DAUPHIN ISLAND	70
FIGURE 16	SHORELINE CHANGES EAST END OF DAUPHIN ISLAND	71
FIGURE 17	MOBILE ENTRANCE CHANNEL 1894	74
FIGURE 18	MOBILE ENTRANCE CHANNEL 1916	75
FIGURE 19	MOBILE ENTRANCE CHANNEL 1921	77
FIGURE 20	MOBILE ENTRANCE CHANNEL 1941	78
FIGURE 21	MOBILE ENTRANCE CHANNEL 1973	79
FIGURE 22	MISSISSIPPI SOUND SURFACE MEASUREMENTS SALINITY CONCENTRATION - 22 JULY 1971	85

LIST OF FIGURES (Cont'd)

	Title	Page
FIGURE 23	MISSISSIPPI SOUND SURFACE MEASUREMENTS SALINITY CONCENTRATION - 10 NOV 1971	86
FIGURE 24	MISSISSIPPI SOUND SURFACE MEASUREMENTS SALINITY CONCENTRATION - 26 JAN 1972	87
FIGURE 25	MISSISSIPPI SOUND SURFACE MEASUREMENTS SALINITY CONCENTRATION - 2 MAY 1972	88
FIGURE 26	MISSISSIPPI SOUND SURFACE MEASUREMENTS SALINITY CONCENTRATION - 29 JUN 1972	89
FIGURE 27	MISSISSIPPI SOUND SURFACE MEASUREMENTS SALINITY CONCENTRATION - 7 AUG 1972	90
FIGURE 28	MISSISSIPPI SOUND SURFACE MEASUREMENTS SALINITY CONCENTRATION - 25 AUG 72	91
FIGURE 29	MISSISSIPPI SOUND SURFACE MEASUREMENTS SALINITY CONCENTRATION - 28 SEP 1972	92
FIGURE 30	GENERAL RELATIONSHIP OF PLANS FORMULATION STAGES AND FUNCTIONAL PLANNING TASKS	102
FIGURE 31	INFLUENCE OF SEA LEVEL RISE ON THE DEVELOPMENT OF BEACH AND OFFSHORE PROFILE	131

LIST OF TABLES

	Title	Page
TABLE 1	ACRES OF COMMERCIAL FOREST LANDS	25
TABLE 2	FISHERY LANDINGS FROM MOBILE BAY DURING THE PERIOD 1963 - 1975	28
TABLE 3	DEMOGRAPHIC CHARACTERISTICS FOR MOBILE COUNTY, THE MOBILE SMSA AND THE STATE OF ALABAMA	31
TABLE 4	SELECTED DATA FOR FEDERAL PROJECTS IN MOBILE COUNTY	33
TABLE 5	TOTAL PERSONAL AND PER CAPITA INCOMES IN 1973 FOR MOBILE COUNTY AND STATE OF ALABAMA	36

LIST OF TABLES (Cont'd)

	Title	Page
TABLE 6	COVERED WAGES FOR 1974, BY MAJOR INDUSTRIAL CLASS FOR MOBILE COUNTY AND THE STATE OF ALABAMA	37
TABLE 7	PROJECTED NONAGRICULTURAL EARNINGS BY MAJOR INDUSTRIAL CLASS FOR THE MOBILE SMSA AND THE STATE OF ALABAMA	39
TABLE 8	PROJECTED POPULATION, TOTAL PERSONAL INCOME AND PER CAPITA INCOME FOR THE MOBILE SMSA AND THE STATE OF ALABAMA	40
TABLE 9	HURRICANES AFFECTING ALABAMA (1711-1969)	43
TABLE 10	STORM TIDES IN ALABAMA (1772-1964)	44
TABLE 11	EXTREME PRESSURE AND WIND DATA OF HURRICANES RECORDED ALONG THE ALABAMA COAST SINCE 1892	45
TABLE 12	PAST HURRICANE LOSSES IN ALABAMA	46
TABLE 13	SUMMARY OF DAMAGES IN MOBILE, ALABAMA, 1906 STORM	48
TABLE 14	SUMMARY OF DAMAGES ALABAMA COAST - 5 JULY 1916 STORM	49
TABLE 15	SUMMARY OF ESTIMATED DAMAGES WITHIN INUNDATED AREAS IN MOBILE COUNTY (IN $1,000) (HURRICANE CAMILLE, 1969)	52
TABLE 16	SUMMARY OF AVERAGE ANNUAL DAMAGES (In $1,000'S)	53
TABLE 17	AREAS OF LAND FILL - MOBILE HARBOR AREA	59
TABLE 18	SHORELINE CHANGES MEASURED AT SELECTED IDENTIFIABLE POINTS ALONG THE WESTERN SHORE OF MOBILE BAY	61
TABLE 19	SHORELINE CHANGES MEASURED AT SELECTED IDENTIFIABLE POINTS ALONG THE NORTHERN SHORE OF MISSISSIPPI SOUND	62
TABLE 20	HISTORIC DATA ON PETIT BOIS PASS	63
TABLE 21	CHANGES - MOBILE BAY INLET	81
TABLE 22	APPROXIMATE VOLUMETRIC CHANGES - DAUPHIN ISLAND	82
TABLE 23	POSSIBLE SOLUTIONS	103

LIST OF TABLES (Cont'd)

	Title	Page
TABLE 24	STAGE 1 ALTERNATIVES AND PLANNING OBJECTIVES THEY MEET	104
TABLE 25	INTERMEDIATE ALTERNATIVES CONSIDERED	107

LIST OF PLATES

No.	Title
I	GENERAL MAP
II	GULF OF MEXICO CHANGES IN SEA LEVEL, 1895-1974
III	PARTIAL CLOSURE PETIT BOIS PASS, ALABAMA AND MISSISSIPPI
IV	SELECTED PLAN

LIST OF ATTACHMENTS

ATCH 1	SPECIES LIST OF ALGAE, PLANTS AND ANIMALS IN THE MOBILE BAY AREA
ATCH 2	THREATENED FISH AND WILDLIFE
ATCH 3	OTHER STORMS AFFECTING ALABAMA

LIST OF APPENDICES

APP. A	FLOOD HAZARD INFORMATION REPORT
APP. B	PERTINENT CORRESPONDENCE

THE STUDY AND REPORT

PURPOSE AND AUTHORITY

1. The purpose of this study was to investigate beach erosion, hurricane protection and related problems along the shores of Mobile County and Dauphin Island. Inherent in the investigation was the development of the most suitable plan for alleviating those problems. Plan economics and feasibility were also studied and recommendations are presented.

2. The study and report are in compliance with the following resolution adopted 27 October 1970 by the Committee on Public Works of the United States Senate, which reads:

> In accordance with Section 110 of the River and Harbor Act of 1962, the Secretary of the Army, be, and is hereby requested to cause to be made, under the direction of the Chief of Engineers, a survey of the shores of Mobile County, Alabama, and such adjacent shores as may be necessary, including Dauphin Island, in the interest of beach erosion control, hurricane protection, and related purposes.

SCOPE OF THE STUDY

3. This study was primarily concerned with an investigation of the cause of beach erosion within Mobile County including Dauphin Island, and a determination of the economic, social and environmental feasibility of controlling this erosion. Hurricane protective measures were a secondary consideration. The depth and detail of the study were commensurate with the objectives of selecting the most suitable plan and establishing its feasibility and acceptability.

STUDY OBJECTIVES

4. Procedures prescribed in the Water Resource Council's "Principles and Standards for Planning Water and Related Land Resources" require that Federal and Federally-assisted water and related land planning be directed to achieve National Economic Development and Environmental Quality as equal national objectives. Principles and Standards also require that the impacts of proposed actions be measured and the results displayed or accounted for in terms of contributions to the four accounts of: National Economic Development, Environmental Quality, Regional Development and Social Well-being.

5. Special interest was also taken throughout the study to assure that plans were formulated to meet the specified needs and concerns of the public within the study area. The specific concerns identified included the needs to:

a. Respond to expressed public desires and preferences for erosion control along the western shores of Mobile Bay and Dauphin Island;

b. Address the area needs for hurricane related flood protection;

c. Consider fish and wildlife needs with particular reference to the effects of the eroding and opening of Petit Bois Pass; and

d. Be implementable with respect to financial and institutional capabilities and public consensus.

6. Within the framework of the general study objectives and goals, plans were formulated to control beach erosion along the shores of Mobile County and Dauphin Island.

7. A number of different types of alternative plans to satisfy the study objectives were considered during formulation. These plans included:

a. A plan that maximized net economic benefits; national economic development plan.

b. A plan that emphasized contributions to aesthetic, ecological, and cultural values; environmental quality plan.

c. A "No Action" plan.

STUDY PARTICIPANTS AND COORDINATION

8. The Corps of Engineers was responsible for the conduct and coordination of the study, consolidation of information from other agencies, formulation of a plan and preparation of the report. At the District level, a multi-disciplinary team was used to conduct the study and compile the report.

9. The studies and investigation were performed with data extracted from reports and maps prepared by the following entities:

Geological Survey of Alabama
U. S. National Climatic Center
U. S. Geological Survey
U. S. Coastal and Geodetic Survey
U. S. Army Engineer Waterways Experiment Station
Coastal Engineering Research Center
Louisiana State University

10. The initial public meeting was held in Mobile, Alabama on 31 July 1973. The purpose of the meeting was to introduce the general public to the study and obtain public opinions and data on local needs, goals and objectives. Excluding Corps personnel, about 213 persons attended the meeting. Testimony at the meeting emphasized the severity of shore erosion along the shores of Mobile County and Dauphin Island. Suggested methods of correcting

the erosion problems included a program of implantation of marsh grasses and restoration of eroded areas with material dredged from navigation projects.

11. A formal workshop meeting was held on 31 March 1975 to discuss with shoreline property owners possible erosion control and hurricane protection alternatives and the ramifications of various plans. Excluding Corps of Engineers personnel, about 150 persons attended the meeting. Little interest was exhibited at the meeting for structural plans that could be implemented under existing Federal authorities for beach erosion control. Substantial interest was indicated in the concept of deposition of dredged material from the ship channel along the west bay shoreline of Mobile Bay and along the Gulf Shore of Dauphin Island for the abatement of erosion.

THE REPORT

12. This report presents a description of the study area; a discussion of the needs and problems; the formulation of a plan for satisfying those needs; a summary of economic studies showing the benefits, costs, and justification; a delineation of plan responsibilities in terms of Federal and non-Federal contributions; a summary of environmental, social, and economic impacts; and recommendations for implementing the selected plan. It is intended to serve both as a basis for approval of a project for construction by the Chief of Engineers and a basis for preparation of plans and specifications.

PRIOR STUDIES AND REPORTS

13. There have been no prior Corps of Engineers reports on beach erosion in Mobile County. Studies on the general subject of

hurricane problems and an inventory of beach erosion problems in Alabama are contained in the following reports:

a. Report on Hurricane Survey of Alabama Coast (House Document No. 108, 90th Congress, 1st Session) transmitted to Congress 14 April 1967.

b. National Shoreline Study - Regional Inventory Report, South Atlantic-Gulf Region, Puerto Rico and the Virgin Islands, published by SAD, August 1971.

14. Projects related to navigation works in the Mobile Bay area were authorized as follows:

a. Dauphin Island Bay, Alabama - Authorized by River and Harbor Act of 2 March 1945 (House Document 333, 76th Congress, 1st Session) and 3 September 1954 (House Document 394, 82nd Congress, 2d Session).

b. Dog and Fowl Rivers, Alabama - Authorized 16 May 1965 by the Chief of Engineers in accordance with recommendations in a detailed project report prepared under the authority of Section 107 of the 1960 River and Harbor Act.

c. Fly Creek, Fairhope, Alabama - Authorized by the River and Harbor Act of 17 May 1950 (House Document 194, 81st Congress, 1st Session).

d. Mobile Harbor, Alabama - Authorized by Section 104 of the River and Harbor Act of 3 September 1954 (House Document 74, 83rd Congress, 1st Session) and previous acts.

e. Mobile Harbor, Alabama (Theodore Ship Channel) - Authorized by the Senate Public Works Committee on 16 July 1970 and the House Public Works Committee on 15 December 1970, under the provisions of Section 201 of the 1965 Flood Control Act (House Document 91-335, 91st Congress, 2d Session). The authorized project was further modified in accordance with Public Law 94-587, enacted by the 94th Congress, 22 October 1976.

NATURAL RESOURCES

15. To a large degree, the resources of a region determine the status of its environmental and economic well-being and growth potential. A general understanding of these resources and developmental trends of the study area is helpful in identifying its problems and needs and selecting appropriate solutions. The following pages discuss the natural and human resources of the area as well as its development and economy.

PHYSICAL SETTING

16. Mobile County is located in southwest Alabama and is one of the two coastal counties in Alabama. Mobile County has a total salt water shoreline of about 134 miles on several bodies of water; mainly Mobile Bay, Mississippi Sound, and the Gulf of Mexico. The City of Mobile is centered on the west bank of the Mobile River near its mouth at the head of Mobile Bay and extends southward for about 9 miles along the west shore of Mobile Bay to the mouth of Dog River.

17. Mobile Bay (shown on Plate I) is an arm of the Gulf of Mexico, separated from the gulf by Dauphin Island on the west and on the east by a peninsula terminating at Mobile Point. The bay is roughly a pear-shaped estuary 30 miles long and varying in width from 8 miles at its northern end to 20 miles in its lower portion. The bay covers an area of approximately 392 square miles. The entire western shore of Mobile Bay is within Mobile County.

18. The Port of Mobile is located on the northwest shore of Mobile Bay. Major commercial development in the port area, the development along the entire western shore of Mobile Bay is predominantly residential. The southern mainland shore of the county is fronted by Mississippi Sound and is comprised of salt marsh and swamp interlaced by several tidal streams or bayous.

19. Dauphin Island lies about 4 miles south of the mainland. It is the easternmost of the chain of offshore islands that form the southern boundary of Mississippi Sound. The island is about 15 miles long and one mile wide at its widest point, and is connected to the mainland by a two-lane highway bridge. The gulf shoreline of the island has a broad, well-developed beach comprised mostly of white quartz sand. The eastern Mississippi Sound side is generally marsh with the western spit having a narrow beach. Most of the population is concentrated on the eastern 7 miles of the island.

20. In summary, Mobile County has about 15.2 miles of gulf shoreline, all broad, well-developed beach, and 118.8 miles of bay/estuary shoreline of which 22.3 miles are narrow poor beach and 96.5 miles are marsh. The major part of the county's shoreline is privately-owned. The entire 15.2 miles of gulf shoreline lies along the coast of Dauphin Island. Gulf shoreline ownership is 0.4 mile Federal, 1.5 miles non-Federal public and 13.3 miles private. Bay/estuary shoreline ownership is 1.9 miles Federal, 5.0 miles non-Federal public; and 114.1 miles private. Most of the 5 miles of non-Federal public bay/estuary shoreline is controlled by the city and is being developed for commercial use. The 1.5 miles of non-Federal public gulf shoreline is controlled by the county and developed for recreational use. However, facilities are minimal and are poorly maintained.

MORPHOMETRY

21. Natural depth in Mobile Bay averages 8 to 10 feet and ranges from shallow mud flats at the head of the bay to depths of about 25 feet near the entrance. The western shore of Mobile Bay is comprised of short sections of poor beach alternating with short reaches of marsh. There are no dunes, but along much of the

reach, bluffs about 10 feet high or greater back the shoreline. The southern end of the bay has two natural openings, one into the Gulf of Mexico at the main pass and another on the western side into Mississippi Sound between Cedar Point and Dauphin Island. These passes have cross-sectional areas of about 275,000 square feet and 43,000 square feet, respectively. A dredged channel, the Gulf Intracoastal Waterway, extends from the southeastern shore of Mobile Bay to Perdido Bay, Florida. The bay receives fresh water principally from four river inlets at the north end of the bay. These inlets and cross-sectional areas are the Mobile River, 23,000 square feet; the Tensaw River, 31,000 square feet; the Apalachee River, 22,000 square feet, and the Blakeley River, 22,000 square feet. In addition, three tidal creeks, Dog River, Deer River and Fowl River enter the bay on the western shore.

22. A 40-foot deep, 400-foot wide ship channel runs down the midwestern section of the bay. Material dredged from the channel is discharged on both margins of the channel with the western side receiving the major portion of deposition. The channel and the buildup from adjacent disposal areas divide Mobile Bay into eastern and western components. This division is most pronounced in the upper bay. With the exception of these channels and scattered oyster beds, the bottom of the bay slopes gradually from the sides and head of the bay toward the center and main entrance pass.

23. Mississippi Sound extends about 100 miles west from Mobile Bay to Lake Borgne, Louisiana. The southern boundary of the sound is formed by a chain of barrier islands which lie offshore of the coasts of Alabama, Mississippi and Louisiana. The maximum Alabama length of the sound is 16.2 miles with a maximum width of 12.8 miles and an area of about 179.3 square miles. The depth averages about 9.2 feet. This section of the sound is joined to the Gulf of Mexico by Petit Bois Pass, a natural pass located at

the western boundary of Dauphin Island. Petit Bois Pass has a top width of about 4.66 miles, a maximum depth of about 20 feet and a cross-sectioned area of about 181,000 square feet.

24. The northern shore of the section of Mississippi Sound under study is comprised predominantly of low-lying salt marsh with numerous tidal creeks, the principal ones being West Fowl River, Bayou Cedar and Bayou La Batre. A 12-foot deep, Federally-authorized navigation project extends from the 12-foot depth contour in Mississippi Sound to the mouth of Bayou La Batre, thence up the bayou to the City of Bayou La Batre. An 8-foot deep navigation channel extends from the Bayou La Batre channel, just north of Isle Aux Herbes, through Portersville Bay to Bayou Coden, thence up Bayou Coden 3,000 feet to the vicinity of the La Belle Avenue Bridge.

25. The natural inlet into Mobile Bay from the Gulf of Mexico is fronted on its seaward side by a very large bar formation. The bar extends about 26,000 feet into the gulf and is comprised of two triangular segments separated by a channel. The east bay which once had a small island, Dixie Island, now contains about 1.9×10^{10} cubic yards of material. The shoreward section of the bar is cut by a 7-foot deep swash channel. The west bar has several small ephemeral islands along the seaward edge of the bar; Sand Island, West Sand Island and Pelican Island. The west bar contains about 4.9×10^{8} cubic yards of material and is cut by a 10-foot deep swash channel near Dauphin Island. The channel extends 30,000 feet into the gulf. The throat of the channel has a natural depth and width of about 52 feet and 3,000 feet respectively. The seaward section of the channel has a natural depth of about 20 feet but is maintained by dredging to a depth of 42 feet.

CLIMATE

26. The climate of Mobile County is characterized by warm, humid summers and mild winters punctuated with occasional cold wave invasions. The mean annual temperature is 68 degrees and, during the winter, averages 53 degrees. The maximum temperature recorded was 104 degrees in July 1952, and the minimum was 1 degree in February 1899. The average annual rainfall is about 68 inches. July is the wettest month with an average of about 10 inches. October is the direst month with an average of about 3.5 inches. The maximum annual rainfall of about 91 inches was recorded in 1900, and the minimum of about 42 inches occurred in 1954.

GEOMORPHOLOGY

27. The Mobile area is located in the Southern Pine Hills and Coastal Lowlands of the East Gulf Coastal Plain section of the Coastal Plain Physiographic Province. The underlying terrigenous rock strata dip southward about 40 feet per mile. Between 17,000 and 20,000 years ago, sea level was about 350 feet lower than at present. At the time, the existing streams were entrenched in deep, narrow valleys. The sea level has continued to rise erratically during recent geological history, filling the valleys and inundating the lowlands. The Mobile Bay estaurine system is a drowned river valley that is filling with sediments introduced principally by the Mobile River system. Accordingly, Mobile Bay is a transient geological feature that will ultimately be transformed into marsh and tidal flat by deltaic deposits. An estimated annual average of 4.7 million tons of suspended sediment and an unknown quantity of bed load are currently being transported into Mobile Bay by the Mobile River system.

HYDROLOGIC FEATURES

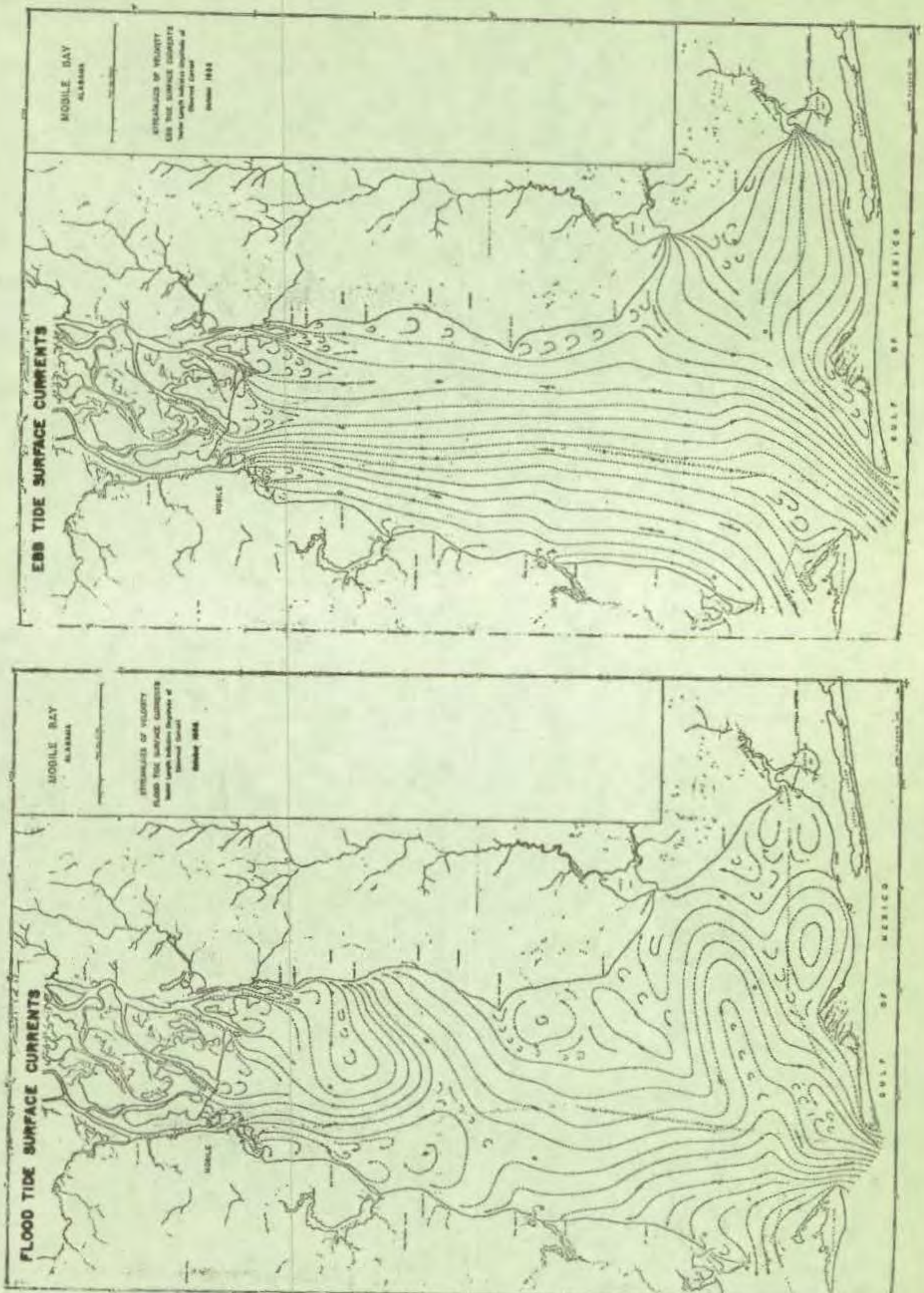
28. The hydrologic characteristics of Mobile Bay fluctuate seasonally and are influenced by a variable volume of stream discharge, wind and tides. The bay receives fresh water principally from the Mobile River. However, several small streams and rivers with small flows enter Mobile Bay below Battleship Parkway. The average annual fresh water flow into the bay is about 63,700 cubic feet per second (cfs). However, stream discharges range from a maximum of about 590,000 cfs, to a minimum of about 5,100 cfs. Under relatively low river discharge conditions, about 12,000 cfs, the flushing time of Mobile Bay is between 45 and 54 days.

29. The estuary has a tide which is diurnal with a mean tidal range varying from 1.5 feet at the head of the bay to 1.3 feet at the entrance. High tide and low tide at the head of the bay occur about 1.76 hours and 1.53 hours respectively, after the occurrence of these tides at the entrance channel. The mean tidal prism of the bay is about 1.46×10^{10} cubic feet. It is estimated that 85 percent of the water transported into and out of Mobile Bay passes through the main pass between Dauphin Island and Mobile Point; while 15 percent flows through Mississippi Sound. According to Austin[1], incoming waters entering through the Main Pass, are deflected to the east then gradually back to the west, thence northward along the east shore of Mobile Bay, with eddies in Bon Secour Bay. In the northern section of the bay, the river flow from the Mobile River system is deflected to the western side of the bay and continues to move down the bay even during flood tide. Consequently, a counterclockwise circulation is set up in the northern section of the bay, with the northerly flowing flood tide being deflected toward the eastern shore. The circulation pattern is much simpler at ebb tide. The water in the entire bay moves predominantly south in a generally clockwise circulation.

Circulation patterns in the bay as described by Austin[2] are shown on figure 1.

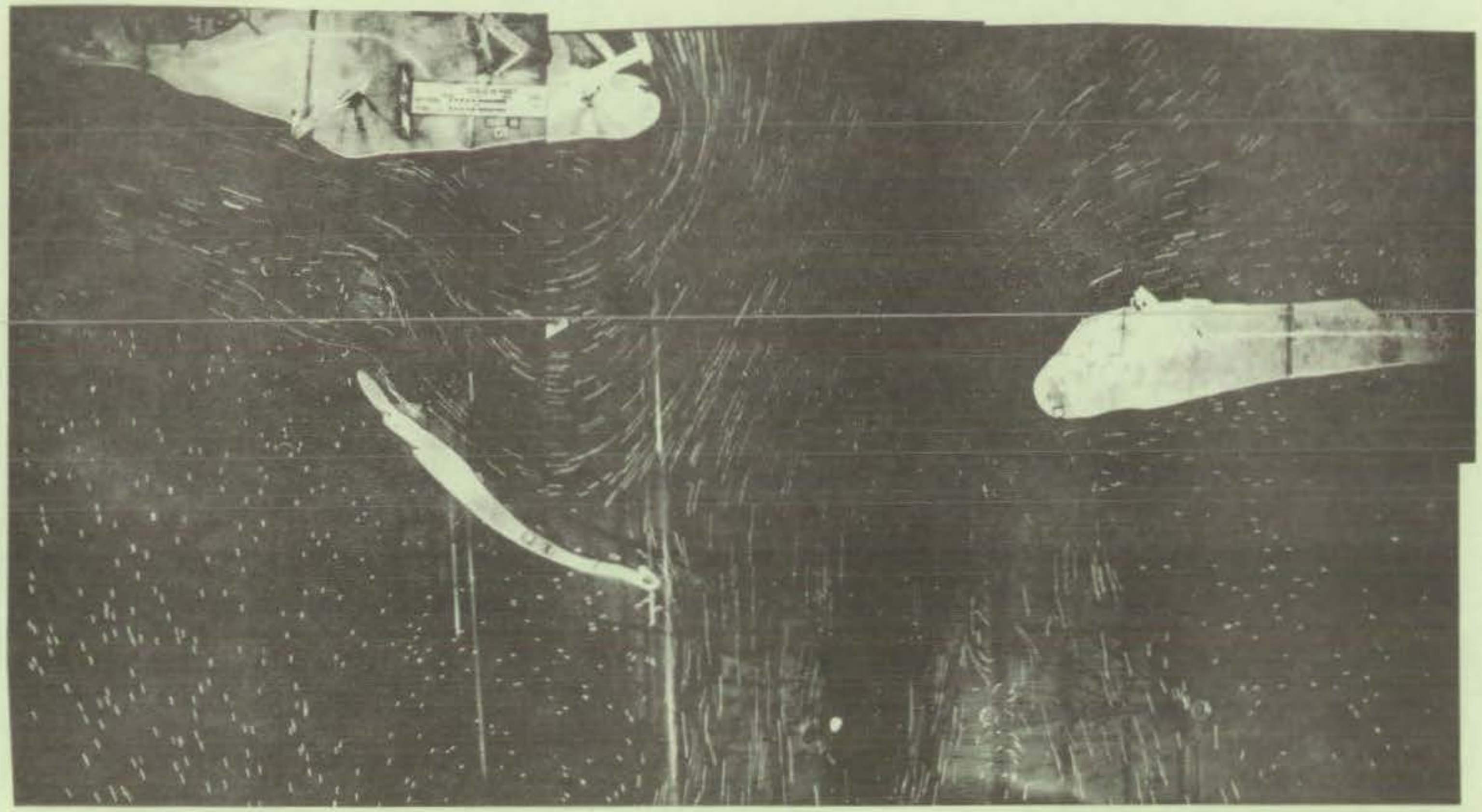
30. Ebb and flood flows through the inlet from the gulf into Mobile Bay,as monitored by WES on the Mobile Bay model, are shown on figures 2 and 3, respectively. As shown on figure 2, during ebb flow, water from the bay mostly flows through the inlets and to the southwest over the west bar. Flows to the southwest are diverted to a westward direction by West Sand Island; thus a swash channel is formed near Dauphin Island. It is significant to note that as the ephemeral islands on the seaward edge of the inlet's west bar elongate and move shoreward, the previously mentioned swash channel will also migrate shoreward. Consequently, it is reasonable to assume that, during periods when the islands are not well-formed, the shore in the vicinity of the swash channel will accrete material. Similarly, during periods when the islands are well-formed across the seaward edge of the bar, and are extending landward, erosion will occur along the shore in the vicinity of the swash channel. Flows across the east bar are not well-established and are interrupted by eddy currents near the seaward edge of the bar. During flood flows, water from the southwest is diverted around Sand Island into the inlet channel to the south and into the swash channel near Dauphin Island to the north. Also, during this time, water enters the bay from the east across the bar, east of the inlet channel.

31. Since Mobile Bay is fairly long and wide, water levels in the bay are often influenced by the wind. Northerly winds tend to depress the water level, whereas, southerly winds raise the water above normal levels. The highest water level reported for Mobile occurred during the 1916 hurricane, when the water reached 10.8 feet above mean sea level (msl). During the same storm, a high water level of 7.7 feet above msl was recorded at Dauphin Island. In 1926, hurricane strength winds depressed the



Drawing taken from Agricultural and Mechanical College of Texas, Dept. of Oceanography, College Station, Texas. "On the Circulation and Tidal Flushing of Mobile Bay, Alabama, Part I", by George B. Austin, April 1954 Project 24.

Figure 1



Photograph was taken from WES, Mobile Bay Model.

VELOCITY SCALE

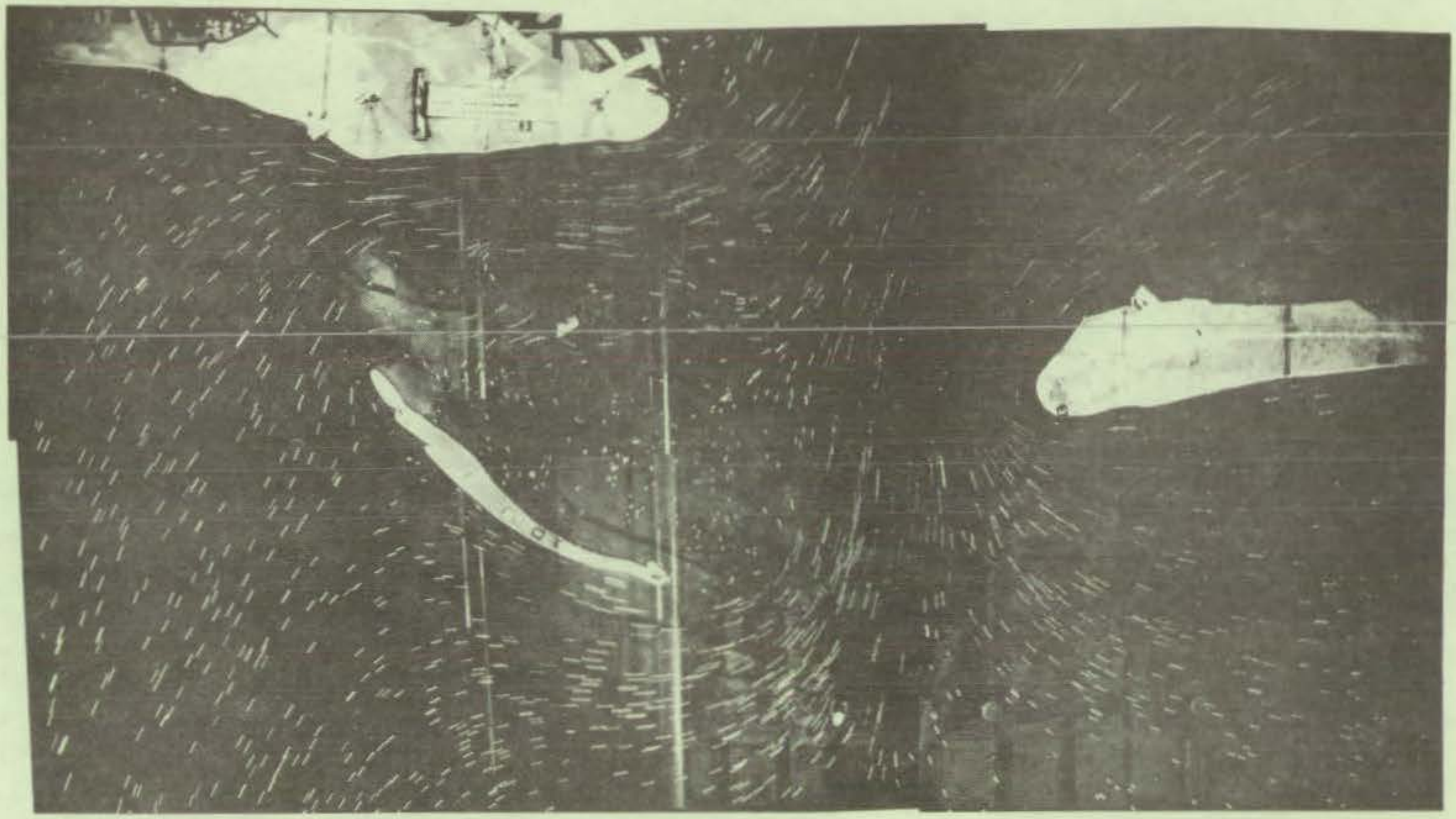
5 0 5 10 FPS

Ebb Tide

Figure 2

40-FT NAVIGATION CANAL

INFLOW 115,000 CFS



Photograph was taken from WES, Mobile Bay Model.

VELOCITY SCALE

5 0 5 10 FPS

Flood Tide

Figure 3

40-FT NAVIGATION CANAL

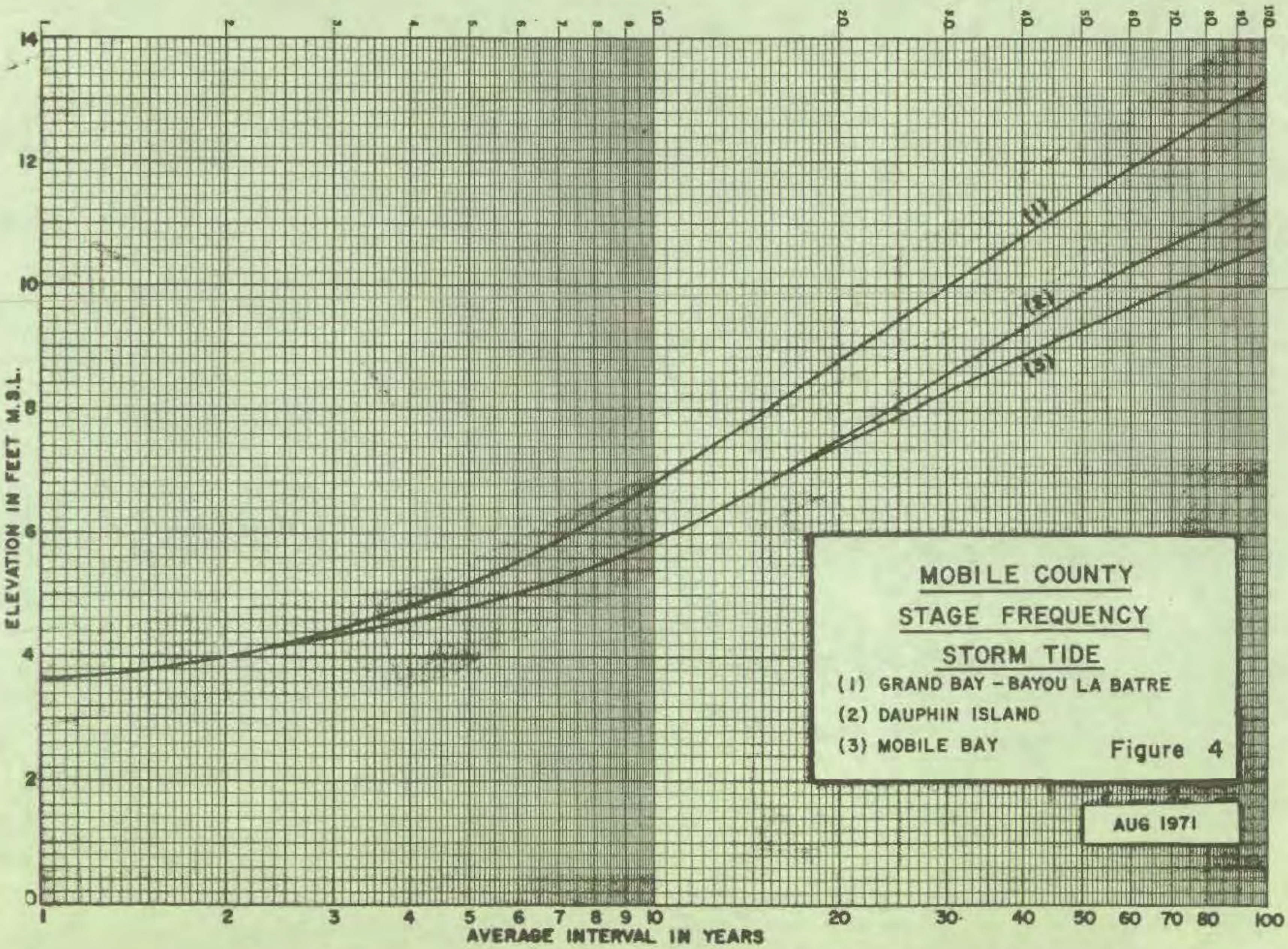
INFLOW 115,000 CFS

water level at Mobile to a low of 10.5 feet below msl. Stage frequency relations were developed for the area as part of the Federal Insurance Administration's 1972 Flood Insurance Study. These relations are shown on figure 4. On this figure, Curve 1 is for the northern shore of Mississippi Sound, Curve 2 is for the gulf shore of Dauphin Island, and Curve 3 is for the western shore of Mobile Bay.

SHORE PROCESSES - GULF SHORE

32. Winds in the northern part of the Gulf of Mexico are predominantly from the eastern quadrant; therefore, waves are predominantly from an eastward direction. It is believed that these waves constitute the principal agent for sand transport along the shoreline. The volume of littoral drift along the shores of the study area has not been measured in the field. Based on a methodology developed by the University of Florida, Walton[3] estimates that the net littoral drift in the study area is about 457,000 cubic yards per year to the west, 139,000 cubic yards per year to the east, and about 596,000 cubic yards to the west. However, these transport rates are only a first approximation.

33. When the littoral material is transported into the Mobile Bay inlet, tidal currents carry the material into the bay during flood tide and out of the bay during ebb tide. Primarily because of the large volume of flow into the bay from the Mobile River system, the forces for moving material out of the bay are greater than the forces for carrying material into the bay. Before the dredging of the Mobile Ship Channel in 1932, the tidal currents and other littoral forces were such that the depth of water over the seaward end of the inlet channel (outer bar) was only about 20 feet. Thus, at that time, material was carried into the channel by wave action, transported into the


MOBILE COUNTY
STAGE FREQUENCY
STORM TIDE
(1) GRAND BAY - BAYOU LA BATRE
(2) DAUPHIN ISLAND
(3) MOBILE BAY
Figure 4
AUG 1971
ELEVATION IN FEET M.S.L.
AVERAGE INTERVAL IN YEARS
(1)
(2)
(3)
0
2
4
6
8
10
12
14
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
100

inlet by tidal currents, and then carried out of the inlet and deposited in water varying in depth from 20 feet on the outer bar to 42 feet at the seaward end of the inlet bar system. Waves acting with ebb currents then transported the material mostly to the west and shoreward where it was deposited on the shore of Dauphin Island or the inlet bar. Following the dredging of the ship channel through the bar, it is reasonable to assume that the part of the littoral drift that would normally have been transported to the west onto the relatively shallow outer bar is deposited in the ship channel, then removed by a hopper dredge. The material removed by the hopper dredge is transported 7,500 feet to the west and deposited in water with a depth of 40 feet or greater.

34. Based on dredging records between 1939 and 1975, maintenance of the bar channel has required the dredging of about 6.8 million yards of material. Between 1939 and 1955, the depth of the ship channel across the bar was 36 feet and an average of 211,000 cubic yards of material per year was removed from the channel as part of the maintenance program. After deepening the channel to 42 feet in 1957, the average annual maintenance dredging required increased to 264,000 cubic yards. Based upon this data, it is estimated that, before dredging of the outer bar, about 264,000 cubic yards of material per year moved across the bar between the 20-foot and 42-foot depths, and about 471,000 cubic yards of material per year moved across the bar between the 42-foot and 60-foot depths.

TERRESTRIAL ENVIRONMENT

35. The terrestrial environment is made up of assemblages of the various plants and animals which inhabit the nonaquatic portions of the study area. Each of these assemblages constitutes

a habitat with its characteristic flora and fauna. Between the habitats are "ecotones" where adjacent habitats overlap. At the edge of the bay, marine and dry land habitats blend. The emergent plants of the salt marsh yield to the following wetland as well as terrestrial vegetation: Baccharis, Eleocharis, wax myrtle, torpedo grass, common reed, tallow tree, three-cornered grass, and wire grass. Back from the shoreline, wax myrtle and Baccharis are prevalent and broom sedge and loblolly pine begin to appear. Farther upland, the vegetation is predominantly pine mixed with various hardwoods. In areas where the soil is sandy with poor drainage, pine flatwood habitats occur. If the soil is fairly rich in organics and is moist, a hardwood forest will be formed. Attachment 1 lists the flora and fauna of the study area. A total of 121 reptiles and amphibians, 318 birds, and 59 mammals can be expected to occur in the study area. Common mammals include muskrat, nutria, raccoon, opossum, deer, squirrel, rabbit and various species of small rodents; although not common, the bobcat is also present. The important game fowl include dove, quail, turkey, snipe, woodcock, rail, gallinule, coot, geese and legal ducks.

AQUATIC ENVIRONMENT

36. The aquatic, as the terrestrial environment, is made up of various habitats, each supporting a particular community of plants and animals. The aquatic environment begins at the marsh with the major emergent estuarine plants; those which contribute directly to fisheries production in the bay include needlerush, smooth cordgrass, salt meadow cordgrass, alligator weed, sedges and canes. Submersed plants which occur chiefly in the upper half of Mobile Bay in shallow water include ruppia, common waternymph, horn pondweed, pondweed, water stargrass and stonewort. Common hornwort and water celery are also found floating unattached

on the surface of the bay. Attachment 1 contains a list of the plants and animals of the Mobile Bay area. Generally submersed grasses are not abundant in Mobile Bay because of periodic and wide fluctuations in salinity, temperature, turbidity and the flocculent silty bottom. There are about 21,400 acres of tidal marsh and 12,500 acres of aquatics in Mobile Bay and Delta (Crance 1971)[4].

37. Thirteen species of blue-green algae and 24 green planktonic algae have been noted in Mobile Bay, but the diversity of green algae is extremely low, and the several red and brown algae that occur frequently in southern saltwater have not been found (Lackey, et al., 1973)[5]. The paucity of macroscopic algae is due to the fluctuating environmental conditions and the flocculent, silty substrate resulting in high turbidities.

38. The plankton of Mobile Bay have never been thoroughly studied. However, Jones (1974)[6] recorded 257 species of protozoans from the bay in a study beginning in July 1970. It is his view that much adaptation appears to have taken place in the protozoan population since no clear-cut distinction between freshwater and marine species can be made for the bay. He also indicated that turbidity induced by riverborne silt, channel and shell dredging, shoreline drainage, and wave action influences protozoans indirectly through reducing photosynthesis by phytoplankton. Low phytoplankton yield results in lowered protozoan productivity. Lackey, et al (1973)[7], observed 186 species during May of 1973 while monitoring the effects of channel dredging on bacteria, plankton, and the macrobenthos of the bay. During this period, he characterized the plankton population as predominantly freshwater, high in diversity, and low in total number of organisms. Seasonally, plankton volume is greatest during the summer, due in part to the presence of numerous meroplanktonic forms. Copepods constitute the most abundant group of 300 zooplankton.

39. Parker (1974)[8], in his study of the bottom of the bay, indicates that four faunal assemblages are traversed by the Mobile Ship Channel. Diversity increases markedly from the river mouth to bay entrance and offshore. Only four species of mollusks are commonly found in the upper bay area and near delta (river-influenced, low-salinity assemblage), while 11 species are found in similar sediments but higher salinities of the open sound or open bay center habitat. A small survey by May (1973)[9] indicated that both standing crop and diversity are lower on the west side of Mobile Bay than on the east side. These data suggest that the ship channel forms an effective barrier between the habitats. Parker[10], in his review of Chermock (1974), states that bay bottom areas least sensitive to increased or additional human disturbance would be the clayey bottoms of the bay center and the upper third of Mobile Bay. Lackey's (1973)[11] report suggests that somewhat lower populations of polychaete worms and clams can be associated with proximity to the ship channel. Major invertebrate estuarine animals in the bay include several species of polychaete worms, clams, snails, isopod and amphipod crustaceans, hermit crabs, grass shrimp, squid, and common valuable brown and white shrimp, oysters and blue crabs.

40. A total of 238 species of fish have been identified in the Mobile Bay area (Swingle, 1971)[12]. The most abundant fishes taken by seine were gulf menhaden, bay anchovy, spot, striped mullet, tidewater silverside, and rough silverside, while the most numerous species taken by trawling were bay anchovy, Atlantic croaker, spot, sea catfish, sand seatrout, fringed flounder, gulf menhaden, blackcheek tonguefish, and striped mullet. In the Mobile delta, where salinities were much lower, different species were dominant. The most abundant fishes taken in seines were tidewater silverside, redear sunfish, large-mouth bass, bluegill, spotted sunfish, bay anchovy, coastal

shiner, rainwater killifish, sport and gulf killifish. Studies indicate that fishes are less abundant numerically in the Mobile ship channel than in other areas of the bay, but about one-third more species are present in the channel than in adjacent areas. The high diversity of species is believed to be due to the presence of high salinity species which do not tolerate the lower salinity outside the influence of the channel.

THREATENED FISH AND WILDLIFE

41. The U. S. Department of the Interior, Fish and Wildlife Service, includes in their list of "Endangered and Threatened Wildlife and Plants" of 14 July 1977, five mammals, seven birds, and four reptiles that may occur in Mobile and Baldwin Counties and offshore waters. (See attachment 2). The mammals are the Indiana bat, Florida panther, finback whale, humpback whale, and sperm whale. The birds are the Mississippi snadhill crane, Southern bald eagle, peregrine falcon, brown pelican, Bachman's warbler, ivory-billed woodpecker, and recockaded woodpecker. The reptiles are the American alligator, Atlantic Ridley sea turtle, hawksbill sea turtle, leather back sea turtle, and the loggerhead turtle.

42. Bachman's warbler and the ivorybilled woodpecker have not been reported from the area in many years.

43. Endangered and Threatened Plants and Animals of Alabama, published by the Alabama Museum of Natural History, 15 October 1976, lists an additional 40 plants, six fishes, 14 amphibians and reptiles, and 15 birds from Mobile and Baldwin Counties as endangered, threatened or of special concern in Alabama.

AESTHETIC AND HUMAN INTEREST AREA

44. Because the salt and freshwater environments are dominant features of the area, water-oriented activities are popular among residents and tourists. Boating, water skiing, fishing, water fowl hunting and beach activities are popular sports. In the study area, very little of the land has officially been designated as "scenic." However, beaches, bays and lakes have always been attractive to people for their beauty. The Red Bluff area at Montrose, Alabama on the east side of the bay, at an elevation of 113 feet above mean sea level, is the highest coastal elevation between Maine and Texas. The Styx and Perdido Rivers in Baldwin County and the Escatawpa River in Mobile County have been suggested for study as potential entrants into the Federal program of The Wild and Scenic Rivers Act (PL 90-542). There are no Federal parklands in the area, however, the State has set aside a number of parks. The largest, Gulf State Park in Baldwin County, occupies 6,160 acres and is a major recreation and vacation facility. This park provides campgrounds, motel and cabins, picnic areas, playing fields, fishing piers, and swimming (both salt and freshwater). Few geographic areas in the eastern United States have as much potential for archeological study as the Bay-Delta area. Five hundred archeological sites have been located within the area, three hundred in Mobile County and two hundred in Baldwin County. A major prehistoric ceremonial center, now known as the Bottle Creek site, is found in the delta. This site along with a few other significant sites has been included in the Register of Historic Places.

The major tourist attractions and events in Mobile and Baldwin Counties are as follows:

Major Attractions	Location
Bellingrath Gardens	Mobile County
Battleship Alabama	Mobile County
Fort Gaines	Mobile County
Dauphin Island	Mobile County
Azalea Trail	Mobile County
Alabama State Docks	Mobile County
Auditorium/Plaza Complex	Mobile County
Museums	Mobile County
Historic Homes	Mobile County
Fort Morgan	Baldwin County
Gulf Shores	Baldwin County
Grand Hotel	Baldwin County
Miscellaneous Historic Sites	Mobile & Baldwin County
Indian Mounds	Mobile & Baldwin County
Saltwater Fishing	Mobile & Baldwin County
Freshwater Fishing	Mobile & Baldwin County
Boating and Water Sports	Mobile & Baldwin County
Hunting	Mobile & Baldwin County

Major Events	Location
Senior Bowl	Mobile County
Junior Miss Pageant	Mobile County
Mardi Gras	Mobile County
Blessing of Shrimp Fleet	Mobile County
Deep Sea Fishing Rodeo	Mobile & Baldwin County
Fish Jubilees	Mobile & Baldwin County
Golf Tournaments	Mobile & Baldwin County
Sailing Regattas	Mobile & Baldwin County

SALT WATER RELATED RECREATIONAL DEMANDS

45. A wide variety of water-oriented recreational resources and facilities are available in Mobile County. The rivers flowing into Mobile Bay provide freshwater recreational opportunities while the bay offers a brackish water environment. Dauphin Island, in the southern part of the county, provides recreational access to the Gulf of Mexico. At present, Mobile County maintains, at no charge, 12 public boat ramps on the east end of the island. A 1975 survey of marine recreational fishing, conducted by the Alabama Marine Resources Laboratory, indicated

6,000 boat launchings from these facilities. East of the ramps, a 250-foot, no fee, fishing pier accommodating 50-75 people extends into Mobile Bay. On the south side of the island, the Casino Pier extends 500-600 feet into the gulf. This pier accommodates 200 fishermen at a charge of $1.00 per person. In 1975, 17,617 persons paid to utilize the pier. On the gulf side of the island, a public beach draws swimmers and sunbathers. The Fort Gaines and Peavy Island Campgrounds make available 250 and 50-60 campsites, respectively. Dauphin Island's beaches, tidal flats, and bays make it an ideal location to enjoy the growing sport of bird-watching. As a barrier island, it is the first or last landfall in the area for birds migrating from or to the Yucatan Peninsula. Thus, it is a popular "birding" area and draws bird-watchers from across the nation.

RESOURCE PRODUCTS

46. The commercially valuable resources of the bay area include forests, minerals, gas and oil, oyster shell and fisheries products. Lumber, wood, paper and allied industries are basic industries dependent upon the considerable acreage of commercial forest land presented in the following table.

TABLE 1

Acres of Commercial Forest Lands

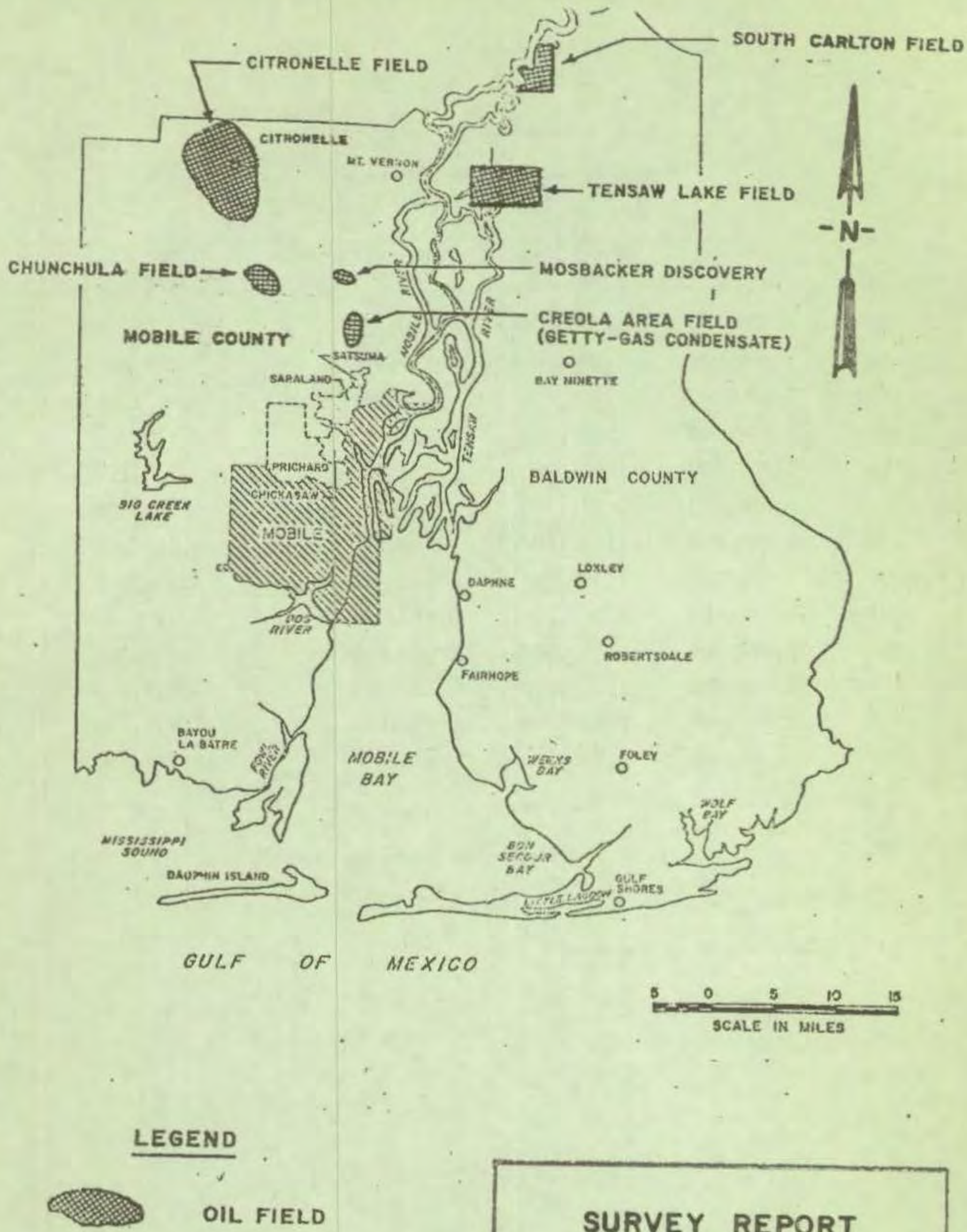
County	Acres
Baldwin	701,800
Mobile	522,700
Region	1,224,500

Source: USDA Forest Service, 1972

NOTE: "Commercial forest lands" are lands either producing or capable of producing crops of wood for various industrial uses.

47. The principal inorganic mineral resources consist of clay, sand and gravel. It has been estimated that Mobile County has 240 million tons of sand available for commercial use.

48. The Citronelle Oil Field in north Mobile County is currently the largest producing field in south Alabama. By the end of 1974, this field contained 415 wells which had produced 112 million barrels of oil. The oil field's reserves are estimated to be 28 million barrels. Figure 5 indicates the location of existing and newly discovered oil fields. In addition, major oil companies have obtained oil leases in the Gulf of Mexico offshore from Mobile and Baldwin Counties. At least one company has scheduled exploratory drilling for oil in lower Mobile Bay. Mobile Bay contains a considerable buried shell resource. Principal uses of this resource include the production of cement and lime, poultry feed supplement, road-building materials, cement block building materials, and oyster cultch. As of January 1970, the buried shell resource in the bay was estimated by the State to be approximately 93 million cubic yards, of which 46 million cubic yards are retrievable, and have an estimated value of $67,000,000. Radcliff Materials, Inc., has engaged in dredging the buried dead-reef shells since 1946, and has removed an average of 1.8 million cubic yards per year. Fisheries products include oysters, shrimp, crabs, and finfish. Table 2 presents a summary of the commercial fisheries products caught in Mobile Bay for the years 1964 through 1975. During this period, fish and shellfish landings have fluctuated around an average of 4 million pounds, worth about $740,200 at the dock. Wade (1977)[13] studied the contribution of the marine recreational fishery in the Mobile Bay area. He reports that, during 1975, 8,027,779 pounds were landed by sport fishermen. The three most abundant fishes were king mackerel, Spanish mackerel, and bluefish. This catch resulted from 308,045 fishing trips, accomplished at an out-of-pocket cost of $4,953,427.



SURVEY REPORT
ON
MOBILE COUNTY, ALABAMA

OIL & GAS FIELD MAP

Prepared by: South Alabama Regional Planning Commission

Figure 5

Table 2

Fishery Landings from Mobile Bay 1/

During the Period 1963 - 1975

Year	Fish (lbs)	Shellfish (lbs)	Total Value 2/ (Dollars) 3/	Total (lbs)
1963	1,374,700	3,366,100	800,355	4,740,800
1964	1,042,400	2,188,500	599,946	3,230,900
1965	1,296,200	1,781,600	471,829	3,077,800
1966	1,116,500	1,993,800	627,920	3,110,300
1967	3,748,300	3,811,900	1,197,280	7,560,200
1968	3,351,700	2,696,700	854,219	6,048,400
1969	3,065,800	1,751,500	746,504	4,817,300
1970	2,939,200	1,302,800	571,897	4,242,000
1971	2,168,600	1,257,500	495,970	3,426,100
1972	1,317,700	1,557,600	694,028	2,875,300
1973	2,435,300	1,381,900	780,248	3,817,200
1974	1,672,300	1,323,800	847,640	2,996,100
1975	1,293,900	1,300,400	934,328	2,594,300

1/ Data supplied by. National Marine Fisheries Service

2/ Dockside

3/ Dollar values as report by year.

AIR POLLUTION

49. Air quality in Mobile County is measured by the Mobile County Board of Health. The ambient air is monitored for particulates, sulfur dioxide and ozone. In downtown Mobile, the ambient air quality standard for ozone is being violated. The ambient air quality standards for sulfur dioxide are being met. A plan to assess the added effect of future air pollution on air quality and to determine if new regulations are required is presently being completed by the Division of Air Pollution Control.

NOISE POLLUTION

50. The most commonly-used unit of noise measurement is the decibel, a logarithmic term representing the amount of power behind a sound-producing wavefront. In terms of everyday noises, levels range from about 50 decibels for background sounds in a typical office, to about 70 decibels for freeway traffic at a distance of 50 feet, to 100 decibels for a jet takeoff at 2,000 feet. Contributions to hearing impairments begin around 70 decibels, or at the noise level associated with freeway traffic. In the area surrounding the bay, trucks and automobile traffic, as well as the heavy machinery associated with loading and unloading at the docks, are the major sources of noise. While this noise may be annoying to persons passing through the area, it does not pose a health problem and does not approach the levels set as standards by the Occupational Safety and Health Act.

HUMAN RESOURCES

COMMUNITY COHESION

51. Community cohesion refers to the relationship among people who have resided in an area for a sufficient period of time to have created a sense of identity.

as a group. Mobile County covers 1,242 square miles and had a 1970 population of 317,308. Eighty-one percent of the people are in urban areas, with 59 percent, 190,026 living in the City of Mobile. The population consist of about 67 percent white, 32 percent blacks and 1 percent of other minority groups.

52. The area is rich in history and a cohesive segment of the region's population traces its ancestry back to early colonists. This group constitutes "old Mobile" and comprises the leaders of society and cultural development, and forms a significant political base in the community. Many of this group are not considered supportive of substantial additional development in the area. However, others are committed to economic growth. The Mobile Area Chamber of Commerce, representing 3,600 members and 1,600 business establishments, is seeking to attract a mix of industry to the region to provide the area greater economic security.

DEMOGRAPHIC SKETCH

53. The estimated Mobile County population in 1974 was 330,600. Mobile, the largest city in the county, had a 1973 estimated population of 188,531. In 1970, the urban population of the county was 82 percent of the total, while the percentage of people residing in urban areas in the state was only 58.4 percent. Between 1960 and 1970, the county gained 1.0 percent in population compared to an increase for the state of 5.4 percent. This was due primarily to the phase-out of Brookley Air Force Base during the late 1960's when southern Alabama had a significant out-migration of 42,000 people. The Mobile County density of 256 persons per square mile reflects the impact of the City of Mobile on county statistics. Pertinent demographic data for Mobile County, the Mobile SMSA and the State of Alabama are presented in table 3.

Table 3

1970 Demographic Characteristics for Mobile County, the Mobile SMSA and the State of Alabama

Item	Mobile County	Mobile SMSA	State of Alabama
Total Population	317,308	376,690	3,444,165
Density (per sq. mil)	256	134	68
Percent Urban	82.0	73.3	58.4
Percent Increase, 1960-1970	1.0	3.7	5.4
Age Distribution (%)			
Under 5 years	9.1	9.0	8.7
5 - 17 years	21.3	20.9	17.8
18 - 64 years	61.7	61.8	64.0
65 years and over	7.9	8.3	9.5

Source: County and City Data Book, 1972, U. S. Department of Commerce, Washington, D. C.

EDUCATION

54. The educational level in Mobile County is slightly higher than that in the State of Alabama. In 1970, the median number of school years completed by persons 25 years old and older in Mobile County was 11.1 compared to the state average of 10.8 years. On a percentage basis, 8.8 percent of the persons in this age group had completed less than 5 years of school, 42.6 percent had completed high school and some college, while 7.5 percent had 4 or more years of college education.

Educational data for the Mobile SMSA generally parallels information for Mobile County. Comparatively, in 1970, the state had 10.7 percent with less than 5 years of school, 41.3 percent completed high school, and 7.8 percent finished 4 or more years of college.

HOUSING

55. In 1970, there were 121,244 housing units available in the Mobile SMSA. In Baldwin County, 78 percent were owner-occupied while in Mobile County the owner occupancy rate was 66 percent. The median number of rooms per unit in the area was 5.1. More than one person per room, per unit is indicative of overcrowding; 1.51 persons per room is regarded as severe overcrowding. Twelve percent of the housing units in the area experienced some degree of overcrowding; 4 percent were severely overcrowded. The median value of the owner-occupied, 1-family unit was $11,100 and $12,900 in Baldwin County and Mobile County, respectively. In Mobile County, 26 percent of the houses were built after 1959, 31 percent from 1950-1959, and 43 percent before 1950.

ECONOMY AND DEVELOPMENT

56. The primary study area is Mobile County. Accordingly, county data is used when available. Where county data is not published, information prepared for the Mobile SMSA (Standard Metropolitan Statistical Area) will be employed. Use of this type data is considered applicable since Mobile and Baldwin Counties comprise the Mobile SMSA. Pertinent economic data describing the existing and future economy of Mobile County, the Mobile SMSA and the State of Alabama are presented in the following paragraphs.

EXISTING FEDERAL WATER RESOURCE PROJECTS

57. Mobile County has a number of Federal Water resource projects, including deep-draft channels required to service the Port of Mobile and several small boat harbors. Small boat projects are located at Bayou La Batre, Bayou Coden, Dauphin Island and Fowl River. A 40-foot deep-draft channel was authorized for Theodore Industrial Park in December 1970. Table 4 lists selected characteristics of the Federal projects; the illustration shown on page 34, indicates project locations.

Table 4

Selected Data for Federal Projects in Mobile County

Project	Depth	Width	Date Completed to Project Dimensions
Mobile Harbor	40	400-775'	1965
Bayou La Batre	12	75-100'	1967
Bayou Coden	8	60-100'	1975
Dauphin Island	7	40-150'	1959
Fowl River	8	100'	1973

Note: Data shown above indicates the general nature and completion dates of the various projects as shown in Water Resources Development by the U. S. Army Corps of Engineers, South Atlantic Division, Atlanta, Georgia, 1 March 1975.

58. The Mobile Ship Channel and Gulf Intracoastal Waterway provide Mobile County commercial interests with economical water transportation to both foreign and domestic markets. Ships calling at the Port of Mobile are able to utilize a 40-foot channel and thus compete with vessels operating from most other ports. For domestic traffic, the Gulf Intracoastal Waterway

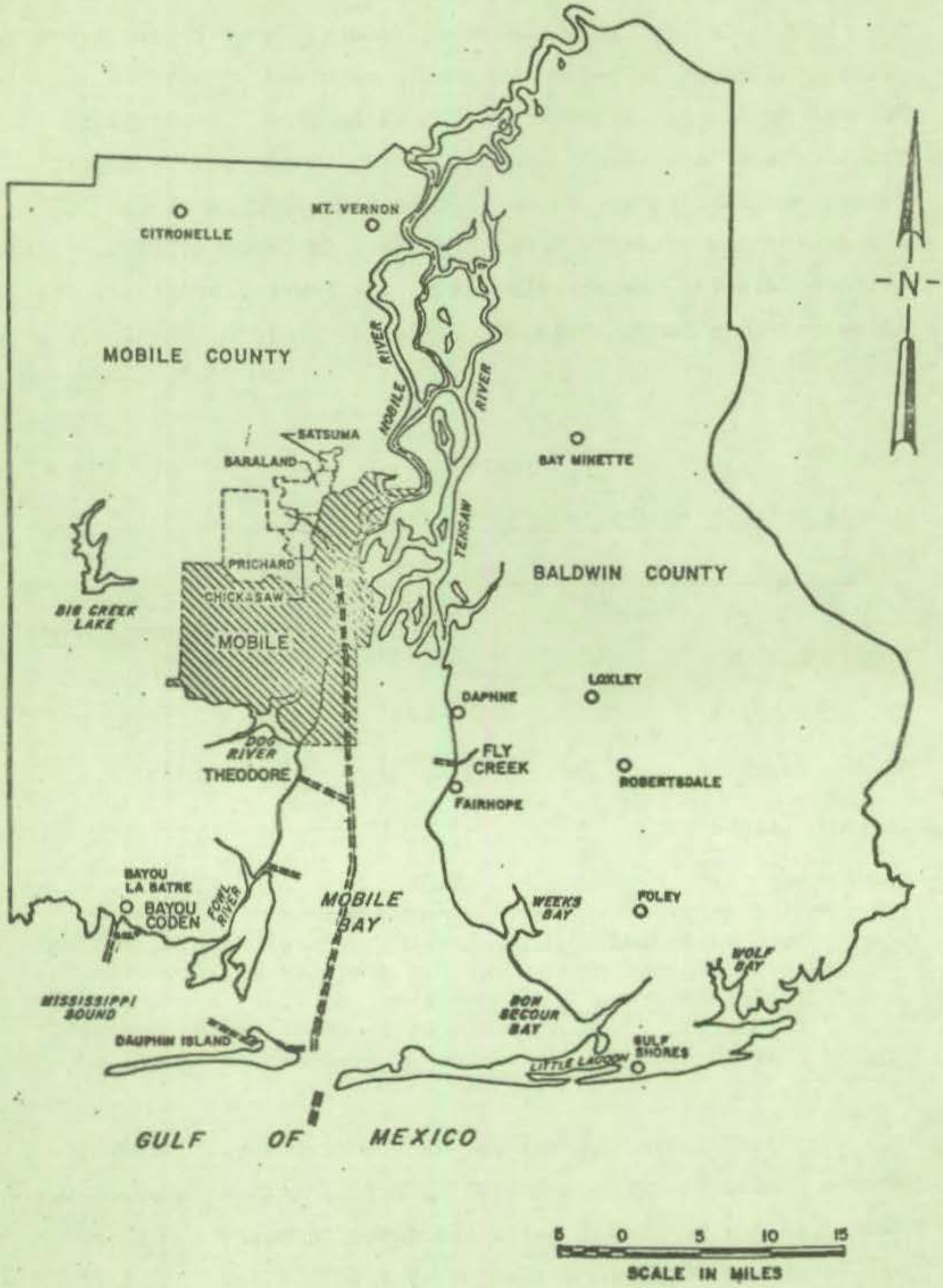


Illustration Indicating Project Locations in Study Area

(GIWW), with minimum dimensions of 12 by 125 feet, serves shallow-draft commercial and recreational craft between Brownsville, Texas and Carrabelle, Florida.

PORT USE

59. Mobile County has a deep-draft port located at the City of Mobile and four small boat harbors situated in the southern part of the county. The Mobile Harbor facility is principally used to move waterborne bulk and general cargo tonnages in foreign and coastwise trade. Total tonnage handled at the port has increased from 21.8 million tons in 1965 to 33.2 in 1974, an increase of about 52 percent. Major tonnage items handled included iron ore, aluminum ore, coal, grain and grain products. Small boat harbors are located at Bayou Coden, Bayou La Batre, Dauphin Island, Dog River and Fowl River. The project at Bayou Coden is utilized by commercial fishing interests; the remaining projects are beneficial to both commercial fishing and recreational boating interests. A review of vessel trip data for the various projects indicates that port activity has been increasing.

ECOMOMIC DEVELOPMENT

60. INCOME. Total personal and per capita incomes in 1973 for Mobile County and the State of Alabama are presented in table 5. The total personal income for the county increased 31.3 percent from 1970 to 1973, while the state experienced an increase of 23.7 percent for the period. Per capita income for the county in 1973 was $3,792 or about $72 less than the state average.

Table 5

Total Personal and Per Capita Incomes in 1973 for Mobile County and State of Alabama

Area	Total Personal Income (in millions of $)	Per Capita (in dollars)
Mobile County	$ 1,233.6	$3,792
State of Alabama	13,699.9	3,864

Source: Economic Abstract of Alabama, 1975, Center for Business and Economic Research, Graduate School of Business, The University of Alabama, December 1975

61. Covered Wages by Major Industry Sector. Covered wages for Mobile County were $732.2 million in 1974, approximately 10 percent of the total covered wages in Alabama. Manufacturing wages accounted for 32.1 percent of the county's total wages. Trade and service were important sectors with 23.5 and 13.3 percent, respectively, of Mobile County covered wages. These three sectors were also the most important segments of the state's total covered wages. Manufacturing comprised 40.3 percent of covered wages followed by trade with 20.5 percent and service, 12.1 percent. A summary of covered wages by major industrial class and their percent of total earnings for Mobile County and the State of Alabama is presented in table 6.

62. Employment. The total civilian labor force for the Mobile SMSA was 151,900 in March 1974. Unemployment totaled only 5,600 for a rate of 3.7 percent. Nonmanufacturing activities accounted for about 82 percent of total employment. Employment for the state totaled 1,387,100 in March 1974. The unemployment rate was 4.0 percent. Manufacturing was the largest

employment sector with 25.2 percent of total state employment, followed by government and wholesale and retail trade with 16.5 and 16.0 percent, respectively.

Table 6

Covered Wages for 1974, by Major Industrial Class for Mobile County and the State of Alabama

	Earnings (in millions of dollars)			
	Mobile County		State	
Industry	Earnings	Percent of total	Earnings	Percent of total
Total	$732.2	100.0	$7,368.1	100.0
Mining	3.8	.5	117.7	1.6
Contract Construction	76.9	10.5	660.7	9.0
Manufacturing	235.3	32.1	2,969.8	40.3
Transportation, Communication, etc.	73.7	10.1	545.1	7.4
Trade	172.2	23.5	1,512.9	20.5
Finance	40.7	5.6	397.1	5.4
Service	97.2	13.3	890.6	12.1
All other	32.4 1/	4.4	274.2 1/	3.7

1/ Data adjusted to balance with total figures

Source: Economic Abstract of Alabama, 1975, Center for Business Research, Graduate School of Business, The University of Alabama, December 1975

63. Estimates of future population, total personal income, per capita income and earnings by major industrial class are presented in tables 7 and 8. Population in the SMSA is projected to increase by 7.8 percent from 1972 to 1980, while the state's population growth is expected to be only 6.8 percent. During the period 1980-2020, the population of the SMSA and state is forecast to grow 21 and 24 percent, respectively.

64. Total personal income for the SMSA is expected to expand at a significant average annual rate of 4.3 percent from 1972 to 1980. This growth is anticipated to slow in subsequent years, but is still forecast to increase at a 3.4 percent average annual rate for the period 1980 to 2020. The total SMSA personal income for 2020 is projected at $5,591.8 million - more than 5 times the 1972 level. Comparatively, personal income for the state is forecast to increase more slowly than the SMSA. An average annual rate of increase of 3.8 and 3.4 percent, respectively, is forecast for the state for the periods 1972-1980 and 1980-2020. The Mobile SMSA per capita income is estimated to be $3,577 in 1980, which is almost the same as the projected state per capita of $3,579. The SMSA per capita income is forecast to be slightly less than that of the state during the period 1980-2020.

65. Services, wholesale and retail trade, and manufacturing will continue to be the major industrial sectors of both the SMSA and the state in the future. Future services will grow in relative importance reflecting population growth and increased tourism. Services in the Mobile SMSA are expected to account for 30.8 percent of earnings in 2020, an increase of 56.3 percent over 1972. Services in the state sector are forecast to be 29.4 percent of earnings in 2020, up 68 percent over 1972.

Table 7

Projected nonagricultural earnings by major industrial class for the Mobile SMSA and the State of Alabama

(in millions of 1967 $)

Industry	1972 Mobile SMSA Earnings	1972 Mobile SMSA Percent	1972 State of Alabama Earnings	1972 State of Alabama Percent	1980 Mobile SMSA Earnings	1980 Mobile SMSA Percent	1980 State of Alabama Earnings	1980 State of Alabama Percent	1990 Mobile SMSA Earnings	1990 Mobile SMSA Percent	1990 State of Alabama Earnings	1990 State of Alabama Percent
Mining	$ 1.3	(.2)	$ 79.0	(1.3)	$ 2.8	(.3)	$ 81.1	(1.0)	$ 3.3	(.2)	$ 92.4	(.8)
Contract Construction	62.4	(9.5)	455.1	7.8)	97.8	(10.5)	602.1	(7.5)	136.0	(10.1)	852.0	(7.4)
Manufacturing	193.0	(29.5)	2,252.2	(38.5)	262.2	(28.1)	3,008.0	(37.7)	371.4	(27.6)	4,176.0	(36.3)
Transportation, Communications, Utilities	83.9	(12.8)	518.2	(8.9)	105.1	(11.2)	640.1	(8.1)	140.0	(10.4)	899.9	(7.8)
Wholesale, Retail	147.5	(22.6)	1,191.8	(20.4)	199.5	(21.4)	1,538.1	(19.3)	272.5	(20.2)	2,110.7	(18.3)
Finance, Insurance Real Estate	37.3	(5.7)	326.3	(5.6)	59.9	(6.4)	482.5	(6.0)	93.3	(6.9)	743.8	(6.5)
Services	128.8	(19.7)	1,020.0	(17.5)	207.0	(22.2)	1,629.8	(20.4)	330.7	(24.6)	2,629.1	(22.9)
TOTAL	654.2	(100.0)	$5,842.6	(100.0)	$934.3	(100.0)	$7,981.7	(100.0)	$1,347.2	(100.0)	$11,503.9	(100.0)

Industry	2000 Mobile SMSA Earnings	2000 Mobile SMSA Percent	2000 State of Alabama Earnings	2000 State of Alabama Percent	2010 Mobile SMSA Earnings	2010 Mobile SMSA Percent	2010 State of Alabama Earnings	2010 State of Alabama Percent	2020 Mobile SMSA Earnings	2020 Mobile SMSA Percent	2020 State of Alabama Earnings	2020 State of Alabama Percent
Mining	$ 3.7	(.2)	$ 107.5	(.7)	$ 4.2	(.2)	$ 127.1	(.6)	$ 4.6	(.1)	$ 144.4	(.5)
Contract Construction	181.8	(9.6)	1,179.2	(7.2)	242.1	(9.1)	1,618.9	(7.1)	299.6	(8.7)	2,074.2	(6.9)
Manufacturing	511.4	(26.9)	5,656.3	(34.7)	697.8	(26.3)	7,634.7	(33.2)	874.7	(25.5)	9,586.6	(31.9)
Transportation, Communications, Utilities	186.5	(9.8)	1,257.1	(7.7)	250.1	(9.4)	1,754.3	(7.6)	314.1	(9.2)	2,280.1	(7.6)
Wholesale, Retail	368.3	(19.4)	2,891.9	(17.7)	492.7	(18.6)	3,924.8	(17.1)	615.6	(18.0)	4,975.6	(16.6)
Finance, Insurance Real Estate	138.4	(7.3)	1,104.8	(6.8)	200.5	(7.6)	1,608.3	(7.0)	264.9	(7.7)	2,139.5	(7.1)
Services	507.9	(26.8)	4,111.9	(25.2)	765.1	(28.8)	6,298.3	(27.4)	1,056.3	(30.8)	8,810.2	(29.4)
TOTAL	$1,898.0	(100.0)	$16,318.7	(100.0)	$2,652.5	(100.0)	$22,966.4	(100.0)	$3,429.8	(100.0)	$30,010.6	(100.0)

Source: 1972-E OBERS Projections Economic Activity in Alabama, prepared by the U. S. Department of Commerce, Bureau of Economic Analysis, May 1976

Table 8

Projected population, total personal income and per capita income for the Mobile SMSA and the State of Alabama

Year	Population (1,000's)		Total Personal Income (In millions of 1967 $)		Per Capita Income (1967 $)	
	Mobile SMSA	State of Alabama	Mobile SMSA	State of Alabama	Mobile SMSA	State of Alabama
1972	386.3	3,590.6	$1,067.3	$ 9,956.8	$ 2,763	$ 2,837
1980	416.5	3,746.7	1,489.7	13,408.1	3,577	3,579
1990	457.9	4,090.4	2,166.9	19,467.2	4,732	4,759
2000	476.6	4,284.3	3,074.4	27,772.0	6,450	6,482
2010	493.4	4,465.7	4,287.8	39,072.3	8,690	8,749
2020	505.8	4,649.7	5,591.8	51,686.3	11,054	11,116

Source: 1972-E OBERS Projections Economic Activity in Alabama, prepared by the U. S. Department of Commerce, Bureau of Economic Analysis, May 1976.

AREA FINANCIAL RESOURCES

66. Total receipts from taxes and other revenues for Mobile County in 1967 were $69.1 million. Disbursements during the year were $70.6 million or $223 on a per capita basis. The 1967 total receipts for the State of Alabama were $676.6 million while expenditures were $707.7 million or $205 per capita.

TRANSPORTATION

67. Mobile County and the Mobile SMSA are served by a number of Federal, state and county roads. Interstate 10 and U. S. Highways 90 and 98 provide east-west routes, while Interstate 65 and U. S. Highways 31, 43 and 45 give access to interior points in Alabama and the U. S. There are also numerous state and county roads in the area. Rail service to the SMSA is provided by four rail lines. The Illinois Central-Gulf, Louisville and Nashville, Southern, and St. Louis - San Francisco Railway Companies connect the SMSA with terminals along the coast and throughout the interior of the U. S. Commercial and private air transportation are available at the municipally owned Bates Field and the Brookley Aerospace Center. The area is served by Eastern, National and Southern Airlines.

PROBLEMS AND NEEDS

THE STORM PROBLEM

68. The storm problems are concerned with flooding from gulf and bay waters as a result of hurricanes making landfall at or near the study area. Storm surges created by high winds, low barometric pressure and accompanying wave action have inundated developed areas with resultant property damage and danger to health and safety. On the average, a hurricane affects the Alabama coast once every 4 1/3 years.

STORMS OF RECORD

69. Records of hurricanes affecting Alabama are fairly complete since the settlement of Mobile in 1702. In the 254-year period since 1711, 53 tropical storms considered to be of hurricane intensity are known to have crossed the Alabama coast or passed near enough to affect the study area. Contemporary newspaper accounts indicate that only the major intensity hurricanes were recorded during the first 100 years or more of this period, and many occurrences must have been unreported. Since 1886, Alabama has been affected by 21 storms of full hurricane intensity and 17 tropical disturbances. The area within a 50-mile radius of Mobile, which encompasses the entire coast of Alabama, has been visited by 12 hurricanes since 1886, a frequency of one every 6 years. A chronological list of storms of hurricane intensity is given in table 9. Statistical analyses of the storms affecting Alabama are presented in tables 10, 11, and 12. Those hurricanes which caused extensive damage in the study area are discussed in the following paragraphs. Detailed accounts of other hurricanes affecting Alabama, abstracted from various sources, including Cline's "Tropical Cyclones", Tannehill's "Hurricanes, Their Nature and History", publications by the U.S. Weather Bureau, and contemporary newspapers, are contained in Attachment 3.

Table 9

Hurricanes affecting Alabama (1711-1969)

Date	Landfall	Origin	Principal Gulf area affected
11-13 Sep. 1711	1/	1/	New Orleans, La.
12-13 Sep. 1722	1/	1/	New Orleans, La.
1732	1/	1/	Mobile, Ala.
1736	1/	1/	Pensacola, Fla.
12 Sep. 1740	1/	1/	Pensacola, Fla.
Sep. 1759	1/	1/	Gulf coast
22 Oct. 1766	1/	1/	Pensacola, Fla.
4 Sep. 1772	1/	1/	Louisiana
10 July 1776	1/	1/	New Orleans, La.
18 Aug. 1779	1/	1/	New Orleans, La.
7-10 Oct. 1779	1/	1/	New Orleans, La.
24 Aug. 1780	1/	1/	New Orleans, La.
23 Aug. 1781	1/	1/	New Orleans, La.
Aug. 1800	1/	1/	New Orleans, La.
1811	1/	1/	New Orleans, La.
19 Aug. 1812	1/	1/	New Orleans, La.
19 Aug. 1813	1/	1/	Gulf coast
25-28 Aug. 1819	1/	1/	Bay St. Louis, Miss.
1821	1/	1/	New Orleans, La.
11 July 1822	1/	1/	Mobile, Ala.
16 Aug. 1831	1/	Atlantic	Mouth of Miss. River
7 Oct. 1837	New Orleans, La.	Caribbean	New Orleans, La.
18-22 Sep. 1842	1/	1/	Gulf coast
12 Oct. 1846	1/	1/	New Orleans, La.
23 Aug. 1852	1/	1/	Mobile, Ala.
12 Aug. 1856	1/	1/	Louisiana
30 Aug. 1856	Mobile, Ala.	1/	Mobile, Ala.
11 Aug. 1860	1/	1/	Mobile, Ala.
15 Sep. 1860	1/	1/	Mobile, Ala.
30 July 1870	1/	1/	Mobile, Ala.
21 Sep. 1877	1/	1/	Gulf coast
26-30 Aug. 1880	Mobile, Ala.	Atlantic	Mobile, Ala.
10 Sep. 1882	Mobile, Ala.	1/	Mobile, Ala.
19 Oct. 1887	Grand Isle, La.	Atlantic	Mississippi coast
19 Aug. 1888	Lake Charles, La.	Atlantic	Louisiana to Mobile, Ala.
23 Sep. 1889	Burrwood, La.	Atlantic	Louisiana to Pensacola, Fla
2 Oct. 1893	Pascagoula, Miss.	Caribbean	Louisiana
15 Aug. 1901	Grand Isle, La.	Atlantic	Louisiana
27 Sep. 1906	Pascagoula, Miss.	Caribbean	Mobile, Ala.
20 Sep. 1909	Grand Isle, La.	Caribbean	New Orleans, La.
14 Sep. 1912	Mobile, Ala.	Gulf	Mobile, Ala.
29 Sep. 1915	Grand Isle, La.	Atlantic	New Orleans, La.
5 July 1916	Gulfport, Miss.	Caribbean	Mobile, Ala.
18 Oct. 1916	Pensacola, Fla.	Caribbean	Pensacola, Fla.
28 Sep. 1917	Pensacola, Fla.	Atlantic	Pensacola, Fla.
20 Sep. 1926	Perdido Beach, Ala.	Atlantic	Pensacola, Fla.
1 Sep. 1932	Mobile, Ala.	Atlantic	Mobile, Ala.
19 Sep. 1947	New Orleans, La.	Atlantic	Mississippi coast
4 Sep. 1948	Grand Isle, La.	Gulf	Louisiana
30 Aug. 1950	Mobile, Ala.	Atlantic	Gulf Shores, Ala.
24 Sep. 1956	Fort Walton Beach, Fla.	Caribbean	Alabama and northwest Florida
15 Sep. 1960	Pascagoula, Miss.	Gulf	Mississippi coast
3 Oct. 1964	Franklin, La.	Caribbean	Louisiana
17 Aug. 1969	Waveland, Miss.	Caribbean	Mississippi coast

1/ Not available.

Table 10

Storm tides in Alabama (1772-1964)

Date storm crossed coast	Landfall	Stage: (feet above mean sea level) Bayou La Batre	Coden	Dauphin Island	Mobile	Gulf Shores
4 Sep. 1772	1/				8.2	
23 Aug. 1852	1/				8.0	
11 Aug. 1860	1/				6.4	
15 Sep. 1860	1/				7.0	
30 July 1870	1/				7.0	
19 Aug. 1888	Lake Charles, La.				7.2	
2 Oct. 1893	Pascagoula, Miss.				8.4	4.9
15 Aug. 1901	Grand Isle, La.				7.4	
27 Sep. 1906	Mobile, Ala.		10.8		9.1	11.8
20 Sep. 1909	Grand Isle, La.				7.0	
14 Sep. 1912	Mobile, Ala.				4.4	
29 Sep. 1915	Grand Isle, La.		10.0 2/		6.4	
5 July 1916	Gulfport, Miss.		10.8	7.7	10.8	11.3
18 Oct. 1916	Pensacola, Fla.				3.2	
28 Sep. 1917	Pensacola, Fla.				1.2	
20 Sep. 1926	Pensacola, Fla.				4.5	
1 Sep. 1932	Bayou La Batre, Ala.				4.5	
10 Sep. 1944	Mobile, Ala.				3.8	
19 Sep. 1947	New Orleans, La.	8.2	6.1		4.7	7.9
4 Sep. 1948	Grand Isle, La.	6.0	6.0		4.4	
30 Aug. 1950	Mobile, Ala.				3.9	
24 Sep. 1956	Ft. Walton Beach, Fla.	6.3	6.3	3.3	2.2	5.8
15 Sep. 1960	Pascagoula, Miss.			5.0	3.9	
3 Oct. 1964	Franklin, La.	5.5		3.5	4.2	3.1
17 Aug. 1969	Waveland, Miss.			9.2	7.4	9.1

1/ Not available.
2/ Reported as above "normal high".

Table 11

Extreme pressure and wind data of hurricanes recorded along the Alabama coast since 1892

Date hurricane crossed coast	Approx. no. miles and direction center passed Mobile	Lowest barometric pressure (inches)	Location	Max. wind velocity and direction (mph)	Location
2 Oct. 1893	50 W	29.16	Mobile	80 SE	Mobile
15 Aug. 1901	70 W	29.32	Mobile	61	Mobile
27 Sep. 1906	20 SW	28.84	Mobile	94	Ft. Morgan
20 Sep. 1909	150 SW	29.62	Mobile	52	Ft. Morgan
14 Sep. 1912	20 W	29.37	Mobile	60 SE	Mobile
29 Sep. 1915	100 W	29.45	Mobile	60 SE	Mobile
5 July 1916	20 W	28.38	Ft. Morgan	107 E	Mobile
18 Oct. 1916	60 E	29.22	Mobile	128 E	Mobile
28 Sep. 1917	100 SE	29.17	Mobile	96 NNE	Mobile
20 Sep. 1926	30 S	28.20	Perdido Beach	94 N	Mobile
1 Sep. 1932	25 SSW	29.03	Bayou La Batre	57 E	Mobile
19 Sep. 1947	110 SW	29.54	Mobile	53 E	Mobile
4 Sep. 1948	90 W	29.55	Ft. Morgan	42 S	Mobile
30 Aug. 1950	20 E	28.92	Ft. Morgan	75	Ft. Morgan
24 Sep. 1956	80 S	29.49	Mobile	58	Mobile
15 Sep. 1960	80 W	29.48	Mobile	74	Dauphin Island
3 Oct. 1964	230 W	29.39	Alabama Port	80 NNW	Alabama Port
17 Aug. 1969	90 WSW	29.44	Mobile	74	Mobile

Table 12

Past hurricane losses in Alabama

Hurricane	Fatalities	Buildings	Shipping 1/	Transportation	Merchandise	Agriculture	Others	Total
		Damages (as recorded by year)						
15 Aug. 1901	-	-	-	-	-	-	-	$ 100,000
27 Sept. 1906	119	$ 550,000	$175,000	$500,000	$425,000	-	-	1,650,000
20 Sept. 1909	-	-	3,000	-	5,000 2/	-	-	8,000
14 Sept. 1912	1	-	-	-	-	-	-	12,000
29 Sept. 1915	-	-	-	-	-	-	-	75,000
5 July 1916	13	1,300,000	350,000	-	775,000	-	$1,075,000	3,500,000
18 Oct. 1916	1	-	-	-	-	-	-	1,010,000 3/
28 Sept. 1917	-	-	-	-	-	-	-	100,000
20 Sept. 1926	3	-	60,000	-	-	$2,675,000	2,265,000	5,000,000
1 Sept. 1932	2	-	-	-	-	-	-	4/
19 Sept. 1947	-	185,000	8,000	2,000	69,000	870,000	78,000	1,212,000
4 Sept. 1948	-	-	-	-	-	-	-	88,000
30 Aug. 1950	1	-	-	-	-	-	-	500,000
24 Sept. 1956	3	-	-	-	-	-	-	445,000
3 Oct. 1964	-	200,000	25,000	-	-	200,000	175,000	600,000
17 Aug. 1969	-	6,835,000	924,000	1,362,000	-	12,000,000	2,535,000	23,656,000
TOTAL	143							37,956,000

1/ Includes damages to vessels and docks.
2/ Removal of goods to safety reduced damages an estimated $400,000.
3/ Includes $1,000,000 wind damage to Andalusia, Ala.
4/ Minor.

70. 27 September 1906. - First observed in the eastern Caribbean Sea, this storm traveled westward through the Yucatan channel and into the Gulf of Mexico. It then recurved to the north and passed inland a short distance west of Mobile, causing widespread wind and wave damage along the Gulf Coast from Apalachicola, Florida to New Orleans. The storm was the most destructive in the meteorological history of Mobile and Pensacola, the most heavily damaged points. At Fort Morgan, an anemometer recorded a maximum wind velocity of 94 miles per hour and an average wind velocity of 70 miles per hour for a period of 8 hours and 45 minutes before the instrument was blown away. One ship in Mobile Bay capsized with the loss of all but one crewman. Thirty fishing boats were demolished and virtually every house or building along the waterfront was destroyed for a distance of 10 miles. For about 14 hours, the winds came from the north, driving the water out of Mobile Bay and leaving many boats aground. After a brief lull, the winds shifted to the south sending a surge wave back up the bay and inland more than 1-1/2 miles. Many people, who had come out of shelter during the calm to inspect wharves and boats, were drowned. Mobile recorded a tide of 9.1 feet above mean sea level, 6.47 inches of rainfall, and a barometric low of 28.84 inches. At Daphne and Bermuda, Alabama, total storm rainfall amounted to about 11 inches. The following tabulation lists damages in Mobile.

Table 13

Summary of Damages in Mobile, Alabama, 1906 Storm

Property Affected	Damages
Buildings and electric utilities, from wind. . .	$ 500,000
Buildings and electric utilities, from tide. . .	50,000
Merchandise from wind	250,000
Merchandise from tide	175,000
Vessels	175,000
Railroads entering Mobile	500,000
TOTAL	$1,650,000

The storm claimed 119 lives in Alabama. These are tabulated by location as follows:

Mobile	1	Dauphin Island Bay	17
Coden and Sans Souci . . .	31	Alabama Port	2
Navy Cove	6	Delchamps	4
Heron Bay	31	Mon Louis Island	20
Grand Bay	2	Fort Morgan	3
Dauphin Island	2		

71. 5 July 1916. - Spawned in the western Caribbean Sea on the 1st, this storm crossed the Mississippi coast near Gulfport on the afternoon of the 5th. High winds and tides caused extensive damage along the east central Gulf Coast. Thirteen persons were killed and the estimated property damage exceeded $3,500,000. At Mobile, the tide reached a record stage of 10.8 feet above mean sea level, and a total storm rainfall of 14 inches compounded flooding conditions. The water was 2 feet deep across Royal Street, four blocks from the waterfront. Other tides reported along the coast were 10.8 feet at Coden, 7.7 feet at Dauphin Island, and 11.3 feet at Gulf Shores. The wind at Mobile reached intensities of 107 miles per hour for five minutes and blew 99 miles per hour for sustained periods of one hour. Houses and

docks were demolished, shipping destroyed, over 8,000 bales of stored cotton lost, and power poles, trees, shrubbery, and signs blown down throughout the town. Damages along the Alabama coast are given in the following table.

Table 14

Summary of Damages Alabama Coast - 5 July 1916 Storm

Property Affected	Damages
Buildings, streets, and utilities	$1,300,000
Merchandise:	
From tidal flooding	500,000
From rain	200,000
Docks and railroads	200,000
Vessels	150,000
Timber	75,000
Others	1,075,000
TOTAL	$3,500,000

72. 20 September 1926. - One of the most destructive hurricanes of the century, this storm claimed a total of 242 lives and inflicted extensive damage along the east central Gulf Coast from Apalachicola, Florida to the Mississippi coast. After passing over the Bahama Islands, the hurricane struck the Florida peninsula, passing directly over the City of Miami. Continuing across Florida, it entered the gulf and passed 30 miles south of Mobile and directly over Biloxi, Gulfport, and Pass Christian, finally dissipating its energy over eastern Texas. The progress of the hurricane's approach was well publicized in Mobile. The warning is credited with being so effective that no loss of property occurred that could have been averted. The storm was characterized by two barometric minimums lower than any previously recorded at Mobile, by a longer duration of destructive winds than in any former storm

on record, and by an unprecedentedly low tide, which was followed by high water. At Mobile, the barometric pressure began to fall rapidly early on the 20th and continued until a minimum of 28.77 inches was reached. A slight increase to 29.82 was then followed by a fall to 28.76 inches, after which there was a rapid rise. A total precipitation of 19 inches was recorded at Bay Minette, Alabama. The wind velocity was 75 miles per hour or greater for over 9 hours, with a maximum for five minutes of 94 miles per hour from the north. The northerly winds drove the water out of the bay, causing the tide to decrease steadily until an unprecedented low stage of 10.5 feet below mean sea level occurred. The wind then gradually shifted to a southerly direction and a high tide of 4.5 feet above mean sea level was reached. The exceedingly low tide caused the retaining pilings of some of the older docks to give way, resulting in an estimated $60,000 in damage. No substantial buildings were demolished, but chimneys, sheds, fences, sign boards, and power poles were blown down, glass windows broken, and roofs torn off. The wind and rain caused considerable damage to crops in Mobile and Baldwin Counties. Monetary damages were estimated at $175,000 to the pecan crop and $2,500,000 to the cotton crop. About one-quarter of the corn crop was lost, and the damages to other crops were extensive. Some tracts of land had as much as half of the timber felled. Shipping suffered only minor damages because of the advance warning. The total estimated damages for the two counties amounted to $5,000,000. Damage caused by the storm extended some distance inland in southern Alabama. At Jackson, 3 persons drowned when the wind capsized a skiff.

73. <u>17 August 1969</u>. - Hurricane Camille, tightly formed and said to be the most intense hurricane on record to enter the United States mainland, was first reported as a tropical storm in the Caribbean near Grand Cayman Island on 14 August 1969. The storm moved forward north-northwest increasing in intensity. When the center was 140 miles southeast of New Orleans, central pressure was measured at 26.61 inches of mercury, third lowest in history, and surface winds were calculated at 201.5 m.p.h. On 17 August 1969, the storm crossed the Mississippi coast, the eye centered near Bay St. Louis, with winds approaching 200 m.p.h. and tides ranging up to 22 feet above normal, bringing death and destruction. Camille continued her northward movement through Tennessee, Kentucky, West Virginia, and Virginia with heavy rains creating flash floods. Camille killed 262 persons, left tens of thousands homeless, and inflicted over one-half billion dollars in damages in Mississippi and Alabama alone.

74. Although Mississippi bore the brunt of the hurricane, Mobile experienced 44 mile an hour winds with extreme gusts of 74 miles per hour. The lowest barometric pressure in Mobile was 29.44 inches and 6.05 inches of rainfall were recorded over a 32-hour period, 17-18 August. High water elevations recorded were 7 feet above mean sea level (m.s.l.) at the Alabama State Docks in Mobile, 9.2 feet above m.s.l. at Dauphin Island, and 9.1 feet above m.s.l. at Gulf Shores. 82,400 of the county's 794,200 acres were flooded. All the islands along the Alabama coast were completely covered by flood waters, except Dauphin Island, which experienced about 70 percent inundation. Pelican Island, a low sand bar opposite Dauphin Island, disappeared completely.

75. In Alabama, greatest damage was to the causeway (U. S. Highway 90) across upper Mobile Bay, linking Mobile with Baldwin County, and to the seafood villages of Bayou La Batre and Coden.

Extensive damages were sustained by the many motels, restaurants, service stations, and fishing camps lining the causeway. In Mobile, power and telephone service was disrupted and many streets littered by fallen trees and limbs. Sections of roadways in south Mobile County and on Dauphin Island were washed out or covered with sand. Table 15 presents a summary of estimated damages in inundated areas within Mobile County. An additional $6,109,700 in damages was experienced outside flooded areas. Of this total, $5,800,000 was attributed to agricultural losses.

Table 15

Summary of Estimated Damages within Inundated Areas in Mobile County (In $1,000) (Hurricane Camille, 1969)

Public Property	$1,477.0
Marine	230.0
Utilities	790.9
Transportation	1,139.7
Commercial	1,754.9
Private Property	1,481.9
Agricultural	200.0
Debris Removal	48.8
Total	$7,123.2

FLOOD DAMAGE · PROBLEMS

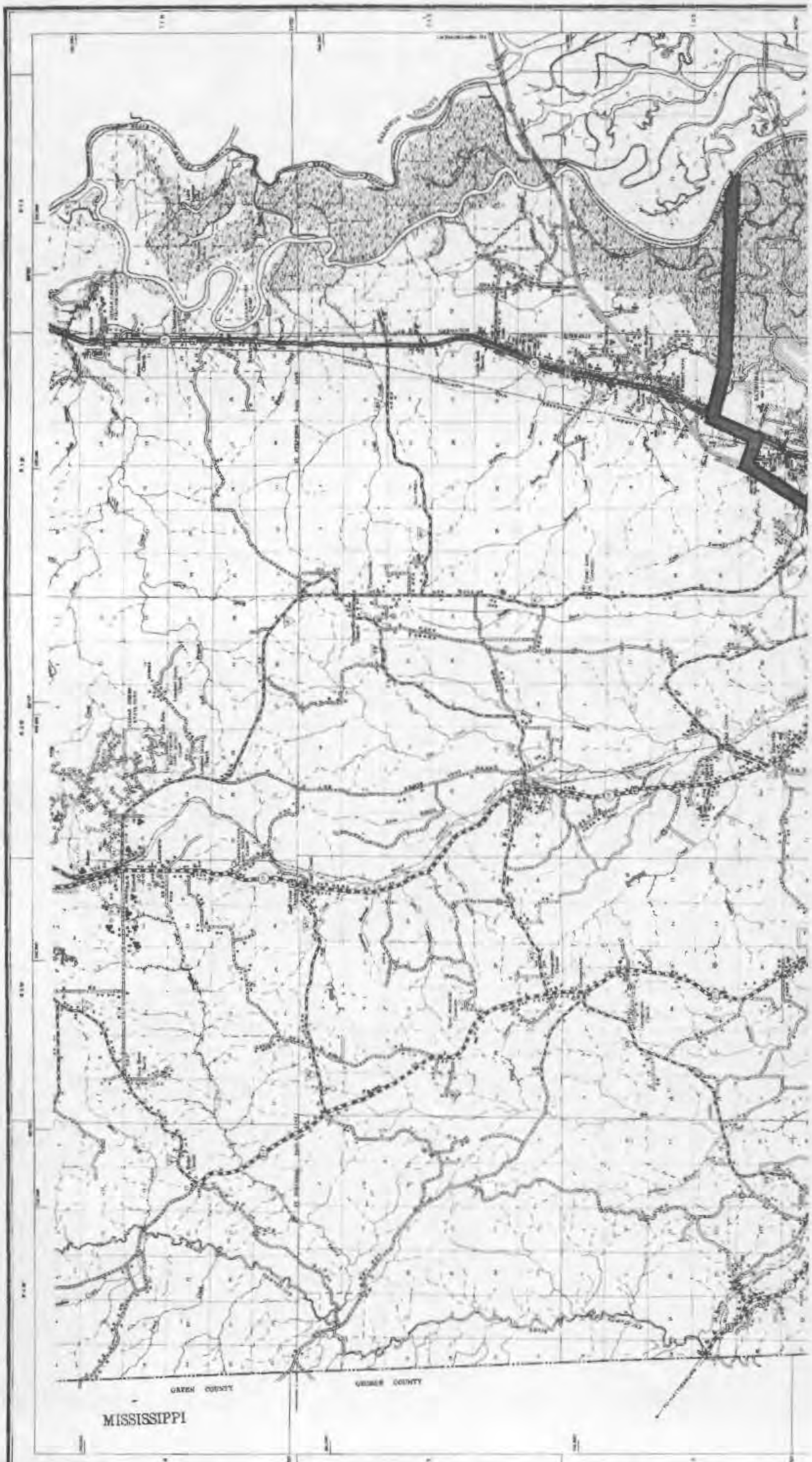
76. As part of the investigation, field surveys were made to determine the flood damage that would occur if the area came under the influence of hurricanes with recurrence intervals of 100 years and 500 years. To facilitate this survey, the area was broken up into 7 sections, as shown on figure 6. Data

from this survey, coupled with the stage frequency relations shown on figure 4, were used to develop damage frequency relations for each of the 7 areas. Based on these damage frequency relations, the total average annual flood damages stemming from hurricane surges that could be expected in the area were computed to be $3,998,000. The total flood damages that would accompany hurricanes with recurring intervals of 500 years were computed to be $186,144,000. Average annual damages by type of property and reach, are summarized in table 16.

Table 16
Summary of Average Annual Damages[1]
(In $1,000's)

Type of Damage	Reach 1	2	3	4	5	6	7	TOTAL	PERCENT OF TOTAL
Residential	669	28	763	140	298	77	22	1997	50.0
Commercial	645	1	82	9	3	51	-	791	19.9
Industrial	157	-	-	-	-	570	32	759	19.0
Institutional	58	1	63	-	2	3	-	127	3.2
Marine	94	44	9	-	110	26	29	312	7.8
Roads and Railroads	-	2	1	-	2	7	--	12	0.1
TOTAL	1623	76	918	149	415	734	83	3998	100.0

[1]Based on 1978 prices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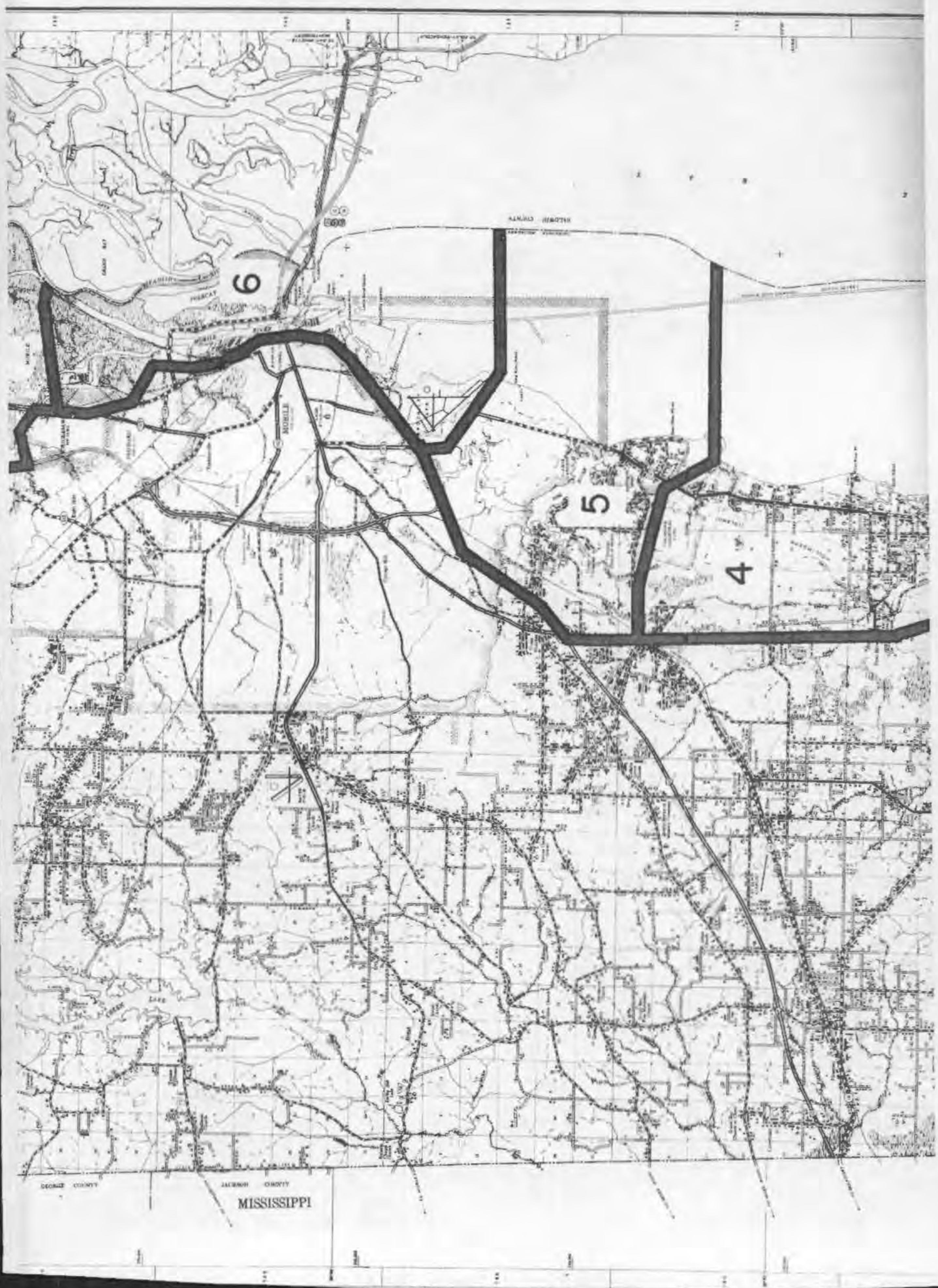
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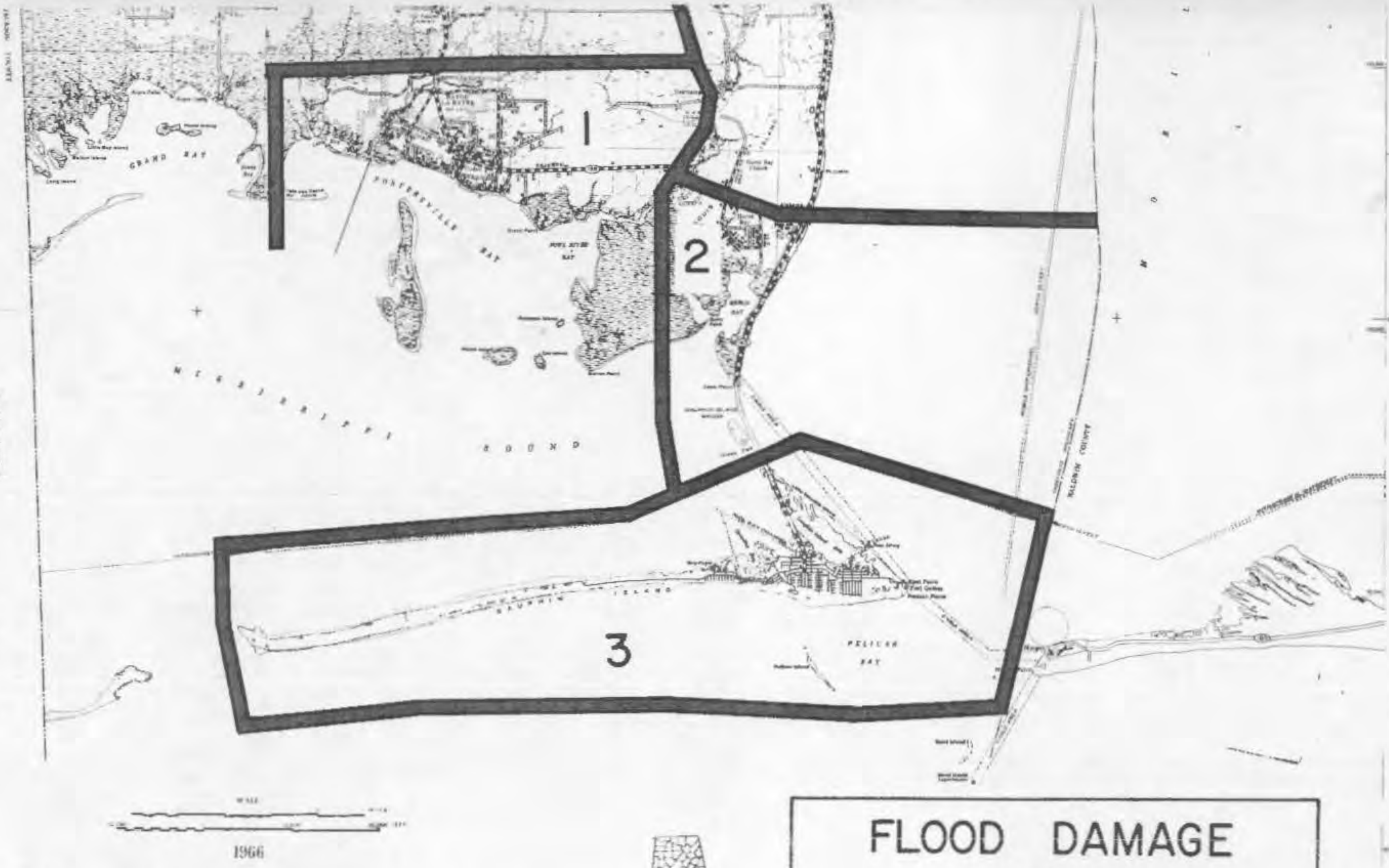


Figure 6

FLOOD DAMAGE SURVEY

STUDY AREA

Figure 6

NOTES:
MAP WAS TAKEN FROM GENERAL HIGHWAY MAP OF MOBILE COUNTY ALABAMA, PREPARED BY THE ALABAMA STATE HIGHWAY DEPARTMENT AND DATED 1966.
NUMBERS MARK THE SEVEN FLOOD DAMAGE AREAS.

THE EROSION PROBLEM

77. Data concerning historical shoreline changes presented herein were extracted from Shoreline Change Maps prepared by the Corps Coastal Engineering Center, and the Geological Survey of Alabama publication, "Shoreline and Bathymetric Cahnges in the Coastal Area of Alabama"[14]. Data used during the preparation of that document included historical and recent nautical charts by the National Ocean Survey, maps prepared by the French colonists, topographic surveys by the U. S. Geological Survey, available aerial photos, and a remote-sensing approach, including Skylab and Landsat - 1 imagery. The various factors contributing to the erosion problems are discussed in the following paragraphs.

SEA LEVEL RISE

78. There have been numerous technical reports on sea level rise published in recent years documenting the fact that sea level is rising slowly and irregularly. Among these are:

a. Per Brunn, W. H. M., (1962), Sea Level Rise As A Cause of Shore Erosion; Engineering Progress at the University of Florida; Leaflet No. 152, Gainesville, FL, (Also published as ASCE Paper 3065, February, 1962, 117-130).

b. U. S. National Ocean Survey, (1973), Trends and Variability of Yearly Mean Sea Level (1893-1970), NOAA Technical Memorandum Nos. 12, Rockville, M.D.

c. King, C. A. M., Beaches and Coasts, 2Ed., St Martin's Press, New York.

Two of these reports (a and c) discuss the beach processes and erosion rates that are affected strongly by variation in sea levels.

79. Plate II shows a plot of the annual mean and 5-year moving average of the sea level stages as recorded at Biloxi, Mississippi. Based on this curve, the average rate of rise between 1896 and 1972 was .009 feet per year. Similarly, the average rate of rise between 1940 and 1972 was about .012 feet per year. The following formula (developed by Per Brunn) can be used for computing the rate of shoreline recession from the rate of sea level rise:

$$x = \frac{ab}{(e+d)}$$

x = shoreline recession per year

a = sea level rise per year

b = distance from shoreline to 60 ft. depth

e = elevation of dune line

d = 60 feet

This formula is based on the assumption that, with a rise in sea level, the nearshore zone is modified by the littoral forces so as to reestablish the same depths relative to the water surface that existed prior to the sea level rise. Based on the above formula, the average shoreline recession attributable to sea level rise between 1896 and 1972 and between 1940 and 1972 was 4.57 feet per year and 6.09 feet per year, respectively.

HISTORIC SHORELINE CHANGES

80. Mobile Harbor Region. - As indicated on figures 7 and 8, the Mobile Harbor region is located along the northwest shore of Mobile Bay, near the mouth of the Mobile River. The most significant characteristic of the area is the extensive accretion of shoreline caused by dredged material disposal and land fill carried out in the development of the harbor and the adjacent industrial complexes. It is estimated that about 1650 acres of land build-up has occurred in the area since 1917. Actual areas of fill for various intervals of time are shown on table 17.

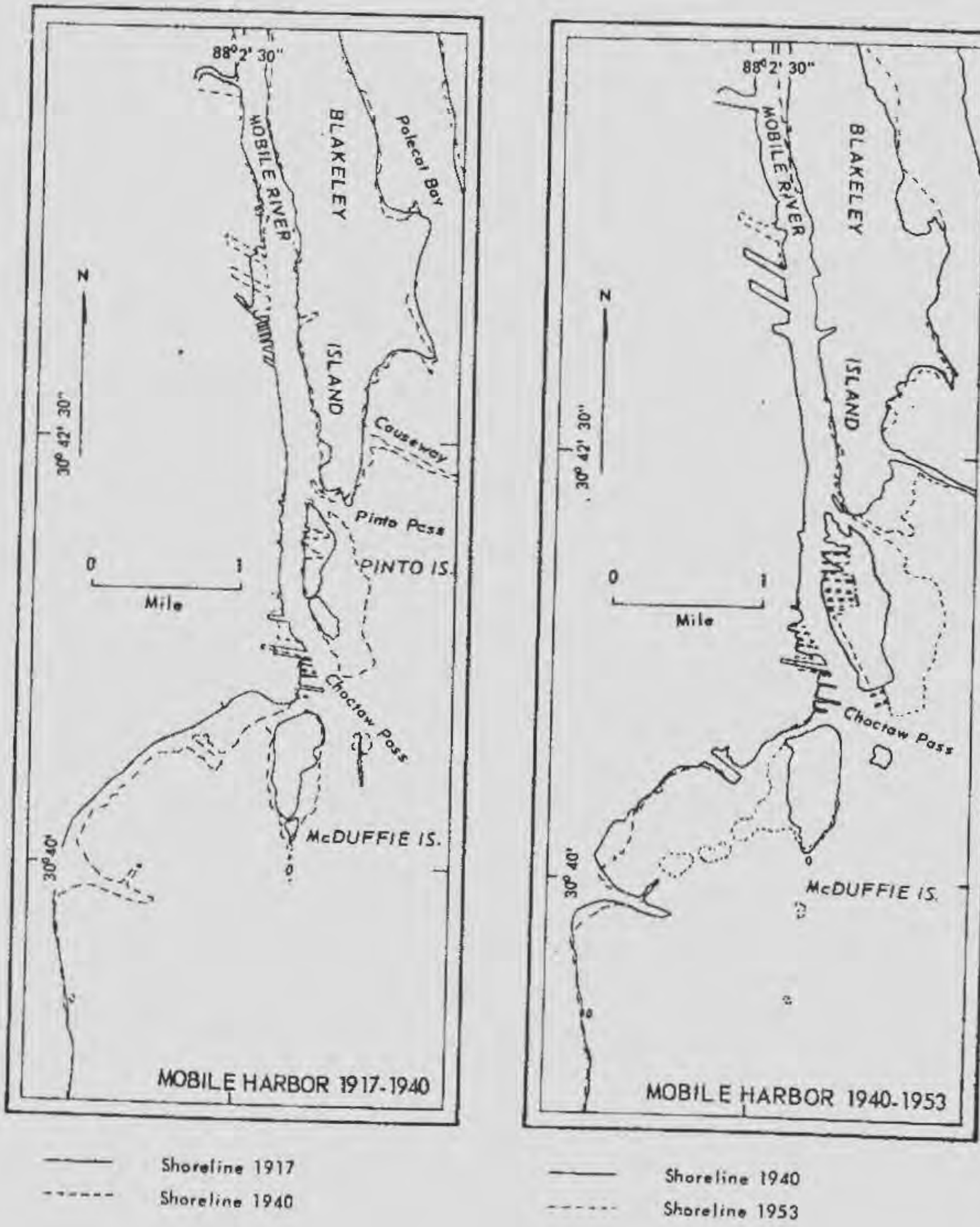


Figure 7 --Areas of shoreline changes in Mobile Harbor between 1918-1940 and 1940-1953

Drawing taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

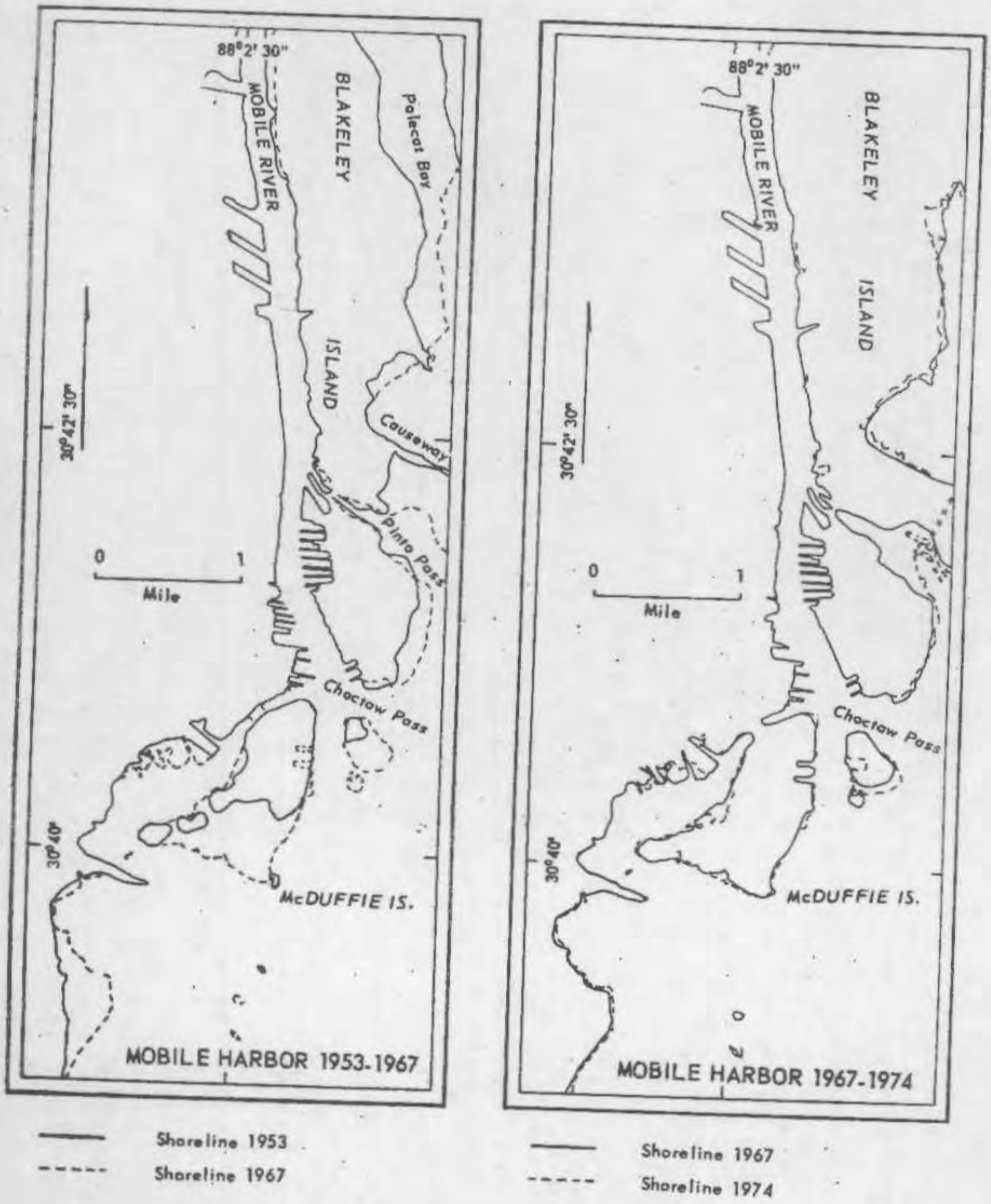


Figure 8 --Areas of shoreline changes in Mobile harbor between 1953-1967 and 1967-1974.

Drawing taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

Figure 8

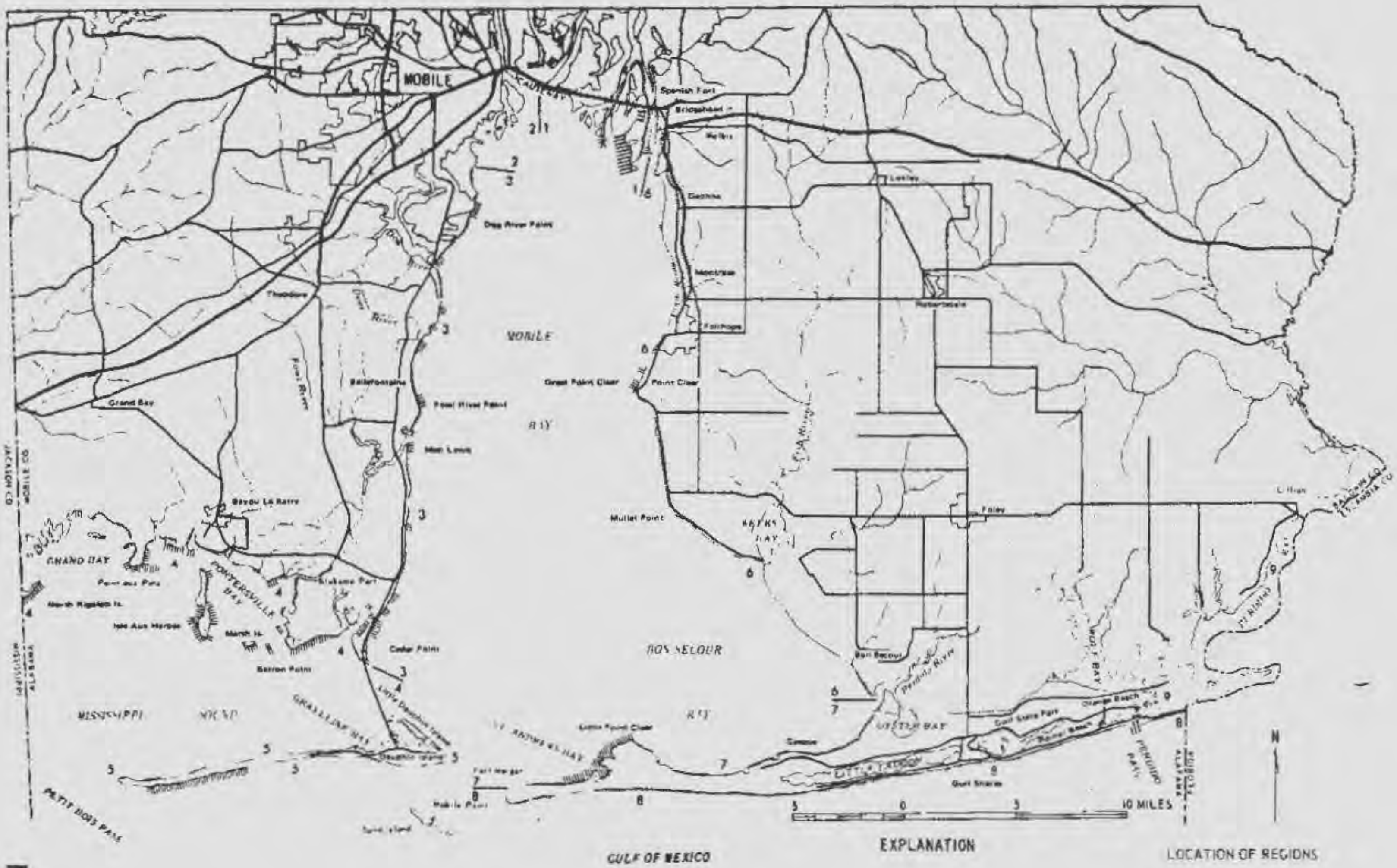
Table 17

Areas of Land Fill - Mobile Harbor Area

Period	Area Build-Up (Acres)
1917-1940	214
1940-1955	200
1955-1967	279
1967-1974	558

81. Western Shore Region. - The western shore area is considered to extend along the western shore of Mobile Bay from the Brookley Aerospace Complex to Cedar Point. As shown on figure 9, erosion has occurred along the entire reach of shore within this region. Measurements for the erosion that has occurred at several identifiable points are listed on table 18. As this table shows, loss of land to erosion at measured points has ranged from 39 feet at Pt. Judith to 488 feet at Cedar Point.

82. North Shore Mississippi Sound. As indicated on figure 9, most of the shore within this region is experiencing erosion. The amount of erosion measured at selected points is shown on table 19. The rate of erosion within the region varies from about 0.5 feet per year along the shores of Grand Bay, to 10.5 feet per year along the Portersville Bay shore of Marsh Island.



EXPLANATION

SHORELINE EROSION

—	0-5 feet per year
IIIII	5-10 feet per year
IIIII	More than 10 feet per year

Base periods vary with location

GEOLOGICAL SURVEY OF ALABAMA
REMOTE SENSING TOPOGRAPHY DIVISION

LOCATION OF REGIONS

1 Mobile delta
2 Mobile harbor
3 Western shore
4 Mississippi Sound, north shore
5 Dauphin Island
6 Eastern shore
7 Morgan Peninsula, bay shore
8 Gulf shore
9 Perdido Bay

Figure 9

Drawing taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

HISTORIC TRENDS OF SHORELINE CHANGES, ALABAMA COASTAL AREA 1917-1974

TABLE 18

Shoreline changes measured at selected identifiable points along the western shore of Mobile Bay.

	Location	*Change**	*Time Period*	*Average annual change*
1.	Dog River Point (at bench mark)	-275 ft (-83.8 m)	1917-1967	5.51 ft (1.68 m)
2.	Mobile Yacht Club (at pier)	-394 ft (-120.1 m)	1917-1967	7.87 ft (2.40 m)
3.	Deer River Point (at new pier)	-157 ft -47.9 m)	1917-1967	3.15 ft (0.96 m)
4.	Bellefontaine (at name on map)	-118 ft (-36.0 m)	1917-1958	2.88 ft (0.88 m)
5.	Sunny Cove (at name)	-173 ft (-52.7 m)	1917-1958	4.23 ft (1.29 m)
6.	Fowl River Point (at bench mark)	-142 ft (-43.3 m)	1917-1958	3.46 ft (1.05 m)
7.	Mon Louis (at name)	-79 ft (-24.1 m)	1917-1958	1.93 ft (0.59 m)
8.	Faustinas (at name)	-98 ft (-29.9 m)	1917-1958	2.40 ft (0.73 m)
9.	Pt. Judith (at name)	-39 ft (-11.9 m)	1917-1974	0.68 ft (0.20 m)
10.	Alabama Port (at name)	-142 ft) (-43.3 m)	1917-1974	2.49 ft (0.76 m)
11.	Cedar Point (at 30°20'00"N. latitude	-354 ft (-107.9 m)	1917-1974	6.22 ft (1.90 m)
12.	Cedar Point (at Hwy 163 symbol)	-488 ft (-148.7 m)	1917-1974	8.56 ft (2.61 m)

*Positive changes show accretion; negative changes show erosion.

Table taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

TABLE 19

Shoreline changes measured at selected identifiable points along the northern shore of Mississippi Sound.

Location	Change*	Time period	Average annual erosion
1. Barron Point	-315 ft (-96.0 m)	1917-1955	7.68 ft (2.34 m)
2. Cat Island (southeast shore)	-331 ft (-101 m)	1917-1958	8.07 ft (2.46 m)
3. Marsh Island (southeast shore) (Portersville Bay)	-434 ft) (-132 m)	1917-1958	10.56 ft (3.77 m)
4. Isle aux Herbes (eastern shore)	-236 ft (-71.9 m)	1917-1958	5.76 ft (1.76 m)
5. Isle aux Dames (long. 88°18'00"W.)	-276 ft (-81.1 m)	1917-1958	6.72 ft (2.05 m)
6. Point aux Pins (at range line)	-236 ft (-71.9 m)	1917-1958	5.76 ft (1.76 m)
7. Marsh Island (mid-island) (Grand Bay)	-157 ft (-47.9 m)	1917-1958	3.84 ft (1.17 m)
8. Grand Batture Islands (South Rigolets Island, 1,000 m east of state line)	-393 ft (-120 m)	1917-1958	9.60 ft (2.93)

*Positive changes show accretion; negative changes show erosion.

Table taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

83. Dauphin Island. The shoreline of Dauphin Island has been greatly modified throughout its known history. Shortly after 1717, a Frenchman, Sr DuSault[15], produced a map of the island that indicated that Dauphin Island and Petit Bois Island were one. Surveys made between 1848 and 1852, as shown on a U. S. Coast and Geodetic Survey (USCGS) chart dated 1894, show Petit Bois Pass to be well-developed with a width of about 1.6 miles and a maximum depth of about 18 feet. At that time, the inlet gorge of the pass was about 3.8 miles east of its present location. The westward movement of the inlet gorge, the eastern end of Petit Bois Island and the western end of Dauphin Island, as well as the widths of Petit Bois Pass for various periods of time, are shown on table 20. Bathymetric contours of Petit Bois Pass for 1917, 1933, 1961 and 1973 are shown on figures 10 and 11. A cross-section of the pass developed from data taken from U. S. Department of Commerce Chart #11373 dated 1973, is shown on figure 12.

TABLE 20

Historic Data on Petit Bois Pass 1/

Year	Pass Width (Miles)	WESTWARD MIGRATION (MILES)		
		West End 2/ Dauphin Is.	Inlet Gorge	East End Petit Bois Is.
1848-50	1.59	0	0	0
1917	4.11	2.80	3.42	5.17
1933 3/	4.11	2.80	3.42	5.17
1957-61	5.13	4.17	3.62	7.61
1973 4/	5.28	4.47	3.82	8.05
Total 1848 to 1973		4.47	3.82	8.05

1/ Taken from CERC Shoreline change Maps except where indicated

2/ Measured west from 1848-50 position

3/ From Reference 1

4/ From USCGS Chart

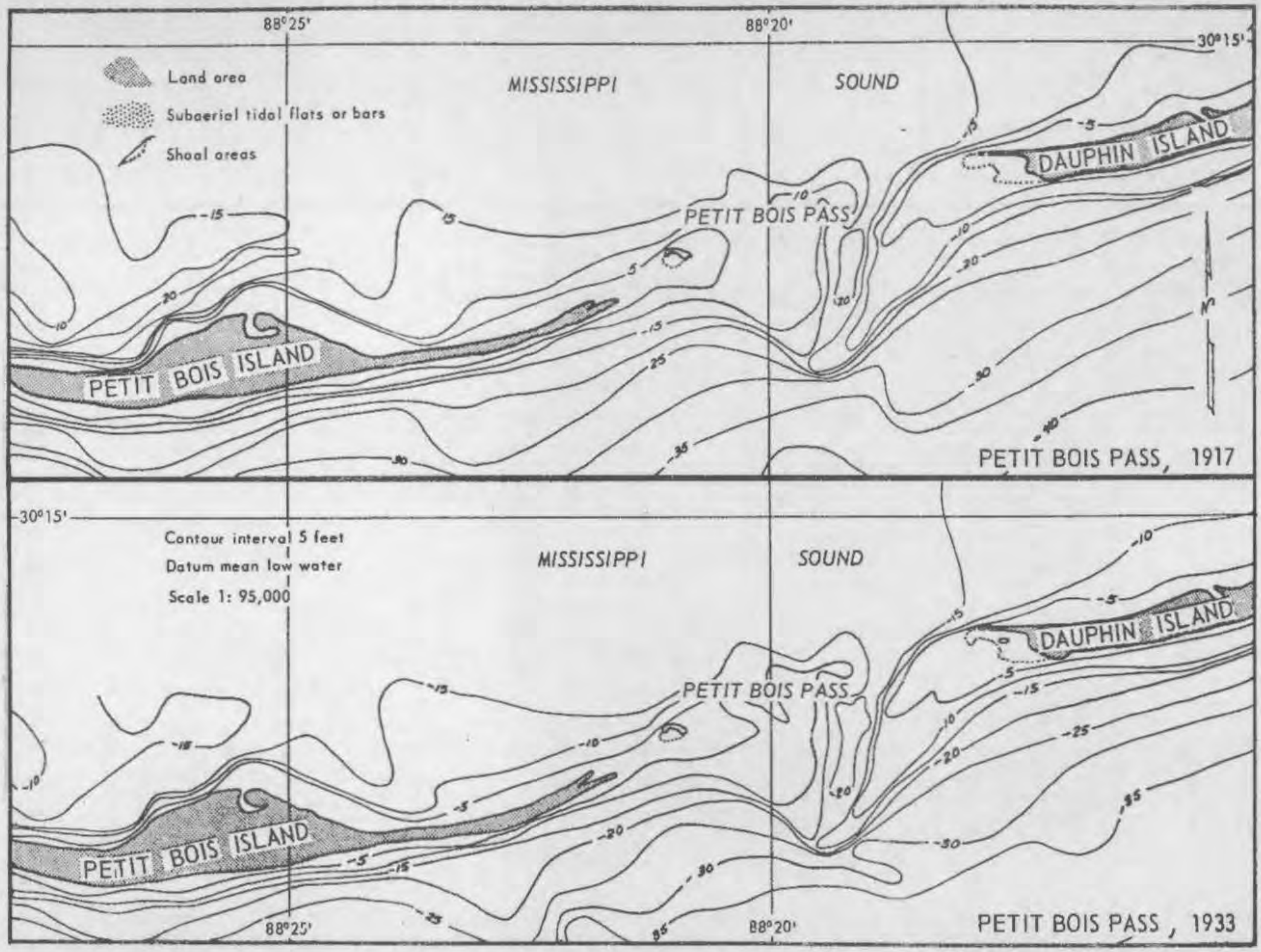


Figure 10--Bathymetric contours, Petit Bois Pass, 1917 and 1933 (data from USCGS charts 1267, 1917 and 1933).

Drawing taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976.

Figure 10

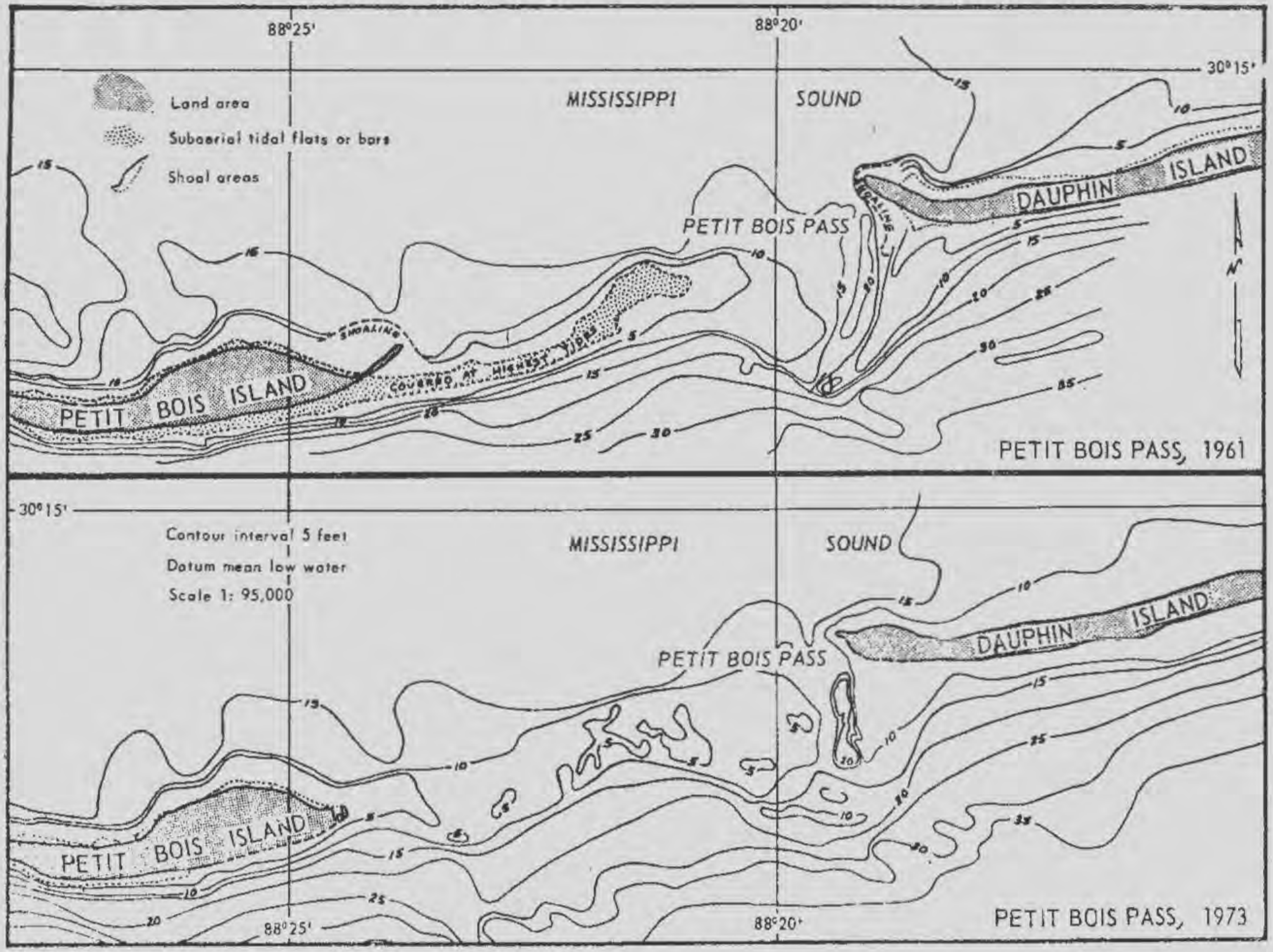
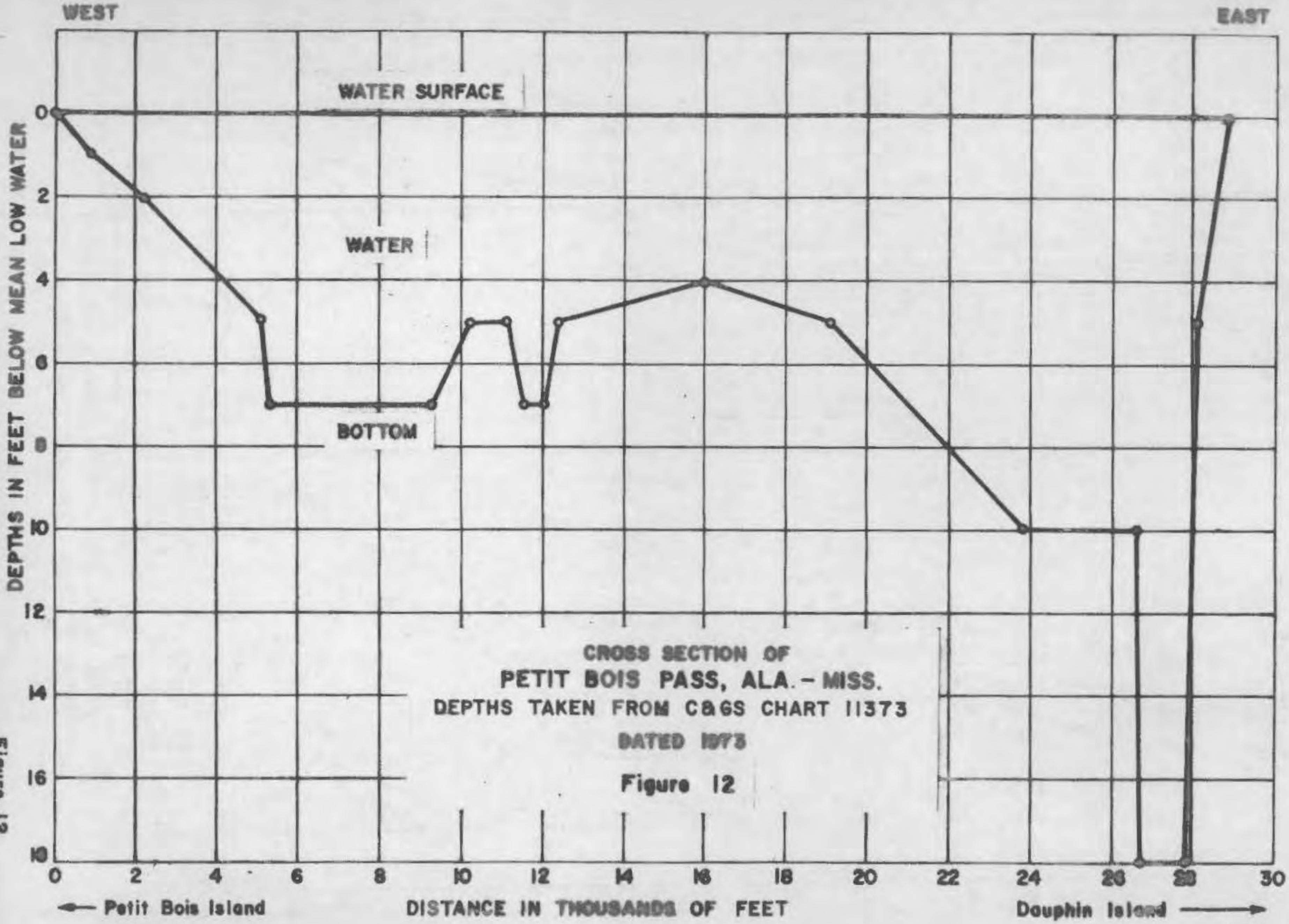


Figure 11.--Bathymetric contours, Petit Bois Pass, 1961 and 1973 (data from USCGS charts 873, 1962, and 1267, 1973).

Drawing taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

Figure 11



CROSS SECTION OF
PETIT BOIS PASS, ALA. - MISS.
DEPTHS TAKEN FROM C&GS CHART 11373
DATED 1973

Figure 12

Figure 12

84. Between 1909 and 1917, hurricane surge and associated waves breached Dauphin Island dividing it into two small islands separated by 5.3 miles of open water, shoals and scattered remnants of the former island. The western and eastern islands were 3.8 miles and 4.2 miles long, respectively. Between 1917 and 1942, the inlet was filled by natural processes, thus rejoining the two islands. The island was breached again during the 4 September 1948 hurricane. The width of this breach is not known; however, aerial photos taken March 1950 show a diagonal breach about 1400 feet wide. Shoreline changes that occurred between 1917 and 1974 are shown on figures 13 and 14. The rate of erosion along the gulf shore of the island at Bienville Beach and in the west central section of the island are illustrated on figure 15. Based on these data, the average rate of shoreline recession along the entire gulf shore of Dauphin Island during the period between 1942 and 1974 was about 6.3 feet per year. During this same period, the average rate of erosion along the western section of the island was about 10.3 feet per year. These figures indicate that, during this time, the east end of the island was relatively stable.

85. These rates of erosion exclude the accretion on the western end of the island. Shoreline changes that have occurred on the east end of Dauphin Island between 1850 and 1957 are shown on figure 16. As noted on this figure, the shoreline in the vicinity of the west boundary of the inlet bar has changed greatly over the period of record, as indicated by the movement of Sand and Pelican Islands. Between 1850 and 1868, the shore in this area accreted about 2000 feet of width, then lost about 1800 feet to erosion over the next 24 years.

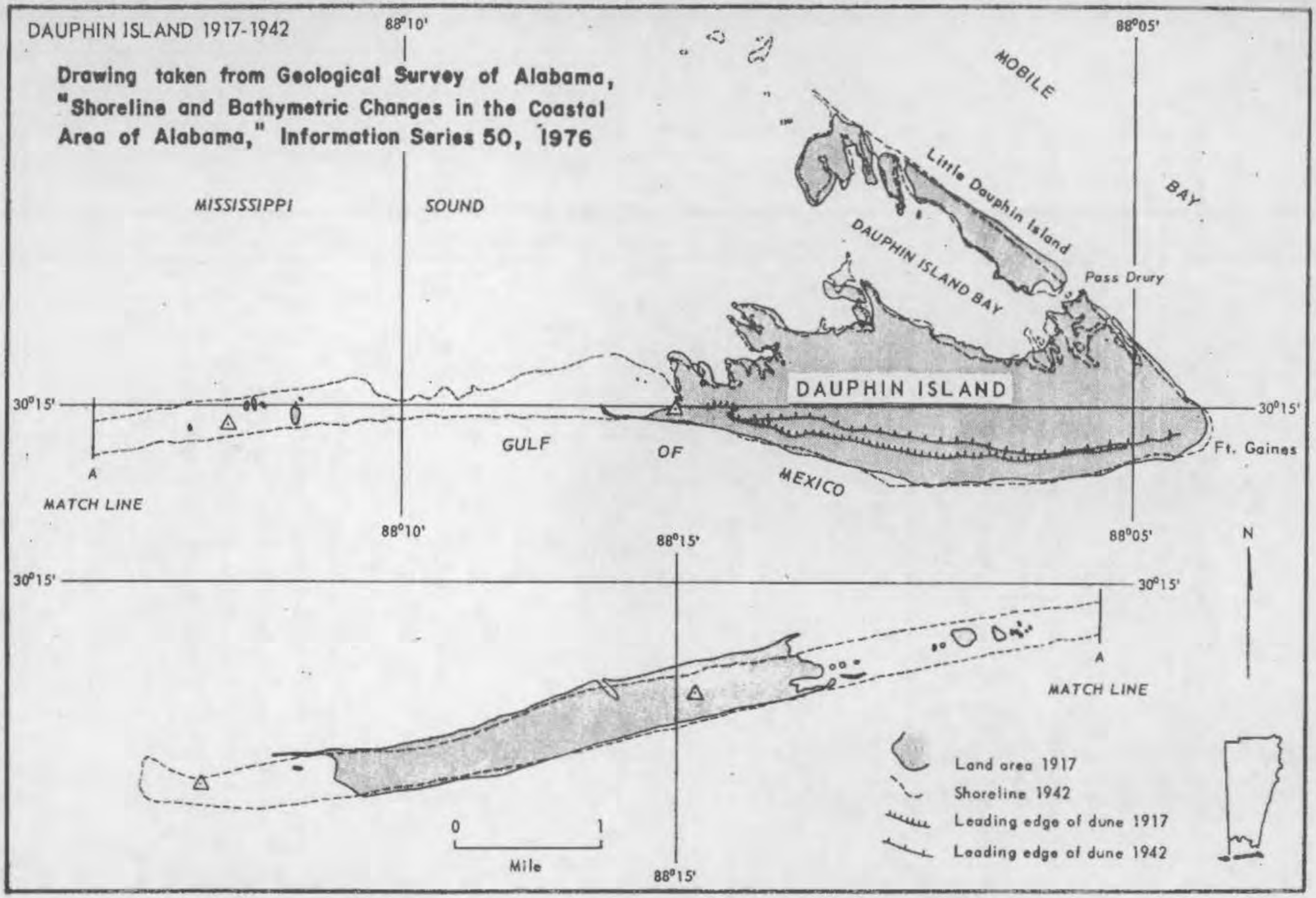


Figure 13 Areas of shoreline changes at Dauphin Island between 1917 and 1942.

Figure 13

Figure 14

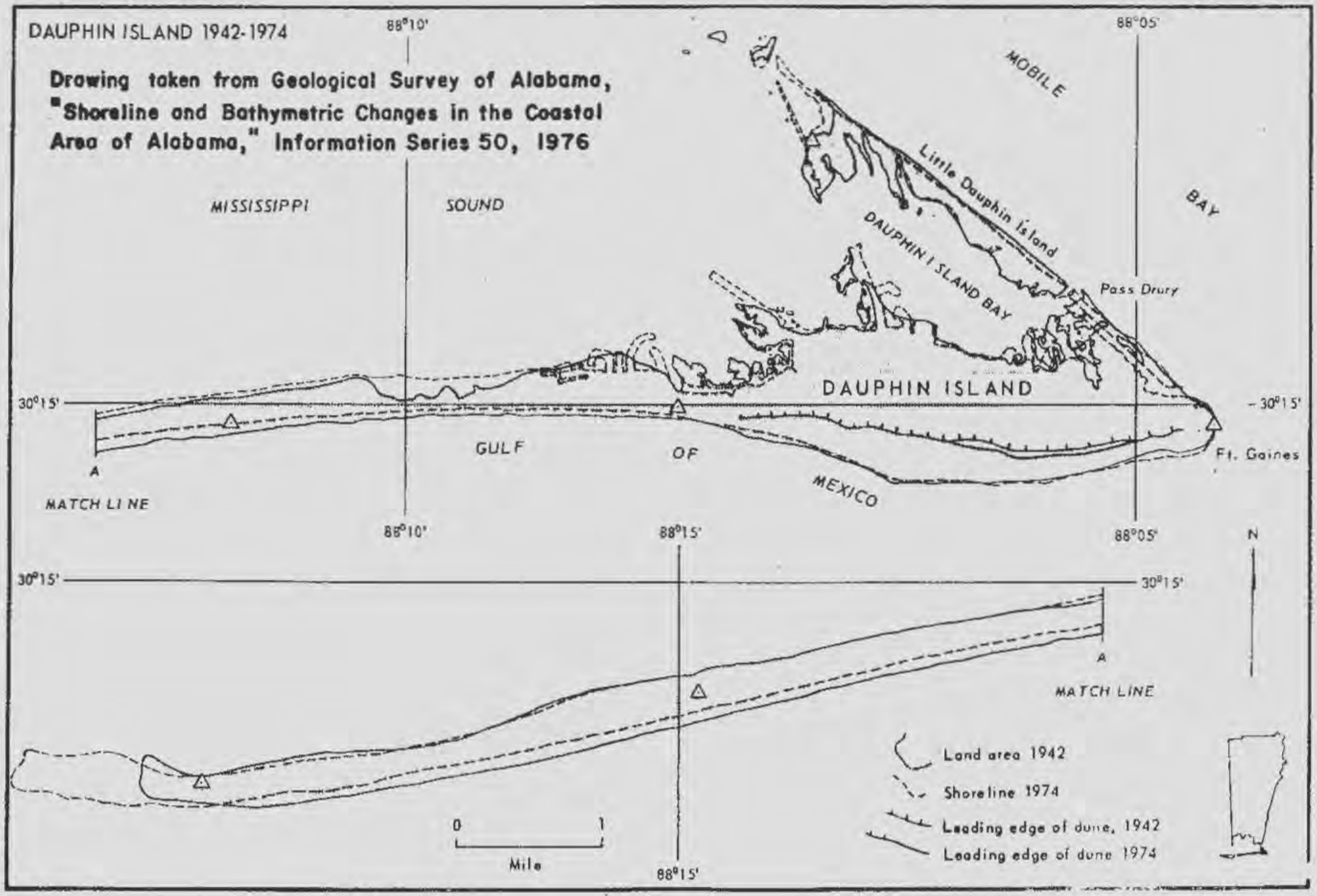


Figure 14 Areas of shoreline changes at Dauphin Island between 1942 and 1974.

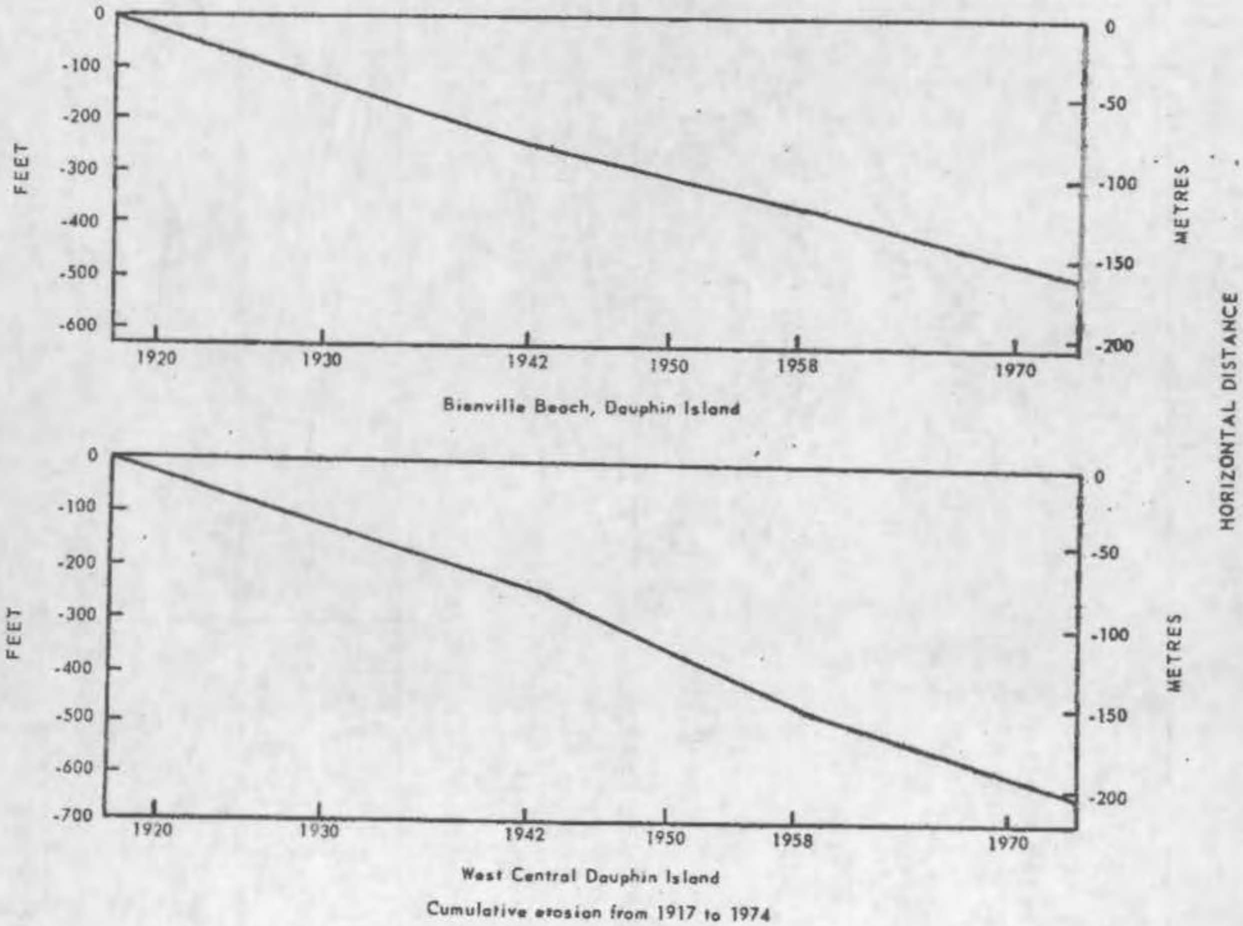
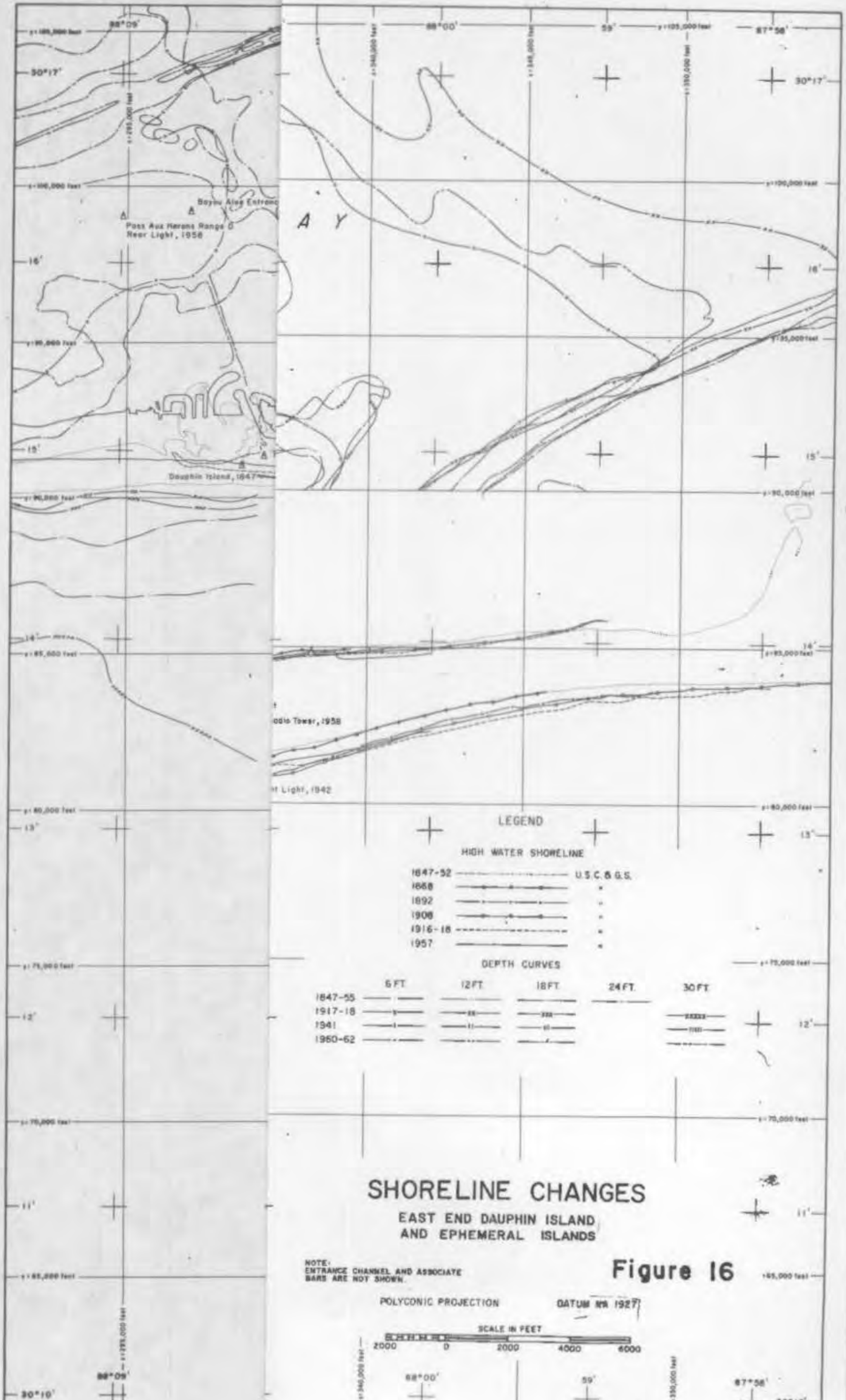


Figure 15 Changes in the rates of erosion for various time periods for Bienville Beach, Dauphin Island (88 07'W.) (upper graph) and west-central Dauphin Island (lower graph).

Drawing taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

Figure 15



SHORELINE CHANGES
EAST END DAUPHIN ISLAND AND EPHEMERAL ISLANDS

Figure 16

86. In summary, during the early part of the 18th century, Dauphin Island and Petit Bois Island were one. By 1848, Petit Bois Pass had divided the island and the gorge of this pass was well-formed and located about 3.8 miles east of its present position; however, most of the western movement of the gorge, 3.4 miles, occurred between 1848 and 1917. Since 1848-1850, the west end of Dauphin Island, the east end of Petit Bois Island and the inlet gorge have moved 4.47 miles, 8.05 miles and 3.82 miles to the west, respectively. In recent years, the rate of western movement of the east end of Petit Bois Island has significantly decreased, and Dauphin Island has started encroaching into what had previously been a relatively stable channel. Surveys made in 1973 indicate that the gorge is not as well-formed as previously and that shoaling is occurring. These surveys also indicate that a second inlet gorge is forming about 3 miles to the west of the present gorge. Accordingly, it is reasonable to assume that Dauphin Island will build across the existing gorge and the new gorge will be deepened by tidal currents. Following the closing of the existing gorge, it is expected that the east end of Dauphin Island will continue to be built to the west, only at a higher rate than during previous years. Since the east end of Petit Bois Island is presently much wider than in past years, it is expected that the rate of movement of this end of the island to the west will be much less than during past years. Consequently, it is probable that the width of Petit Bois Pass will decrease and that the inlet channel will be about 3 miles west of its present position. However, should the area come under the influence of a major hurricane, the island could be breached and new inlets cut through the island as has occurred in the past.

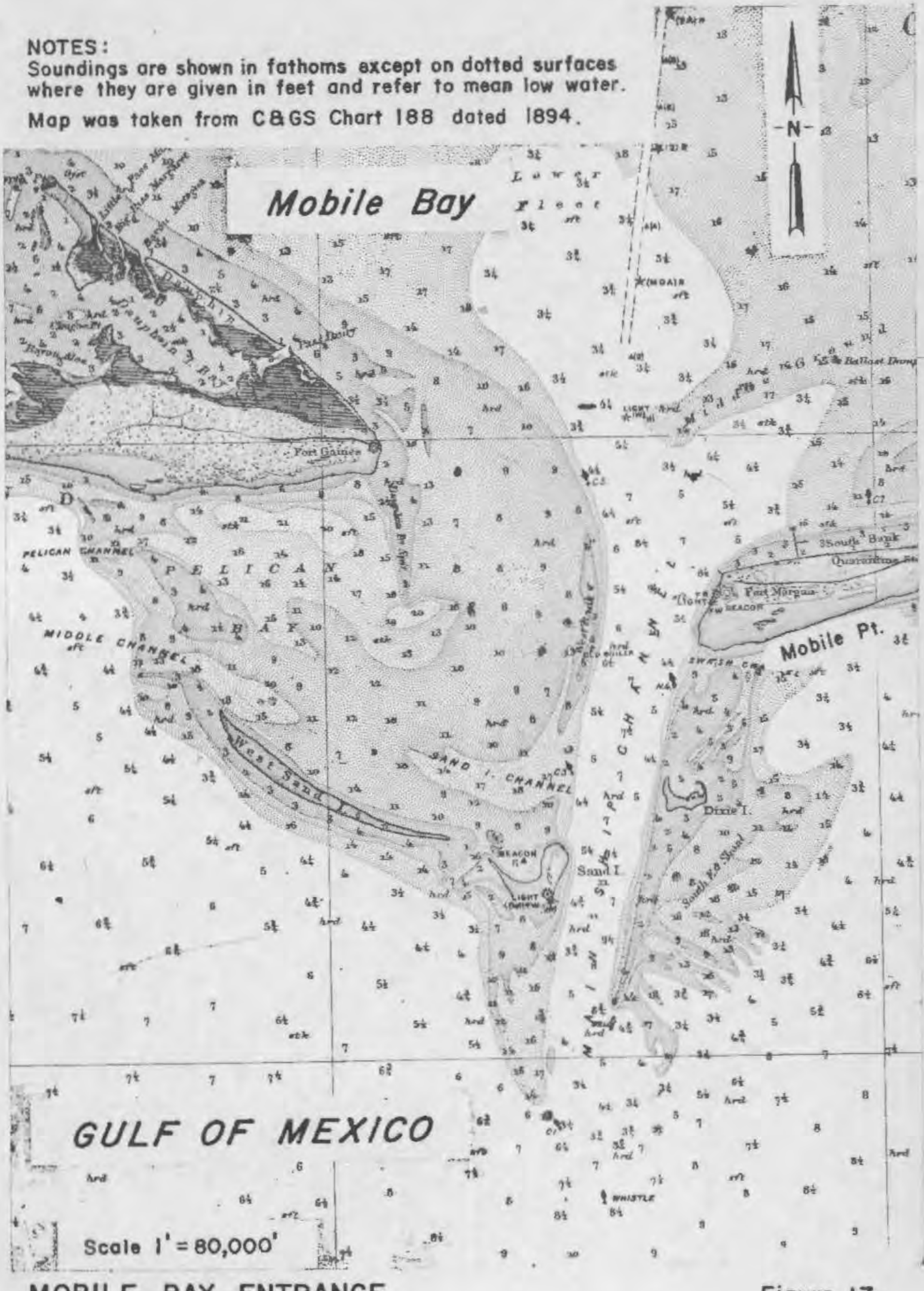
87. Main Entrance Channel. The main entrance to Mobile Bay from the gulf developed from surveys taken between 1847 and 1852, and mapped on USCGS chart dated 1894, is shown on figure 17. At that time, the throat of the inlet gorge had a depth of 57 feet. The maximum depth of the gorge was 66 feet and the depth of water over the outer bar was about 20 feet. The bar fronting the inlet contained about 750 million cubic yards of material and several ephemeral islands, Dixie Island, Sand Island, and West Sand Island.

88. The bar fronting the inlet was comprised of two bars cut by the inlet channel. The bar to the east of the channel was cut by a 7-foot deep swash channel near Mobile Point. The depth of the bar on each side of Dixie Island was about 2 feet. The east bar contained an estimated 227 million cubic yards of material. The bar to the west of the channel contained about 510 million cubic yards of material. Pelican Bay, located on the west bar and protected by Sand Island and West Sand Island, had a depth of about 20 feet and was connected to the gulf by several channels; Pelican Channel with a depth of about 12 feet, Middle Channel with a depth of about 12 feet, and an unnamed channel near Sand Island with a depth of about 7 feet.

89. Figure 18 shows this same area developed from surveys taken between 1909 and 1915, as shown on USCGS chart dated 1916. At that time, the depth in the throat of the inlet gorge was 54 feet, 3 feet less than in 1850. The maximum depth of the gorge was 57 feet, 9 feet less than in 1850; and the depth of water over the outer bar was about the same as in 1850, 20 feet. This survey also showed that the depth of the water over the bar east of the gorge had increased from about 2 feet in 1850 to about 9 feet with Dixie Island completely eroded away. On the bar west of the gorge, West Sand Island had elongated, Sand Island had eroded away, a new island, Pelican Island, had formed, and the depth of Pelican Bay had remained about the same.

NOTES:
Soundings are shown in fathoms except on dotted surfaces where they are given in feet and refer to mean low water.

Map was taken from C&GS Chart 188 dated 1894.

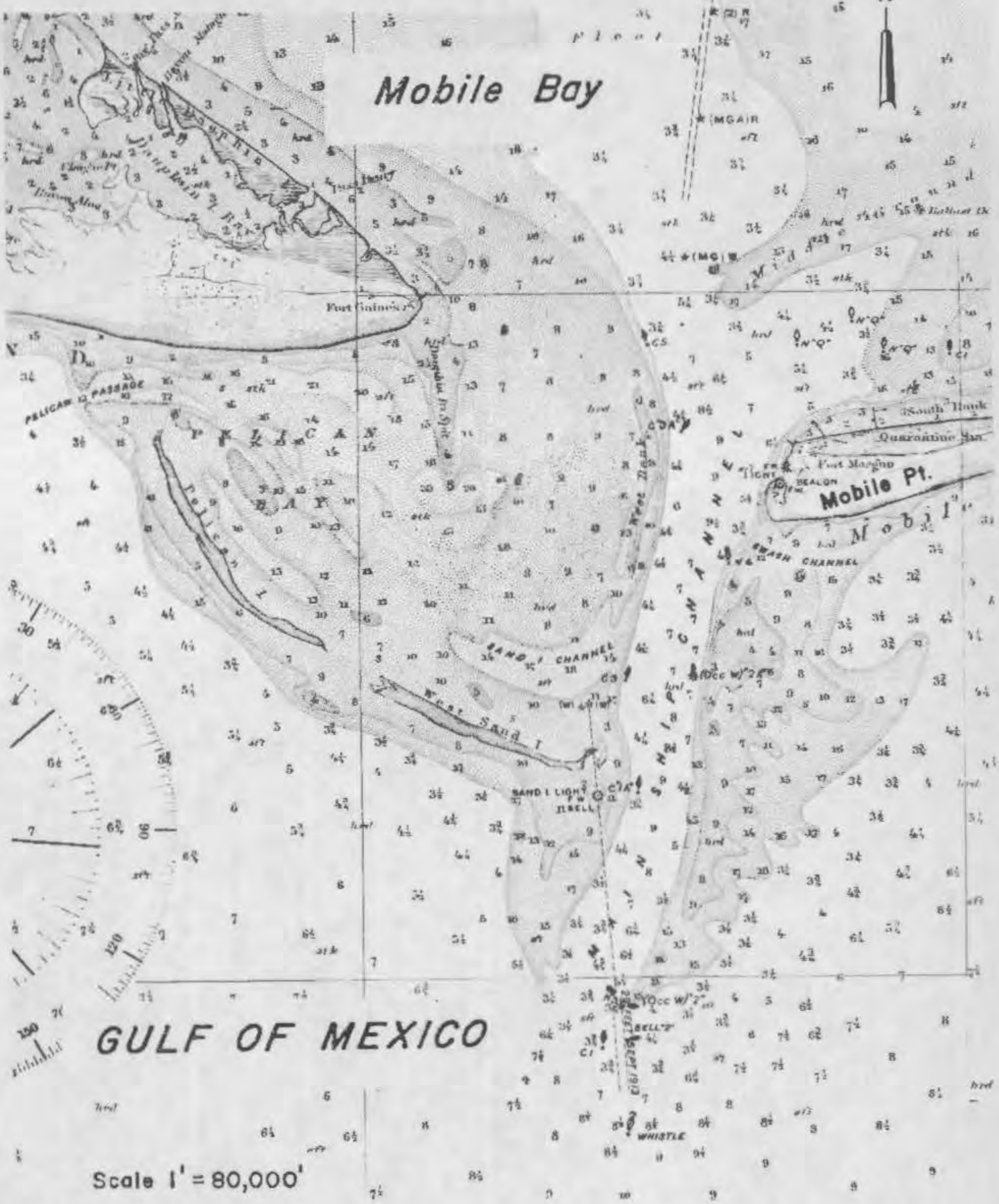


MOBILE BAY ENTRANCE

Figure 17

NOTES:
Soundings are shown in fathoms except on dotted surfaces where they are given in feet and refer to mean low water.

Map was taken from C&GS Chart 188 dated 1916.



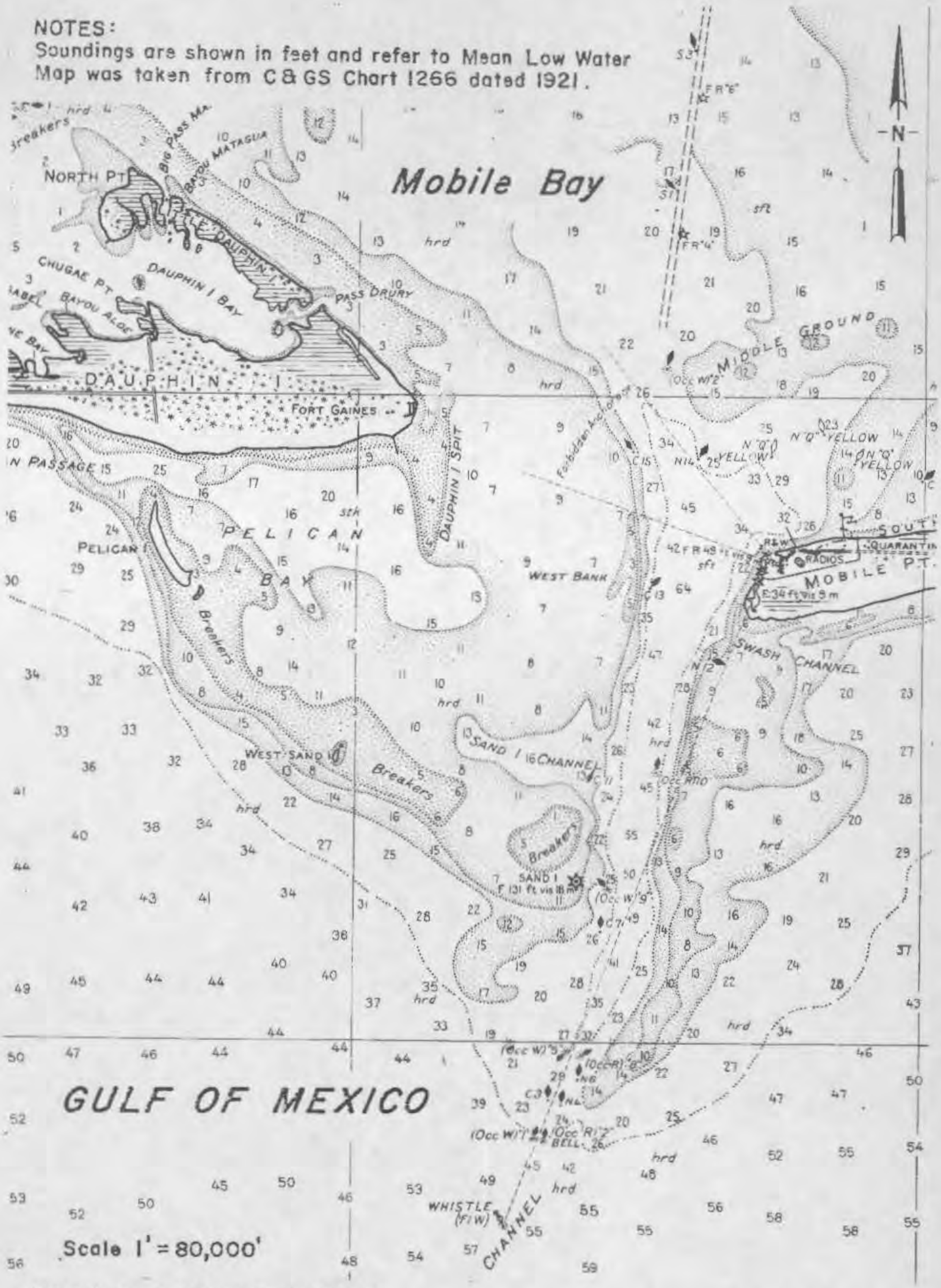
MOBILE BAY ENTRANCE

Figure 18

90. Figure 19, which was taken from USCGS chart dated 1921, shows the affect of the 1916 hurricane on the Mobile inlet. Comparing 1915 conditions to those shown in this figure, the depth of water in the throat of the inlet has been reduced from 54 feet to about 45 feet. The maximum depth of water in the gorge has increased from 57 feet to 64 feet. The depth of water over the bar to the east of the gorge has slightly increased, Sand Island has been eroded away, only a remnant of West Sand Island remains and Pelican Island has been reduced to about one-half of its 1915 size.

91. The Mobile inlet as shown on USCGS chart dated 1941, is shown on figure 20. No major storms affected the Mobile area between 1933 and 1941. Accordingly, this figure indicates the response of the inlet to littoral forces when not influenced by major storms. Comparing the 1941 conditions to those which existed in 1921, the depth of water in the throat of the inlet has increased from 45 feet to 59 feet; the maximum depth of water in the gorge has decreased from 64 feet to 59 feet; the depth of water over the bar to the east of the inlet has remained about the same; Sand Island is emerging; the remnant of West Sand Island has about doubled in size, and Pelican Island has moved slightly to the southeast and approximately doubled in size. Also during this period, significant dredging was performed on the outer bar. In 1932, a 32-foot deep channel was provided over the bar. This channel was deepened to 36 feet in 1939.

92. Figure 21 shows the condition of the inlet in 1973. During the 32-year period between 1946 and 1973, the inlet was under the influence of 7 hurricanes and the channel across the outer bar was deepened to 42 feet. At this time, the bar fronting the inlet contained about 750 million cubic yards of material;



MOBILE BAY ENTRANCE

Figure 19

Drawing taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

Figura 20

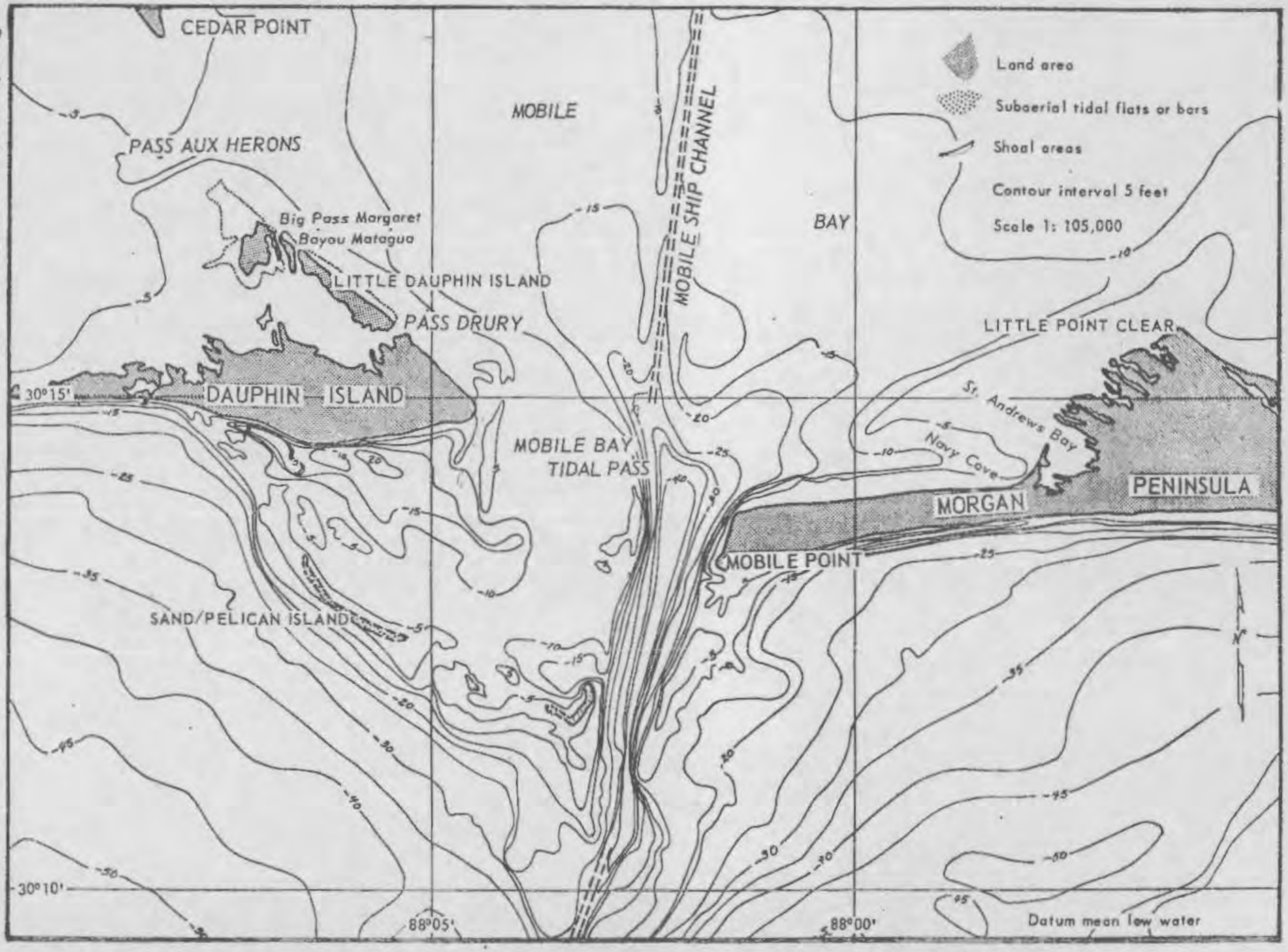


Figure 20 Bathymetric contours, Mobile Bay and associated passes, 1941 (data from USCGS chart 1266, 1941).

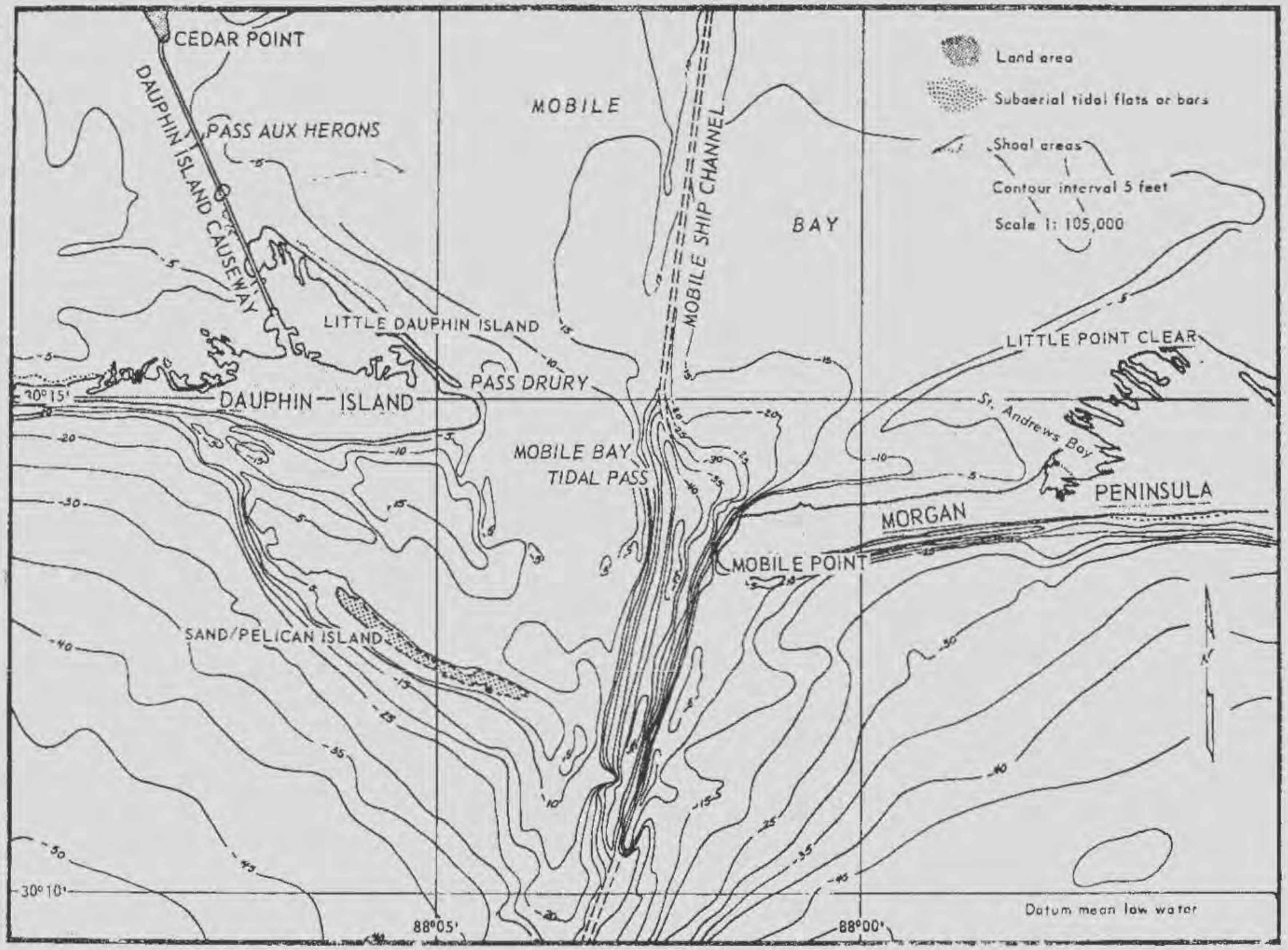


Figure 21 .--Bathymetric contours, Mobile Bay entrance and associated passes, 1973 (data from USCGS chart 1266, 1973).

Drawing taken from Geological Survey of Alabama, "Shoreline and Bathymetric Changes in the Coastal Area of Alabama," Information Series 50, 1976

Figure 21

the depth of water in the throat of the gorge was 44 feet; the maximum depth of the gorge was 52 feet and the depth of water over the bar east of the channel was about the same as in 1941. Also at this time, West Sand Island was the only ephemeral island on the bar.

93. Using 1850 as a base year, the changes that have occurred in the various components of the Mobile entrance inlet at various dates are indicated on table 21. As indicated on this table, the total volume of material in the bar system has remained about constant, however, the east bar has lost material and extended seaward while the west bar has accreted material. Water over the west bar has become shallower. The 30-foot depth contour has remained about constant and the toe of the bar has moved seaward. The gorge of the entrance channel has become shallower. A 42-foot deep channel has been cut through the natural 20-foot depth outer bar; however, the maximum depth of the channel has been reduced 14 feet. Since 1848, it is estimated that about 9 million yards of material have been deposited in the channel. Also since 1939, over 6 million cubic yards of material have been dredged from the outer bar as part of the maintenance dredging of the 42-foot Federal project. The total surface area of the ephemeral islands has varied from a maximum of 3.6 acres in 1850 to 163 acres in 1915, 31 acres following the 1916 hurricane, and 173 acres in 1975.

VOLUMETRIC CHANGES

94. An approximation of volumetric changes that have occurred along the gulf coast of Dauphin Island are given in table 22.

TABLE 21

CHANGES MOBILE BAY INLET

Year	Volume of Material (Millions of CY)			Depth of Water in Gorge[3/] (Feet below MLT)			Ephemeral Islands Percent Decrease or Increase				East Bar	
	East Bar	West Bar	Total	Throat	Maximum	Outer Bar	Dixie	Sand	West Sand	Pelican	Length (ft)	Depth (ft)
1850[1/]	228	517	745	57'	66'	20	31	112	163	0	25,300[4/]	2'
Events												
1915				-3	-9	0	-100	-100	-44	71[2/]	+2,000	+3
Events												
1921				-12	-2		-100	-100	-100	-56	+2,000	+3
Events												
1941				+2	-7	+16	-100	-21	-94	0	+1,500	+3
Events												
1973	-13	+28	+9	-13	-14	+22	-100	-100	+6	-100	+3,300	+3

1/ Base Year except for Pelican Island
2/ Base year for Pelican Island
3/ Negative number indicates decrease in depth
4/ Distance in feet to 42' contour seawall from Mobile Point.

TABLE 22

Approximate Volumetric Changes - Dauphin Island

Event	Change
Recession of Shoreline on[1/] Westernmost 11 Miles	600,000 CY per yr.
Recession of shoreline attributable to sea level rise[1/]	280,000 CY per yr.
Fill of Inlet (1917-1974)	9×10^6 CY = 158,000 CY per yr.
Extension of Island (1917-1974)	2.8×10^6 CY = 49,000 CY per yr.
Dredging of Inlet	260,000 CY per yr.
Breach of Island (1916)	8×10^6 CY = 140,000 CY per yr.

1/ Based on 1 square foot of area equal to 1 cubic yard of material and 0.5 cubic yards of material along the western section and eastern section of the island, respectively.

EFFECT OF MAINTENANCE DREDGING - OUTER BAR

95. Since about 1939, approximately 6.8 million cubic yards of material have been removed from the outer bar of the Mobile Bay inlet as part of the Corps of Engineers maintenance program for the Mobile Ship Channel. Since deepening the bar channel in 1966, maintenance dredging of the channel has resulted in the removal of about 264,000 cubic yards of material per year. Maintenance dredging of the bar channel is accomplished with a hopper dredge. The dredged material is disposed of in a water depth of 40 feet or greater, in an area about 7,500 feet west of the entrance channel. If it is assumed that none of the dredged material returns to shore and that this material would otherwise have been deposited on the shore of the western part of Dauphin Island, the total recession of the shoreline attributable to maintenance dredging of the bar channel since 1939 would be about 119 feet:

$$\frac{6.8 \times 10^{6} \text{ CY} \times 1 \text{ sf/cy}}{57{,}000 \text{ ft.}} = 119.$$

Considering maintenance dredging since 1966, the average loss of shoreline width per year attributable to maintenance dredging of the outer bar would be about 4.6 feet per year:

$$\frac{264{,}000 \text{ CY/Yr.} \times 1 \frac{\text{sf}}{\text{cy}}}{57{,}000 \text{ ft.}} = 4.6 \text{ ft/yr.}$$

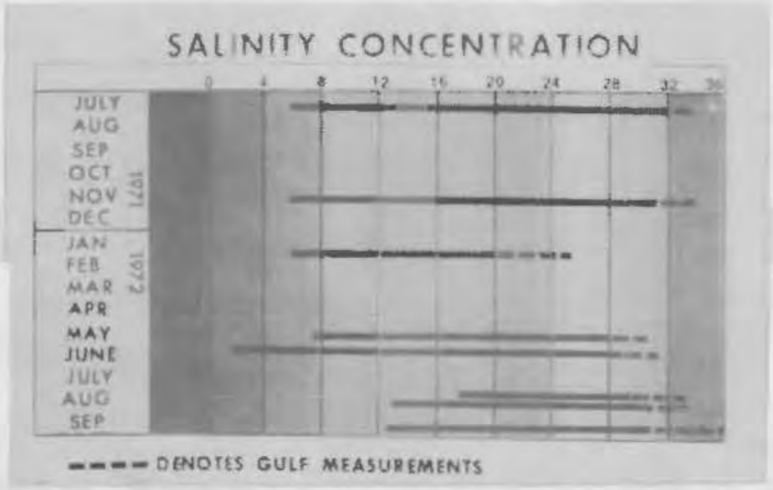
96. Based on these computed losses in width and the volume of littoral material associated with the events listed in table 22, it can be surmised that the removal of 264,000 cubic yards of material per year from the outer bar has a significant effect on the shoreline of the western part of Dauphin Island. If it is assumed that this dredged material is deposited along the shore of the westernmost 11 miles of the island, the average rate of erosion along this reach would be reduced from its present 10.3 feet per year to about 5.7 feet per year.

THE SALINITY PROBLEM

97. Salinity concentrations in Mississippi Sound for various days, as developed by NASA[16], are illustrated on figures 22 through 29. These data extend over a period of fifteen months with at least one set of data for each season. The figures indicate that the western portion of the sound has appreciably lower salinities relative to the eastern portion of the sound. It is likely that the relatively low salinities in the western part of the sound can be attributed primarily to freshwater inflows from the delta area east and south of New Orleans.

98. The 7,000-acre oyster reef near Pass Christian is shown on figure 22. Considering the absence of significant oyster reefs south and east of this reef, it is reasonable to theorize that the salinity of Mississippi Sound at this location is on the threshold of that tolerated by the oyster drill (Thais). Based on data presented in figures 22 through 29, salinities at this location are less than $20^{o}/00$ during most of the year. These data indicate that salinities in Grand Bay and Portersville Bay are greater than $24^{o}/00$ during most of the year.

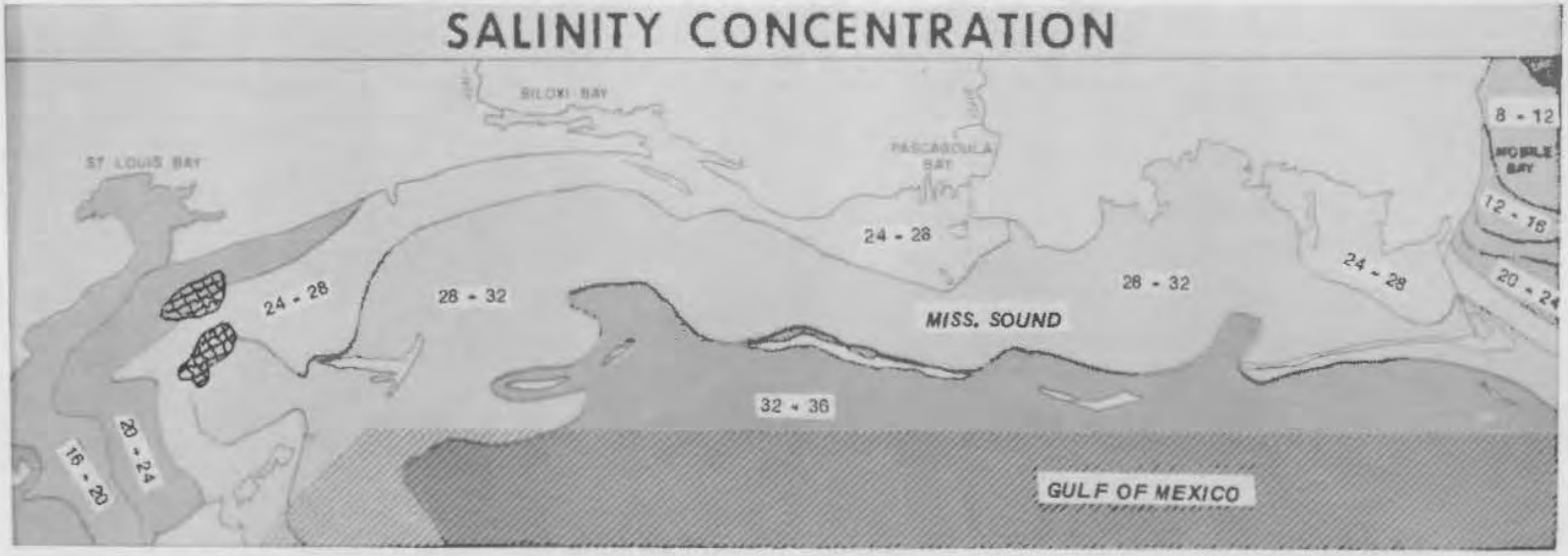
99. Based on data compiled by Alabama's Division of Marine Resources during the late 1800's and early 1900's, Portersville Bay and Grand Bay were significant oyster-growing areas. The oysters from this area of Mississippi Sound supported several oyster canneries. The first cannery was built in 1890. By 1926, there were five canneries operating in Bayou La Batre and Coden. By 1938, the number had decreased to only two companies and the last closed operation by mid-1960. At present, there are no significant amounts of oysters produced in this area. This is attributed to the high mortality of oysters due to oyster drills, as the salinity in the area is often in the range



OYSTER REEF

ESTIMATED FROM SPARSE DATA

MISSISSIPPI SOUND SURFACE MEASUREMENTS



22 JULY 1971

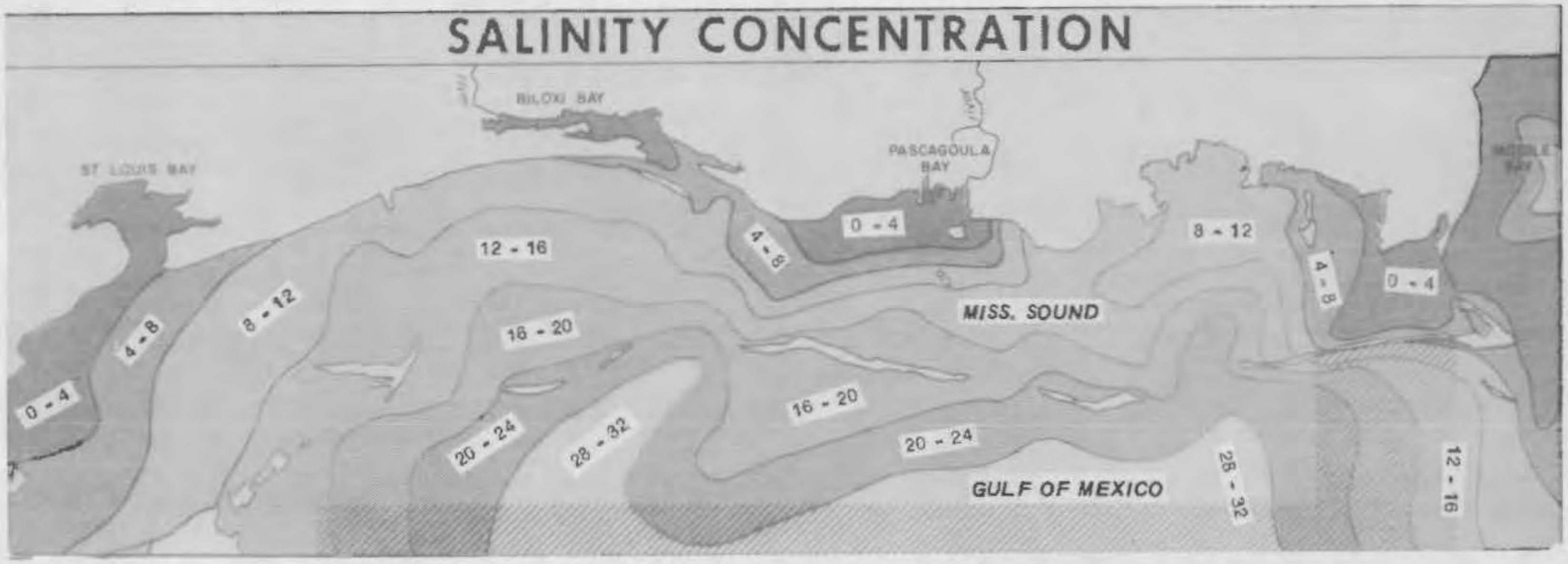
Figure 22

MISSISSIPPI SOUND SURFACE MEASUREMENTS

10 NOVEMBER 1971

Figure 23

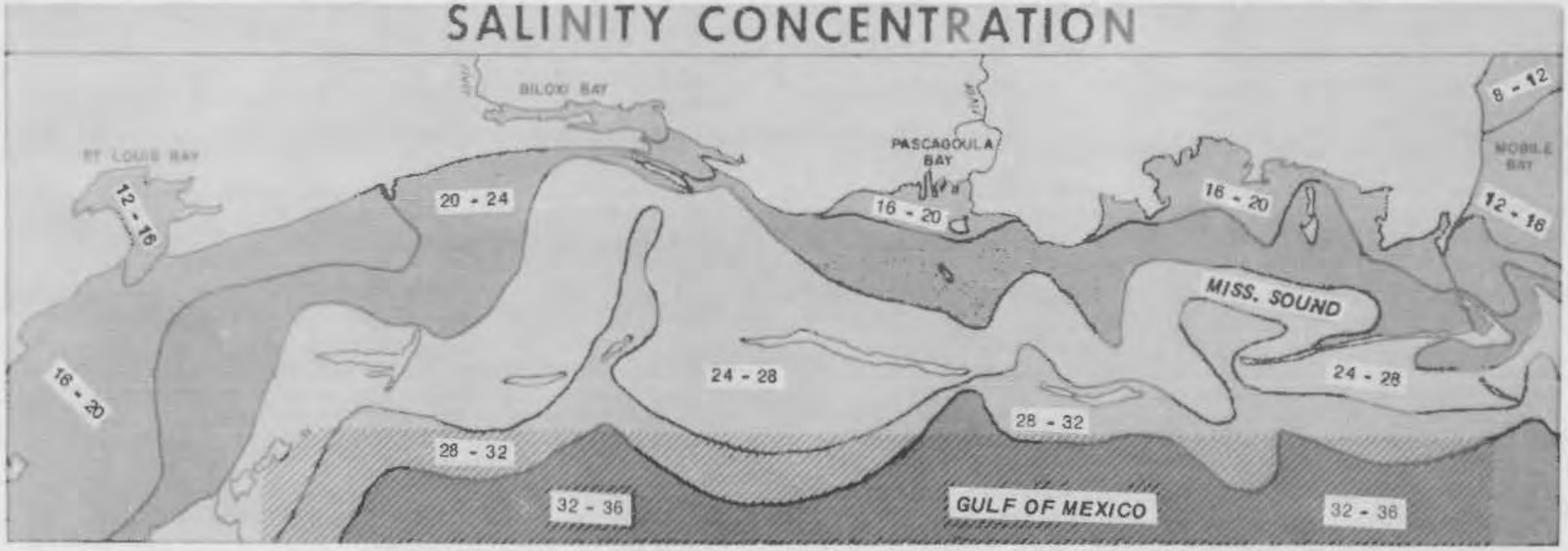
MISSISSIPPI SOUND SURFACE MEASUREMENTS



26 JANUARY 1972

Figure 24

MISSISSIPPI SOUND SURFACE MEASUREMENTS



2 MAY 1972

Figure 25

MISSISSIPPI SOUND SURFACE MEASUREMENTS

29 JUNE 1972

Figure 26

MISSISSIPPI SOUND SURFACE MEASUREMENTS

7 AUGUST 1972

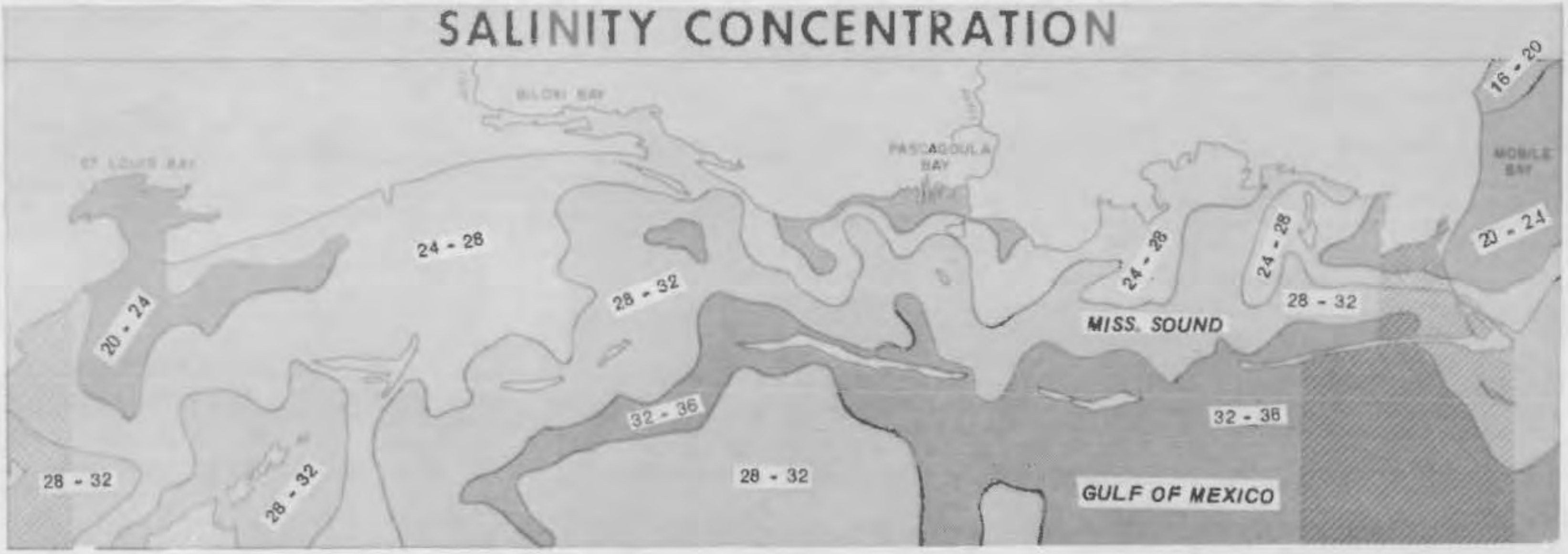
Figure 27

MISSISSIPPI SOUND SURFACE MEASUREMENTS

25 AUGUST 1972

Figure 28

MISSISSIPPI SOUND SURFACE MEASUREMENTS



28 SEPTEMBER 1972

Figure 29

tolerated by the drills. It is estimated by the State's Division of Marine Resources that if 1914 conditions could be established in the northeast section of Mississippi Sound, the economic potential for oyster production would be $7.2 million annually.

100. Sufficient data is not available to establish the exact date that salinities in the northeast section of Mississippi Sound increased to the level favorable to the existence of drills, however, based on the distribution of present foraminiferida,[17] it is estimated that this level of salinity was reached between 1954 and 1968. Isohalines prepared by McPhearson[18] indicate that, in 1963-64, during most of the year, salinities were in the range tolerated by drills. Accordingly, it is reasonable to conclude that the critical level of salinity was reached between 1954 and 1964.

101. The increase in salinities in the northeast part of Mississippi Sound may be attributed to physical changes that were effected between 1954 and 1968. The most apparent physical changes occurring during this period were the building of the bridge from Cedar Point to Dauphin Island, and the significant enlarging of the cross-sectional area of Petit Bois Pass. While it is probable that these two events contributed to the increase in salinity, it is important to note that salinities in the area may have been increasing before 1954, and that these two events only accelerated an ongoing process. Consequently, modifying the Cedar Point bridge or closing Petit Bois Pass may not necessarily result in conditions in Portersville Bay and Grand Bay becoming favorable to oyster production. This hypothesis is supported by evidence that an oyster reef in the vicinity of Round Island became inactive before 1954. Round Island is located in Mississippi Sound about 5 miles north of

Horn Island, Mississippi. Factors which may have contributed to the increased salinity in Mississippi Sound include the following:

a. Restriction of fresh water into east part of Mississippi Sound stemming from:

(1) Construction of the bridge from Cedar Point to Dauphin Island;

(2) Shoaling of this pass into Mississippi Sound from Mobile Bay;

b. Rise in salinity in the western section of the sound stemming from enlarging or shifting the position of Petit Bois Pass and Horn Pass;

c. Change in shape of hydrograph of river flows into Mobile Bay and Mississippi Sound resulting from change in land formation, or damming of rivers, and different farming methods;

d. Dredging and draining marshes;

e. Change in freshwater inflow into north part of the sound stemming from construction of railroads and highways; and

f. Change in circulation patterns of water in Mississippi Sound as the result of deepening of Pascagoula Ship Channel and construction of Bayou Casotte ship channel.

SALT WATER RELATED RECREATION PROBLEMS

102. Water-oriented recreational demands on Dauphin Island are increasing as people have more leisure time and money to spend on recreational pursuits. Dauphin Island has the most popular swimming beaches in Mobile County, in spite of the lack of a bathhouse, adequate restroom facilities, or cleanup provisions. In previous years, to augment the presently owned public beach, the county leased 2 miles of the undeveloped western end of the island from its owners. In 1978, the lease expired and, because promised improvements had not been made by the county, the owners refused to renew the lease. Since less than one mile of public beach remains on the island, it has deteriorated due to pressures from overcrowding and the accumulation of debris. This condition has resulted in fewer people utilizing the island to swim and sunbathe. The problem is such that local businesses report a drop in business since the closing of the 2 miles on the west end.

EXISTING PLANS FOR IMPROVEMENTS

103. There is no record that any major project has been undertaken to control beach erosion or provide hurricane protection works within Mobile County. The main port development at Mobile begins near McDuffie Island and almost all shorelines north of these are bulkheaded. A section of shoreline in the vicinity of Bayou La Batre and Coden is also bulkheaded. The eastern end of Dauphin Island, in the vicinity of Fort Gaines, has been protected with a rubble revetment and several groins extending from the revetment and shore. Several landowners have attempted to protect their property by the construction of bulkheads, break waters (sand grabbers), hauled in fill material, planted grasses and other individual projects.

104. Mobile County has implemented the Federal Flood Insurance Program. Consequently, all construction within the 100-year flood plain is controlled by building codes. These building codes are based on requirements specified in Section 1910.3 of the December 1976 Federal Register and the Southern Building Code. Elements of the Federal Flood Insurance Program are presented in Appendix A.

IMPROVEMENTS DESIRED

105. A public meeting was held on 31 July 1973 in Mobile to obtain the views of local interests in connection with shore erosion and hurricane flooding in Mobile County. Registered attendance at the meeting was 213 persons. Excluding Corps of Engineers personnel, only four government officials attended the meeting; a County Commissioner, a representative from the State Department of Conservation, a representative from the Soil Conservation Department and a representative from the Gulf Islands National Seashore National Park Service.

106. At this meeting, no one made a statement concerning hurricane protection or flooding. Statements made at the meeting concerned the following:

1. Shoreline erosion along the shores of Mobile County.
2. The stabilization of the eastern end of Petit Bois Island.
3. Planting of grass to prevent shore erosion.
4. Restoration of eroded areas with material from dredging operations.
5. Problems from logs washing on the beach along the west shore of Mobile Bay.
6. Opposition to shell dredging operations in Mobile Bay.
7. Criticism of groins used on east end of Dauphin Island.
8. The establishment of wetland vegetation west of Dauphin Island.

107. A workshop meeting was held on 31 March 1975 to discuss with shoreline property owners possible erosion control and hurricane protection alternatives and ramifications of the various plans. Excluding Corps of Engineers personnel, registered attendance at the meeting was 150. Interest exhibited at this meeting was opposed to structural plans that could be implemented under existing Federal authorities for beach erosion control. It was indicated at the meeting that the establishment of public shoreline property would be strongly opposed by existing water-front property owners. However, the need for protection of the eroding shoreline was strongly emphasized. Substantial interest was indicated in the concept of deposition of unconfined dredged material from the ship channel along the western shoreline of the bay and Dauphin Island for the abatement of erosion.

108. By letter, dated 21 July 1975, to the Mobile County Commission, it was proposed that, in view of the indications from the workshop meeting, the ongoing beach erosion and hurricane study for Mobile County should be terminated. The Commission was also advised that the feasibility of placing dredged material from the Mobile ship channel onto the eroding shore would be pursued as part of the ongoing survey study for modifications of the existing Federal Navigation Project for Mobile Harbor. By letter, dated 1 October 1975, the Mobile Commission advised the District Engineer that the Commission concurred with the action stated in the 21 July 1975 letter.

109. The State of Alabama, by letter dated 16 September 1975, expressed the opinion that, as a result of the increase in the width of Petit Bois Pass, the oyster fishery in Portersville Bay was destroyed. The State suggested that structures such as "rock jetties" could be used to close the pass and requested that the Corps develop a project and cost estimate for closing the pass.

110. In a letter dated 11 February 1977, the Mayor of Mobile requested that the Corps of Engineers investigate the feasibility of providing hurricane protection for the City of Mobile and shoreline erosion protection for the western shoreline of Mobile Bay. It was suggested that hurricane protection could be provided by constructing seawalls or a series of ungated barriers strategically positioned in the bay.

111. Local residents of Dauphin Island have expressed the opinion that maintenance dredging of the Mobile Bay entrance channel has contributed to the erosion of Dauphin Island. Accordingly, these interested parties have requested that material dredged from the outer bar be placed on the west bar of the inlet. They contend that placing the dredged material at this location will build up the ephemeral islands on the bar and that the built-up islands would protect the shore from wave action, thus preventing erosion in this area.

FORMULATION OF PLANS

FORMULATION AND EVALUATION CRITERIA

112. Federal policy on multiobjective planning, derived from both legislative and executive authorities, establishes and defines the national objectives for water resource planning, specifies the range of impacts that must be assessed, and sets forth the conditions and criteria which must be applied when evaluating plans. Plans must be formulated with due regard to benefits and costs, both tangible and intangible, and effects on the ecology and social well-being of the region. Plans which recommend nonstructural alternatives must also be given equal consideration. In addition, in formulating alternative plans, the test of acceptability must be applied. The acceptability test refers to the

workability of a plan in the sense of acceptance by the public and compatibility with known institutional constraints.

113. The planning criteria use a framework established in the Water Resource Council's "Principles and Standards for Planning Water and Related Land Resources," which requires the systematic preparation and evaluation of alternative solutions to problems, under the objectives of National Economic Development (NED), Environmental Quality (EQ), Social Well-being (SWB), and Regional Development (RD).

114. Technical Criteria - Within the planning framework, the following technical criteria were adopted:

a. Federal participation in the cost for restoration of beaches shall be limited to areas landward of the limits of the historical shoreline of record;

b. As a reasonable minimum, flood protection should be provided against the 100-year storm surge and waves;

c. Protective works should be planned to prevent overtopping by the design storm; and

d. Wave heights considered should be those expected to occur with the design storm.

115. Economic Criteria - The following economic criteria were established to insure that the selected plan would be the most economical method of meeting the planning objectives.

a. Tangible benefits should exceed project economic costs;

b. Each separable unit of improvement or purpose should provide benefits at least equal to its cost unless justifiable on a noneconomic basis;

c. Each plan, as ultimately formulated, should provide the maximum net benefits possible within the formulation framework;

d. The costs for alternative plans of development should be based on preliminary layouts, estimates of quantities, and 1978 unit prices;

e. The benefits and costs should be in comparable economic terms to the fullest extent possible;

f. Annual costs and benefits are based on a 50-year amortization period and a discount rate of 6-5/8 percent;

g. The annual charges should include the cost of operation and maintenance of the selected plan;

h. Interest during construction should be charged to any portion of the project that averages more than one year to construct;

i. Plans should consider the effects on:

- Employment in the area
- Tax base of the area
- Property values in the area
- Recreation demand
- Regional growth potentials of the area; and

j. Plans should examine the possibly adverse impact of displacement of businesses.

116. Socioeconomic and Environmental Criteria - The criteria for socioeconomic and environmental consideration in water resource planning are prescribed by the National Environmental Policy Act of 1969 (PL 91-190), Section 122 of the River and Harbor and Flood Control Act of 1970, (PL 91-611), and Section 404b of the Federal Water Pollution Control Act Amendments of 1972. The criteria prescribe that all significant adverse and beneficial economic, social, and environmental effects of planned developments be considered and evaluated during formulation.

FORMULATION METHODOLOGY

117. Formulation of plans was through an iterative three-stage process. An abbreviated work sequence diagram graphically illustrating the process is shown in figure 30. The stages were (1) Identification of Possible Solutions, (2) Development of Intermediate Plans, and (3) Development of Detailed Plans. Each stage contains essentially the same sequence of 4 tasks to be performed, but task emphasis shifts as the process proceeds.

PROFILE OF EXISTING CONDITIONS

118. A profile outlining existing physical, economic, social and environmental conditions in the study area was presented earlier. The profile provides the basis for comparison in the formulation of possible solutions to the problems and needs and a comparison of impacts from considered alternatives. Problems and needs identified included: hurricane protection for Mobile, Mobile County, and Dauphin Island; erosion control for Mobile County and Dauphin Island; control and stabilization of Petit Bois Pass; and expanded recreation facilities.

INITIAL ALTERNATIVES CONSIDERED

119. Table 23 lists possible solutions considered in the first stage of formulation. Table 24 shows the planning objectives that each of the alternatives would meet. Various deficiencies in many of the alternatives initially considered are discussed in the following paragraphs.

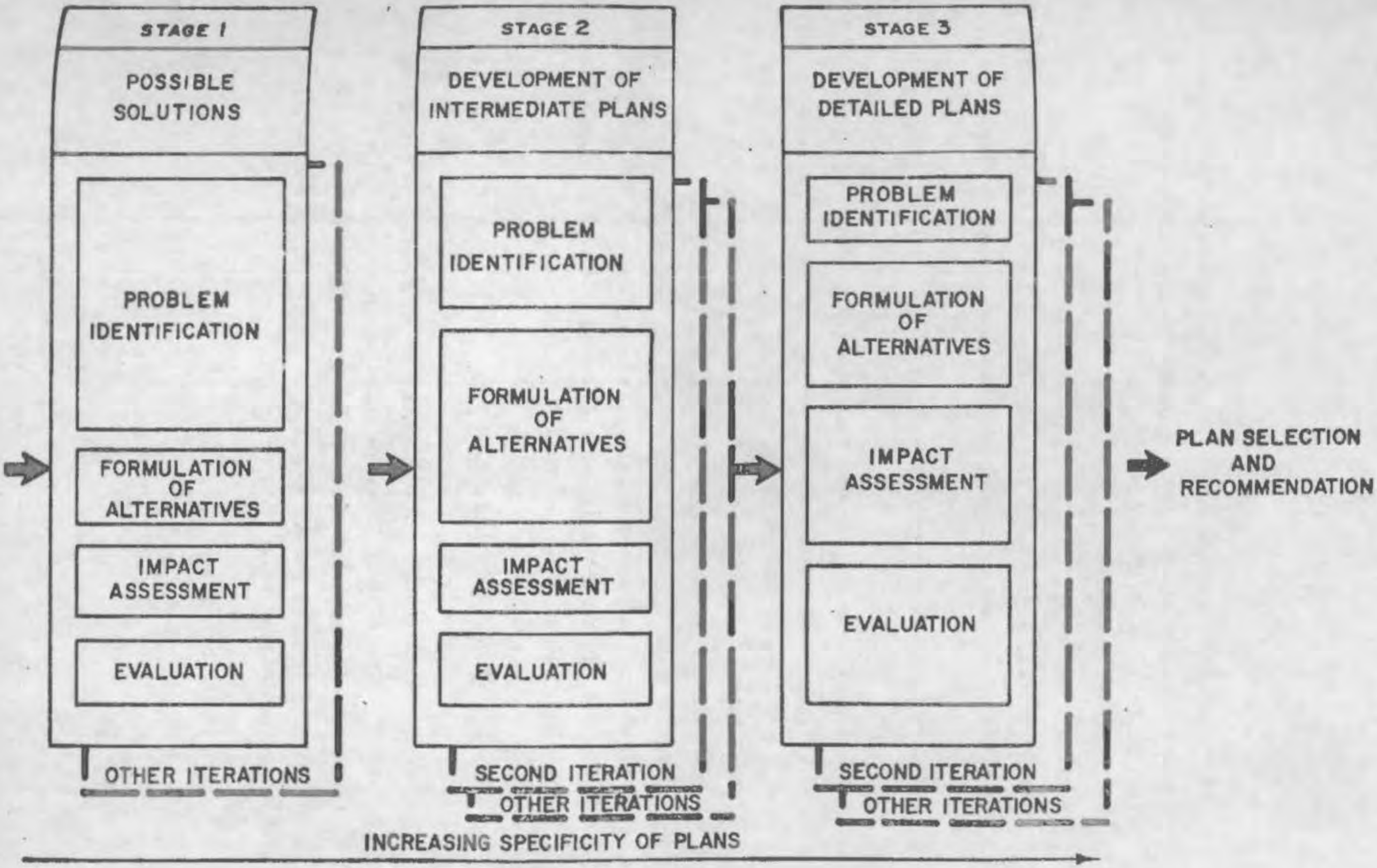


Figure 30. GENERAL RELATIONSHIP OF PLANS FORMULATION STAGES AND FUNCTIONAL PLANNING TASKS.

TABLE 23

Possible Solutions

1. Beach restoration and nourishment
2. Groin system
3. Seawalls
4. Offshore breakwater
5. Relocate structures
6. Flood proof structures
7. Rezone area
8. Modify building codes
9. Moratorium on construction
10. Flood insurance
11. Evacuation planning
12. Nourishment of shore with material from channel maintenance
13. Establish a "no growth" program
14. Grass existing shore
15. Develop artificial dune
16. No further action
17. Various combinations of above

TABLE 24

Stage 1 Alternatives and Planning Objectives They Meet

Alternatives[1]	Local Planning Objectives[2]			Principles and Standards[3]			
	RB	FP	EC	NED	EQ	SWB	RD
1	F[4]	P	P		P	F	F
2	P	P	P		P		
3		P	F			P	P
4	P	P	P		P	P	P
5	P	F			P	P	P
6		P			P	P	
7	P	F			P	P	P
8		P			P	P	
9		P			P	P	
10						P	P
11		P			P	P	
12	P	P	P	F	P	P	P
13					P	P	
14		P	P		P	P	
15					P		

1 Number of alternative refers to those alternative numbers in Table 23.

2 RB = Provisions of recreation beach
FP = Protection from flooding and wave damage
EC = Beach erosion control

3 NED = National economic development
EQ = Environmental quality
SWB = Social well being
RD = Regional development

4 F = Meet fully
P = Meet partially

Blank spaces indicate not meeting objective.

120. Grassing the existing shore would limit the use of the beaches for recreational purposes and would not be very effective in controlling erosion. Also, tests conducted by the Coastal Engineering Research Center indicate that artificial seaweed is not effective in attenuating wave energy at periods commonly found in the gulf. The other structural techniques identified are capable of effectively addressing various aspects of existing problems. However, their effectiveness and contributions to the planning objectives vary significantly.

121. From the array of possible nonstructural alternatives, several, such as a "no growth" program and a moratorium on construction, can be discounted as overall solutions that address existing problems or contribute to the planning objectives. Also, since Mobile County has implemented the Federal Flood Insurance Program, flood plain regulations and building regulations are presently in effect. In addition, evacuation planning has been effected by the Mobile Civil Defense Office. The value of certain construction restraints and nonstructural measures have also been recognized and implemented in the area.

122. In addition to the action courses, there is the "No Action" alternative. This option does not provide a solution to existing problems. However, this alternative is maintained throughout the formulation process since it avoids any undesirable effects that may be associated with other courses of action and thereby provides a basis for comparison.

INTERMEDIATE ALTERNATIVES CONSIDERED

123. The initial 16 possible techniques for addressing the problems and needs of the area were evaluated in terms of their practicality and contributions to the needs of the study area and the planning objectives. From the initial solutions, 10 were selected to address specific objectives and for further consideration. As listed in table 25, the first six of these alternatives are structural in nature, the next three are non-structural or local measures that could be implemented, followed by the "No Action" alternative and the combination of the other options. A further evaluation of these alternatives succeeded in additional eliminations and combinations.

EROSION CONTROL ALTERNATIVES

124. As related to shore erosion, preliminary cost and local requirements were developed for each of the alternatives. This information was coordinated with local interests. As discussed previously, structural plans that could be implemented for protection of the western shore of Mobile Bay, under existing Federal authorities for beach erosion, were strongly opposed by existing waterfront property owners. Accordingly, alternatives three through six were excluded from further consideration.

125. Structural alternative 1, which could be implemented under Federal navigation authorities, was further coordinated under the ongoing study for modifying the existing Federal project for Mobile Harbor. As part of this study, it was established through a direct survey that about 80 percent of the property owners along the west shore of Mobile Bay opposed this alternative. In view of the lack of support, this plan was also dropped.

TABLE 25

Intermediate Alternatives Considered

1. Nourishment of the west shore of Mobile Bay with material from channel maintenance or construction
2. As part of the ongoing maintenance program, place material dredged from the outer bar of the Mobile Ship Channel onto Dauphin Island.
3. Beach restoration and nourishment - offshore borrow area
4. Groin system
5. Seawall
6. Offshore breakwater
7. Sand dune development and stabilization
8. Relocation of structures
9. Rezoning of area
10. No further action
11. Various combinations of above

126. Investigations indicate that erosion occurring along the western 11 miles of Dauphin Island is probably attributed mainly to rising sea level and maintenance dredging of the ship channel through the bar fronting the Mobile Bay entrance channel. These investigations also indicate that material removed from the bar channel is suitable for nourishment of the shore of Dauphin Island. Accordingly, type 2 alternatives will be considered in more detail.

ALTERNATIVE FOR THE CONTROL AND STABILIZATION OF PETIT BOIS PASS

127. Preliminary analysis of the closing of Petit Bois Pass indicates this could best be accomplished by alternative 3, beach restoration and nourishment. Material for the initial fill and subsequent nourishment would be taken from offshore borrow areas at the west end of Dauphin Island, as shown on plate III. The removal of material from the end of Dauphin Island should stabilize the existing gorge of Petit Bois Pass. The initial fill would require about 6.2 million cubic yards. Excluding losses that occur when the area is under the influence of a severe storm, about 400,000 cubic yards of material every three years would be required to nourish the considered works. The initial fill should be to about 5 feet above mean sea level and nourishment could be accomplished by providing a feeder beach at the east end of the fill. Initial cost and annual cost of this alternative are estimated to be approximately $15.6 million and $1.2 million, respectively.

128. As discussed in previous paragraphs, it is indicated that Petit Bois Pass is being closed by the ongoing accretion of material at the west end of Dauphin Island, and that closing of the pass will not necessarily assure conditions in the northeastern part of Mississippi Sound favorable for the production

of oysters. Also, in the event the Mobile entrance channel is deepened and the material removed from the channel is placed in the littoral zone, the westward extension of Dauphin Island may be accelerated. In view of the limitations, potential disadvantages and lack of authority for Federal involvement, this alternative was not evaluated further in this report. Such works could be considered as an integral part of other Federally approved activities being studied in Mississippi Sound.

EXPANDED RECREATION FACILITIES

129. The need for providing expanded recreation facilities on Dauphin Island was presented earlier. The Alabama Statewide Comprehensive Outdoor Recreation Plan, prepared by the Agricultural Experiment Station of Auburn University, inventoried the demand for brackish and salt water swimming in Mobile and Baldwin Counties. The study, published in 1975, indicated that the total resources in the area which are available for this type of swimming consist of almost 500,000 acres of water and 210 miles of sand beaches. This amount is considered adequate for demand to the year 2000.

130. Although ample beach areas exist along the undeveloped west end of Dauphin Island and at the county owned public beach, inaction by the county has prevented full usage by the public. A satisfactory swimming beach must provide sufficient access, facilities and maintenance, and few public beach facilities have been constructed. Therefore, since increased recreational benefits would be dependent on additional facilities and access rather than a need for increased beach area, Federal restoration of beach for recreation was not considered.

FLOOD CONTROL ALTERNATIVES

131. As related to providing hurricane flood protection with structures, preliminary analysis indicated that except at

Dauphin Island, protection can best be provided by the construction of seawalls and related structures. At Dauphin Island sand dune development and stabilization were considered more appropriate. Other alternatives considered would not provide the minimum 100 year degree of protection specified herein by planning criteria.

132. Preliminary design and cost estimates were made for protective systems for each of the study areas shown on figure 6. A summary of these analyses follows. Costs shown are based on the cost of similar structures elsewhere and are to be considered conservative and only a first order of approximation. The surge that would accompany a hurricane with an occurrence interval of once every 100 years was used as the design surge in these analyses. The development survey was completed in January 1977 and values determined based on average 1976 price levels. These values have subsequently been adjusted to reflect 1978 price levels.

133. Area 1 - Bayou La Batre. This area extends along the north of Mississippi Sound about 9 miles east from the Mississippi, Alabama, state line. Development within the 500 year flood plain of the area is comprised of 1468 residential units, valued at $41.4 million; 84 commercial establishments, valued at $6.3 million; and 24 institutional units, valued at $4.3 million; 200 fishing vessels and docking facilities, valued at $5.0 million; and 25 industrial concerns, valued at $3.2 million.

134. The alternative considered for this area provided for about 4.1 miles of levee tied into high ground east of the City of Coden and west of the City of Bayou La Batre, closure structures across Bayou La Batre and Bayou Coden and for two

pumping plants. Annual cost and annual benefits for this alternative were computed to be $3.4 million and $1.2 million, respectively. Annual benefits that would stem from providing protection from flood damage that would result if the area came under the influence of a hurricane with a recurrence interval of 500 years were estimated at $1.5 million.

135. Area 2 - Heron Bay. This area extends south from Alabama Point to Mississippi Sound, thence 4 miles west along the north shore of Mississippi Sound to Area 1. Development within the 500 year flood plain of this area is comprised of 221 residential unites, valued at $2.8 million; 10 commercial establishments, valued at $0.1 million; 5 institutional units valued at $0.2 million; and marine facilities, valued at $0.4 million.

136. The alternative considered for the area provided for encircling the area with about 3 miles of levee and necessary openings to facilitate drainage. The average annual cost and average annual benefits for this alternative were computed to be $0.4 million and $0.02 million, respectively. Annual benefits that would stem from providing protection from the flood damage that would occur if the area came under the influence of a hurricane with a recurrence of 500 years are estimated at $0.03 million.

137. Area 3 - Dauphin Island. Development on Dauphin Island is concentrated primarily on the easternmost seven miles of the island. Development within the 500 year flood plain is comprised of 918 residential units valued at $32.1 million; 31 commercial establishments, valued at $3.6 million; 19 institutional units valued at $2.2 million; and 4 marine installations valued at $2.5 million. Annual benefits that

would stem from protecting the area from flood damage that would accompany hurricanes with recurrence intervals of 100 years and 500 years are estimated to be $0.8 million and $0.9 million, respectively.

138. A protective system for this area would be comprised of a minimum of a protective dune system extending along the gulf shore of the island and a seawall along the Mississippi Sound shore. Since the estimated annual cost of only providing the dune system was estimated to be $1.1 million, protection was not considered economically feasible and no further analyses of protective structures were made.

139. Area 4 - Belle Fontaine. This area extends from Alabama Point to the middle fork of Deer River, a distance of about 11 miles. Development within the area is mostly residential. The surge with a recurrence interval of once every 100 years would affect about 492 residences valued at $14.4 million and about 6 commercial establishments valued at $0.6 million. Annual benefits that would stem from protecting this area from flood damages that would accompany hurricanes with recurrence of 100 years and 500 years are estimated at $0.1 million and $0.1 million, respectively.

140. A plan providing minimum protection for the area would be comprised of a levee extending along the shore of the reach, navigation and drainage openings through the levee system at Fowl River, and levees extending shoreward to high ground at each end of the system. Since the annual cost of only providing a levee fronting the reach is estimated to be $1.4 million, no further analysis of this alternative was made.

141. Area 5 - Hollingers Island. This area extends from the middle fork of Deer River to near Dog River Point, a distance of about 6.5 miles. Development within the 500 year flood plain of the area is comprised of 3492 residential units, valued at $141.9 million; 20 commercial establishments, valued at $0.7 million; 10 institutional units, valued at $1.7 million; 1 industrial facility, valued at $0.01 million; and numerous marine facilities valued at $4.4 million. Annual benefits that would stem from protecting this area from flood damages that would accompany hurricanes with occurrence intervals of 100 years and 500 years are estimated to be $0.1 million and $0.3 million, respectively.

142. The alternative considered for the area would be comprised, at a minimum, of a levee extending along the shore of the reach, navigation and drainage openings, a pumping plant, and back levees at each end of the system. Since the estimated annual cost of navigation structures, $0.5 million, exceeds annual benefits that would stem from the protective works, no further analyses of this alternative were warranted.

143. Area 6 - Mobile. This area extends from Dog River Point to near Chickasaw, a distance of about 15 miles. Development within the 500 year flood plain of the area is located mostly along the shore and is comprised of 1034 residential units, valued at $59.5 million; 81 commercial establishments, valued at $33.5 million; 71 industrial sites, valued at $182.7 million; 8 institutional facilities, valued at $7.2 million; and 21 marine-related activities, valued at $8.3 million. Included in this area are the industrial complex at Brookley Field and the dock facilities at Mobile. Accordingly, any protection plan for the area would have to provide for closure structures across the Mobile Ship Channel. It is estimated that these structures

would cost in excess of $240 million. Annual benefits that would stem from protecting the area from hurricane surges with occurrence intervals of 100 years and 500 years would be $0.09 million and $9.7 million, respectively. Since interest and amortization charges on only the closure structures, $16.6 million, exceed the annual benefits no further analyses of protecting this area with seawalls and associated structures were made.

144. Local interests suggested a plan to protect this area by the construction of a series of ungated barriers extending across the bay. These barriers would be positioned in the bay in such a manner as to intercept storm waves and surges traveling up the bay from the gulf toward the City of Mobile.

145. Detailed analyses of protective systems such as this have been made at other locations. These analyses indicate that along the Atlantic Coast at higher latitudes, such systems can be designed to give a bay area a high degree of protection from hurricane surges. However, this type of protective system was found generally not to be effective in the lower latitudes, particularly along the Gulf Coast of the United States.

146. A barrier system across any part of Mobile Bay would have to contain openings sufficient in size and number to accommodate tidal flows and navigation. Considering the number and size of openings that would be required and the potential duration of the hurricane surge that could be reasonably expected to affect the area, it was concluded that bay barriers with ungated openings would not be effective in significantly reducing flood damage caused by hurricane generated surges. This conclusion

is based on the large volume of water that would pass through the openings during the period the area could be under the influence of the hurricane generated surge.

147. Area 7 - Satsuma. This area extends north from the City of Mobile to Steel Creek just north of the City of Satsuma. Development within the 500 year flood plain of the area is comprised of 357 residential units, valued at $9.6 million; 2 commercial establishments, valued at $1.6 million; 8 industrial concerns, valued at $9.1 million; and 1 marine facility, valued at $0.2 million. A·nual benefits that would stem from protecting this area from flood damages that would accompany hurricanes with recurrence intervals of 100 years or 500 years are estimated to be $7,000.

148. The plan of protection considered for the area would require at a minimum, 1 mile of levee, pumping plants, and drainage structures. Since the estimated annual cost of only the levee system, $0.1 million, exceeds annual benefits that would stem from the protective works, no further analysis of this alternative was made.

149. Since the annual cost of these alternatives greatly exceeds the benefits stemming from them, no further refinement of the costs is warranted and these alternatives were eliminated from further consideration.

150. Nonstructural Measures. Relocating structures and rezoning the area would not be economically feasible, practical or acceptable to local interests. Further investigation of local institutional organization indicated that essentially those nonstructural measures offering potential benefits have been

implemented in the study area. Accordingly, nonstructural measures were not considered further in the plan formulation process.

ALTERNATIVES CONSIDERED FOR FURTHER ANALYSES

151. Except for placement of material dredged during maintenance of the Mobile Ship Channel on the shore of Dauphin Island, preliminary analyses of intermediate alternatives indicate structural alternatives to be either unacceptable to local interests or not economically feasible. These analyses also indicate that essentially nonstructural measures offering potential benefits have been implemented in the study area.

152. As discussed in earlier paragraphs, erosion along the westernmost 11 miles of Dauphin Island averages 10.3 feet per year. This recession of the island's shoreline represents a volumetric loss of about 600,000 cubic yards of material per year. In order to provide a total solution to the erosion problem in this reach it would be necessary to repalce the lost material. This could be accomplished by pumping an equivalent amount of suitable beach nourishment material directly onto the shore. Preliminary estimates indicate that the annual cost of initially restoring the material lost to erosion as well as providing necessary periodic nourishment would be considerably in excess of the expected annual benefits of $584,000. Therefore, a total solution for the island's erosion problem is not economically feasible.

153. Since it is not economically feasible to totally eliminate erosion on Dauphin Island, investigations were made to determine the possibility of partially alleviating the problem. Maintenance

dredging of the Mobile Bay entrance channel has already been discussed as a probable cause for part of the island's erosion problem. About 264,000 cubic yards of material per year are dredged from the entrance channel into Mobile Bay and placed in deep water off the gulf shore of Dauphin Island. This material is essentially lost to the littoral drift system and represents a significant percentage of the total yardage lost to erosion. If this amount of material could be placed directly onshore, or placed so it could reenter the littoral drift system where waves and currents would distribute it and thereby contribute to stabilization of the littoral drift system, erosion could be reduced. Accordingly, the alternative providing for placing material dredged from the outer bar as part of the maintenance program for the Mobile Ship Channel onto Dauphin Island remains as a partial solution to the island's erosion problem. However, before undertaking the development of detailed plans, a further refinement of this alternative was made. The following sub-alternatives were therefore investigated:

a. Place material dredged from the Mobile Bay entrance channel onto the bar west of the channel.

b. Place material dredged from the Mobile Bay entrance channel directly onto the shore of Dauphin Island.

c. Place material dredged from the Mobile Bay entrance channel in the nearshore littoral zone.

154. Based on data previously summarized, it is reasonable to assume that if alternative a. were implemented the ephemeral islands located on the seaward edge of the west bar would enlarge and move shoreward. Consequently, the existing swash channel across the bar would move shoreward. Thus, shore erosion in the area would be accelerated. Accordingly, this alternative was excluded from further consideration.

155. Alternative b. provides for placing material dredged from the Mobile Bay entrance channel directly onto the shore of Dauphin Island. Although the entire gulf shore of the island experiences a degree of erosion, the problem is most severe along its westernmost 11 miles. There the erosion rate is about 10.3 feet per year. Since the erosion rate is greatest in this reach, placing the dredged material directly onto the shore in this area is expected to result in direct benefits by significantly reducing erosion. Therefore, this alternative appears to be a partial solution to the island's erosion problem.

156. Alternative c. proposes an indirect method for alleviating the island's erosion problem. As demonstrated earlier, over 50 percent of the erosion along the gulf shore of Dauphin Island is attributable to rise in sea level. As the sea level rises, material is removed from the shore and deposited along the slope of the nearshore zone. This modification takes place as littoral forces reestablish the same water depths which existed before the rise in sea level. It is reasonable to assume that if material were placed directly onto the slope of the nearshore zone, the slope would tend to stabilize and the amount of material normally removed from the shore as a result of sea level rise would be reduced. Therefore, this alternative would also be effective in decreasing naturally caused erosion on Dauphin Island.

DEVELOPMENT AND EVALUATION OF DETAILED PLANS

157. Therefore, in addition to consideration of the "No Action" plan, two structural plans for partially solving the erosion problem on Dauphin Island were carried forward for more detailed investigation. The alternatives to be evaluated include:

a. No Action

b. Place material dredged from the Mobile Bay entrance channel directly onto the shore of the westernmost 11 miles of Dauphin Island - Beach Nourishment.

c. Place material dredged from the Mobile Bay entrance channel in the nearshore littoral zone - Nearshore Nourishment.

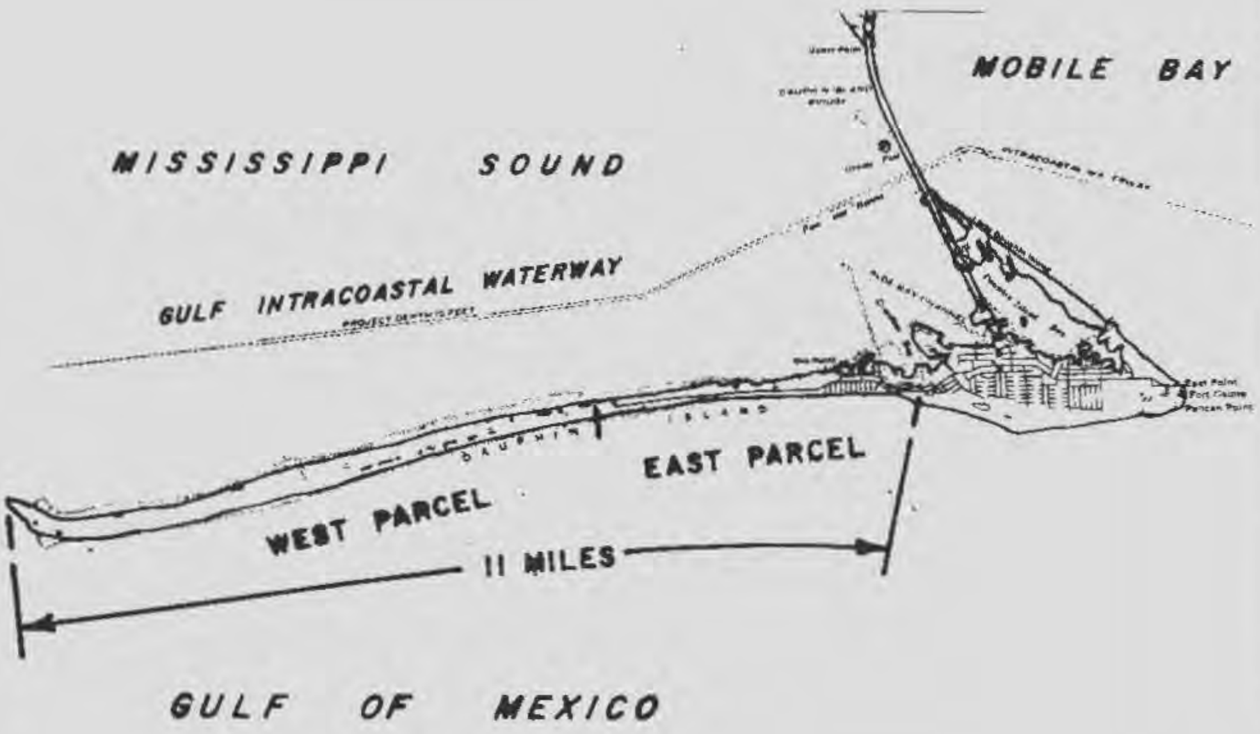
158. No Action. - As stated previously, the "No Action" alternative is not considered to be a viable course of action since it would not solve the existing erosion problem. Material dredged from the Mobile Bay entrance channel would continue to be placed in deep water, thereby contributing to the erosion problem on the gulf shore of Dauphin Island.

159. Beach Nourishment. - The entrance channel into Mobile Bay is dredged approximately once every 1-1/2 years as part of the ongoing maintenance program for the Mobile Harbor Navigation Project. About 396,000 cubic yards of material (264,000 cy/yr x 1-1/2) are removed from the entrance channel each time maintenance dredging is performed. This alternative would provide beach nourishment by placing the material directly onto the shore of the westernmost 11 miles of Dauphin Island. The rate of erosion along this western section of the island averages about 10.3 feet per year. Prior calculations indicate that the loss of about 264,000 cubic yards per year in this reach would result in an average loss of shoreline of about 4.6 feet per year. Therefore, nourishment which would replace an equivalent amount of material would be assumed to reduce the annual erosion rate from 10.3 feet to 5.7 feet. To implement this alternative, the material dredged from the channel would be placed on the beach, west of Bienville Beach ($88^{\circ}07'$). The littoral drift system could then transport the material westward.

The loaded hopper dredge would anchor off the gulf shore of the island near longitude 88°10.5' in 28-30 foot depths. Pipes would extend from the dredge to the beach and the dredged material would be pumped onshore. By moving the pipe or adding on more pipes to the east or west, the material could be spread over a significant reach. Littoral forces would further distribute the material over the island's western gulf nearshore zone. In this manner, about 396,000 cubic yards of material would be pumped onto the beach every 1-1/2 years.

160. Since the charges for maintenance dredging recur regardless of implementation of an erosion abatement plan, only those costs over and above normal costs for present maintenance operations would be charged against this plan. Dredging costs would increase from the present average of $573,000 to $1,577,000, resulting in annual costs of $1,004,000 for this alternative.

161. Benefits accrue to this alternative as a result of reduction in the amount of real estate lost to erosion on the westernmost 11 miles of the island's gulf shore. The estimates used herein were made on certain assumptions; (1) that lands normally considered "back lands" will actually be waterfront as the beach continues to erode; (2) that extra costs encountered in a few areas for relocation of roads or power lines will be more than offset by increased land values as the beachfront moves inland; (3) the 11 miles under consideration can be divided into two distinct parcels, the west parcel and the east parcel, as shown in the following illustration.



WESTERNMOST 11 MILES OF DAUPHIN ISLAND, ALA.

162. The east parcel consists of approximately 3.6 miles of developed property. It contains 142 waterfront lots and a small area of beach seaward of the 3 motels. Estimates regarding the value of these lots are based on 5 lot sales. The 2 latest sales both indicate a value of $1.75 per square foot. Although sales 3, 4, and 5 are older sales and have square foot values of $1.57, $1.42, and $1.25, respectively, it is felt that they support the $1.75 per square foot value of the newest sale. The front foot unit could have been used and would have resulted in values of about $300 per front foot; however, the square foot comparison appeared to be the most consistent. Therefore, the $1.75 value has been used to evaluate the developed beach area.

163. The west parcel is in single, private ownership and consists of about 7.4 miles of undeveloped property. The appraised value of $2,556,000 for this property was established by a local M.A.I. (Member Appraisal Institute) hired by a potential purchaser and the value was agreed to by the owners. It has a front foot value of $91.01. This is about 1/3 the front foot value for developed lots. This 1 to 3 ratio between raw land value and developed land value is the commonly accepted ratio in the real estate field and tends to support the appraised value for the offering. The square foot unit is not a significant figure on this property because of the large amount of extremely low land included in the sale. Applying the 1 to 3 ratio, referred to above, to the $1.75 per square foot value on the developed lots results in a value for this waterfront property of about $0.60 per square foot.

164. It is estimated that 4.6 feet of erosion per year could be alleviated by placing maintenance material directly onto the beach and allowing it to distribute over the western 11 miles of the island. Therefore, benefits gained from reducing erosion by this amount are summarized below.

Annual Benefits Derived From Reducing Erosion 4.6 Feet Per Year

West Parcel:	
7.4 miles = 39,072 ft.	
39,072 ft. x 4.6 ft. = 179,731 sq.ft.	
179,731 sq. ft. x $0.60/sq. ft. =	$108,000
East Parcel:	
3.6 miles = 19,008 ft.	
19,008 ft. x 4.6 ft. = 87,437 sq. ft.	
87,437 sq. ft. x $1.75/sq. ft. =	153,000
Total	$261,000

Average annual benefits accruing to this plan would be $261,000. In view of the increased costs and the benefits realized from this alternative, it would not be an economically feasible action. Therefore, it was dropped from further consideration.

165. Nearshore Nourishment. - On the average, 264,000 cubic yards of material per year are removed from the Mobile Bay entrance channel. With this alternative, the material would be deposited in the nearshore zone off the gulf coast of Dauphin Island in an effort to reduce erosion due to the rise in sea level. Mathematical studies conducted by the Waterways Experiment Station indicate that less than 0.1% of this material will be transported into the surf zone. Therefore, this plan will not directly reduce erosion. As noted earlier, 264,000 cubic yards of material are equivalent to 4.6 feet of erosion over a length of approximately 11 miles. Therefore, it is expected that providing the system with this volume of material will result in a stabilization of the system to effect a reduction in erosion of an equivalent amount of material or a reduction of about 4.6 feet of erosion on the westernmost 11 miles of the island's gulf shore.

166. To accomplish this, the loaded hopper dredge would place the dredged material in a 2 mile reach extending westwardly from longitude 88° 7.8', in waters 26-30 feet deep. About 396,000 cubic yards would be placed in this area every 1-1/2 years. Again, only those costs over and above current costs for present maintenance operations would be charged against this plan. The average annual costs are estimated to increase from the present $573,000 to about $789,000 or an increase of $216,000.

167. Benefits accrued to this alternative by reducing the annual rate of erosion by 4.6 feet. This rate is the same as that

achieved by the Beach Nourishment Alternative. The per square foot real estate values remain constant. Therefore, the benefits to be gained by implementing the Nearshore Nourishment Alternative are the same as those for the Beach Nourishment Alternative. In summary, average annual benefits stemming from this plan would be $261,000 and net benefits would be $45,000. The benefit/cost ratio is 1.21.

EFFECT ASSESSMENT

168. In planning for any action, care must be taken to see that all known and possible or probable effects are taken into consideration. Effect assessment is carried out in terms of the contribution each plan makes to the four accounts; National Economic Development (NED), Environmental Quality (EQ), Regional Development (RD), and Social Well-Being (SWB).

169. Effect assessment identifies the effects of all considered plans to determine the impacts that can be expected. Further, Section 122 of Public Law 91-611 supplements and extends the requirements of the National Environmental Policy Act of 1969 (PL 91-190) by requiring that the effect assessment identify the economic, social, and environmental factors associated with plans under consideration. Section 404 of Public Law 92-500 and Section 103 of Public Law 532 also requires that certain impacts on water quality be investigated and quantified before undertaking any action involving the discharge of dredged material into waters of the United States or ocean waters. Further criteria are established by Executive Orders 11990 and 11988 which direct that all Federal water resource planning minimize destruction, loss or degradation of wetlands and development in the flood plain. Therefore, the effect assessment process is carried out to assure that all significant effects have been identified and their impacts evaluated. A summary of the effects of the considered plans is given in the following paragraphs.

170. The effects of considered structural plans are compared with the "No Action" Alternative as a base condition. Herein only one structural solution, "The Nearshore Nourishment" Plan, has been indicated to be economically advisable and worthy of consideration. This plan relocates the hopper dredge disposal area for maintenance material from the Mobile Harbor entrance channel. With the exception of the direct and indirect monetary savings gained by the considered structural plan, its effects vary little from those that will occur from a continuation of present maintenance operations, as would be the case with the No Action Alternative.

171. The most significant impacts of either the No Action or Nearshore Nourishment Plan are their effects on water quality and marine organisms. In these respects their impacts are similar.

172. Studies conducted to determine the environmental effects of open water disposal of dredged material indicate a relatively minor disruption of the benthos in the disposal area. Motile species normally either avoid or leave the disposal area while the nonmotile forms are directly covered by the dredged material. However, the approximate community structure of both the dredged and disposal areas is essentially fully reestablished within 9 to 18 months after each maintenance operation.

173. Disposal of material dredged from the entrance channel by emptying the hopper dredge has resulted in a buildup of the sea bottom in the present disposal area. The process generates large clouds of suspended solids upon deposition. The time required for the induced turbidity to dissipate has not been specifically documented, but it is considered to be less than

one day. Solid material from the dumping action traps and smothers many organisms living in and traveling through the water column above the dumping grounds, as well as bottom organisms. Fish are frequently seen jumping from the water within the area of the turbid water. It is not known whether they are being pursued by larger predators and have sought cover within the turbid water or if they are jumping to avoid the increased turbidity.

174. Two samples have been taken along the entrance channel during preparation of the Mobile Harbor Operation and Maintenance Environmental Impact Statement. The physical characteristics of both these samples ar such that they are excluded from the requrement of elutriate analysis and are considered acceptable for open-water disposal. This material is characterized by a very high percentage of coarse sand with approximately 7% silts and clays. The silts and clays are responsible for the turbidity increases during the loading and unloading of the hopper dredge.

175. The No Action Alternative perceives a continuation of present conditions and practices without any provisions to reduce potential hurricane flooding or occurring beach erosion. Under this alternative dredged material would continue to be deposited in the closest suitable area to the entrance channel. No monetary or other resources would be expended to transfer the dredged material to Dauphin Island's littoral system, and erosion along the western end of the island could be expected to continue at its present pace. Erosion would continue to claim valuable property on the island, ultimately causing hardships for island property owners and a lessening of the area's attractiveness for recreational activities.

176. The Nearshore Nourishment Plan should significantly reduce the present rate of erosion along the western 11 miles of Dauphin Island producing a net savings in land values over the additional cost for implementing the plan. While not eliminating, it would delay the ultimate effects of the No Action Plan. The savings realized from the Nearshore Nourishment Plan should beneficially affect National economic development; local property values, employment, business activities, tax revenues, and general economic growth; public services and facilities; natural and manmade resources; recreation and aesthetic values; and community and regional cohesion and growth. The plan should have no effects on air quality, noise, known archaeological remains, municipal water supply, or threatened or endangered species. As previously noted the Nearshore Nourishment Plan would have temporary, adverse effects on water quality, benthic life, fisheries, and other marine life similar to the present (No Action Plan) method of operations. No known vegetation or wetlands other than submerged bottoms would be affected. The plan is considered acceptable to local interests and would be completely reversible. It is reasonably certain that benefits for the considered plan will be achieved; however, the effectiveness of the considered plan cannot be fully documented. The area of geographical impact would be limited to the southern shoreline of Dauphin Island and adjoining offshore waters.

177. Wetlands affected by the Nearshore Nourishment Plan are limited to submerged bottoms in the nearshore disposal area. Submerged bottoms in both the presently used disposal area and the new disposal area are characterized as generally clayey sand with occasional pockets of higher concentrations of silts and clays. The area between the considered nearshore disposal area is characterized by bands of clayey and silty sands with increasingly higher concentration of sand toward shore.