Barrier Island Plan

DNR Contract No. 25081-95-02

Phase 1

Evaluation and Recommendation of the Barrier Shoreline Feasibility Study

Final Report

September 5, 1997

T. Baker Smith & Son, Inc.
Houma, La.

PROJECT OVERVIEW

The barrier island plan is authorized by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). The purpose of the study is to assess and quantify wetland loss problems and economic resources linked to the barrier shoreline system along the Louisiana coast. The study will identify potential solutions to these problems, provide an economic evaluation, and determine the barrier configuration that will best protect Louisiana's coastal resources.

The three-year barrier shoreline feasibility study is divided into three phases based on geographical location. Phase 1 is located between the Atchafalaya and Mississippi Rivers. Phase 2 encompasses the chenier plain barrier formations in Vermilion and Cameron Parishes. Phase 3 focuses on the Chandeleur Islands. Phase 1 is the area currently being studied. Phases 2 and 3 were deferred pending initiation by the CWPPRA Task Force and funding availability.

The project is structured to reach an implementation plan by starting from a broad descriptive analysis and gradually becoming more site-specific and detailed as the steps proceed. In all, there are 13 reports that comprise the Barrier Shoreline Feasibility Study, including the final report. Each resource study or island option plan begins with a qualitative assessment and progresses to a more detailed quantitative analysis. As an example, the Step C report (all reports were chronologically written beginning with Step A) qualitatively focuses on the status and trends of resources for the broad study area; whereas, Steps E and F quantitatively assess and inventory the existing environmental and economic resources respectively. Similarly, Step I is a general evaluation of the needs in the study area and development of management alternatives. Later, the Final Report defines the recommended implementation plan from the management alternatives developed in Step I based on the quantitative assessments made in Steps J and K.

The first report completed for the barrier shoreline feasibility study was Step A, a review of prior studies, reports, and existing projects pertaining to the study's purpose, scope, and area. The study team also identified and described existing and potential barrier island and wetland restoration projects that affect the Phase 1 area. Step A was an overall orientation of the project area. The literature review ensures that the study team is knowledgeable and familiar with the most current literature available on the Phase 1 barrier shoreline and is using the most up-to-date information throughout the overall study.

In Step B, the study team developed a conceptual and quantitative framework for the barrier island study. The conceptual framework describes the functions and processes affected by barrier islands and the potential impacts on the significant resources in the study area. The significant resources include economic, cultural, recreational, and land-use resources. Step B also contained a review of the available methods for quantitatively predicting the effects of the barrier islands on environmental and economic resources. This information outlined the study area and described the methodology to be used in Step G to forecast physical and hydrological changes.

Step C consists of qualitative assessments of the status and trends of the resources in the project area. An area was defined that the study team believed was influenced by the barrier islands for the purposes of the Step C general resource assessment. These assessments included economic, social, cultural, water, biological, recreational, and land resources. In addition, the climatology, hydrology, and geological processes were analyzed with regard to their status and trends within the study area. Historical land losses were documented, as well as natural and human factors that contributed to barrier island and wetland change. Impacts to threatened and endangered species were evaluated. This information was gathered to demonstrate the characteristics of the study area and to show the resources at risk due to the loss of the barrier shoreline.

Step D is a quantitative inventory of the physical parameters used to forecast changes in the economic and environmental resources. In the Step D report, the study team delineated zones of environmental and economic analysis in the general study area described in Step B. The zones were designated using the Hurricane Andrew storm surge as criteria. The physical process parameters (waves, wind, sea level, sediment transport, etc.) and the geomorphic parameters (surficial sediments, topography, bathymetry) were identified, including data sources, type and quality of data, and any inconsistencies or “gaps” in the data. This information was later used as input for the modeling and forecasting effort in Step G.

Step E is a quantitative inventory and assessment of existing environmental resource conditions, with an emphasis on those resources considered “significant”. The study team developed the criteria for determining “significant” environmental resources. Wildlife habitats, breeding grounds, and endangered species refuges were among those resources assessed. Step E also included historical habitat/wetland change maps, land loss rates and their associated changes. These data were used to forecast the impact of the no-action scenario for environmental resources.

Step F is a quantitative inventory and assessment of existing economic resource conditions. This assessment included all structures, facilities, farmland acreage, and public resources (roads, channels, bridges, etc.) susceptible to the consequences of wetland/land loss, shoreline erosion, or hurricane induced flooding. The value of these economic resources and their residual worth were included in the assessment. Historical damage and losses caused or induced by oil spills, waves, wetland/land loss, and shoreline erosion were evaluated. These data were used to forecast the impact of the no-action alternative on economic resources.

The forecasted trends of physical and hydrological conditions were analyzed in the Step G report. A 30- and 100-year forecast of the present and future physical conditions were modeled, showing the effects of a no-action scenario. Bathymetry and topography, waves, tides, storm surge, salinity and land loss were forecasted.

The effects on environmental and economic resource conditions were forecasted in two Step H reports (economic and environmental). Projected wetland/land loss was presented for the 30- and 100-year no-action scenarios and used to quantify the effects on habitats, wildlife and economic resources. At the completion of the Step H reports, the study team amassed information detailing the projected changes and the impact to environmental and economic resources in the area. The study team used this information as a baseline for comparing other alternatives.

In Step I, the study team identified and evaluated the strategic options. The Step I report identified problems, needs, and opportunities of the study area and developed strategic options to meet the needs. Options were considered on an island-chain spatial scale. These options included: restoring a historical island configuration, establishing a fall-back line, no-action alternative, preserving present-island configurations, strategic retreat, and other possible options. General assessments of engineering, environmental, economic, and social factors regarding strategic option implementation were considered. Arrays were developed comparing the different options with these factors. Those options that were not recommended by the study team were no longer considered. Management alternatives were developed for detailed analysis in Step J. Step I provided preliminary information about the island size and inlet locations for the numerical modeling performed in Step J.

Step J was the qualitative and quantitative assessment of the management alternatives. This step included a more detailed analysis of the effects of the proposed management alternatives on the environmental and economic resources of the area. The output for Step J was detailed assessment of the effects of the management alternatives on the resources in the area.

In Step K, the study team identified possible engineering techniques for the management alternatives developed in Step I. Various engineering techniques to restore and maintain the alternatives were considered for long-term impacts and effectiveness. Potential use of beach fills, coastal structures, and possible regulatory controls were considered to provide optimal design life and cost effectiveness. Optimal dune crest height and berm and beach slopes were determined to limit wave runup and overtopping. Volumes of beach fill, dune and marsh platform were calculated based on existing information on borrow sites. Cost estimates and volume quantities were developed for various sites and construction methods.

This Final Report summarizes the information provided in all previous documents. The report gives a description of the rationale for selecting the preferred plan. The criteria uses the data generated from the Steps J and K reports to develop a plan with the purpose of helping to preserve ecological integrity, enhance other restoration projects, create habitat, and reduce economic losses where possible. The information in the Final Report and all previous barrier shoreline reports can be used to developed preliminary plans and cost estimates.

FOREWORD

The purpose of this study is to assess and quantify wetland loss problems and economic resources linked to the barrier shoreline system along the Louisiana coast. The study will identify potential solutions to these problems, provide an economic evaluation, and determine the barrier configuration that will best protect Louisiana's coastal resources.

In order to accomplish the desired goals and objectives, the study team has completed the following steps of the study:

Phase 1 - Step A - A Review of Pertinent Literature
Phase 1 - Step B - Conceptual and Quantitative System Framework
Phase 1 - Step C - Assessment of Resource Status and Trends
Phase 1 - Step D - Quantitative Inventory and Assessment of Physical Conditions and Parameters
Phase 1 - Step E - Inventory and Assessment of Existing Environmental Resource Conditions
Phase 1 - Step F - Inventory and Assessment of Existing Economic Resource Conditions
Phase 1 - Step G - Forecasted Trends in Physical and Hydrological Conditions
Phase 1 - Step H(i) - Forecasted Trends in Environmental Resource Conditions
Phase 1 - Step H(ii) - Forecasted Trends in Economic Resource Conditions
Phase 1 - Step I - Forecasted Trends in Formulation and Assessment of Strategic Options
Phase 1 - Step J - Assessment of Management Alternatives
Phase 1 - Step K - Identification and Assessment of Management and Engineering Techniques

This Final Report summarizes information from the previous reports including a description of the study, the existing conditions, and the problems and needs in the study area. The options evaluated by the study team are described including the rationale and description of the alternatives resulting from this step. The benefits and estimated cost for each alternative are summarized. Then, a recommended plan is developed based on the cost effectiveness and benefits provided. The final plan is described including costs and potential funding sources.

The following is the list of personnel who have contributed to this study:

T. Baker Smith & Son, Inc.
Wm. Clifford Smith, P.E., P.L.S.
Marc J. Rogers, Sr., P.E.
Stephen C. Smith, J.D.
Stephen A. Gilbreath, M.S.
Donald W. Davis, Ph.D.
Steve Farber, Ph.D.

Coastal Engineering and Environmental Consultants, Inc.
Oneil P. Malbrough, Jr., REM
Subrata Bandyopadhyay, Ph.D.
Murali M. Dronamraju, Ph.D., MBA

Applied Technology Research Corporation
Lawrence S. McKenzie, III, M.S.
Lorna Guynn

Louisiana State University
Mark R. Byrnes, Ph.D.
Randolph A. McBride, M.S.
Gregory W. Stone, Ph.D.
Joseph N. Suhayda, Ph.D.
Bruce A. Thompson, Ph.D.

University of New Orleans
Denise J. Reed, Ph.D.

The study was conducted by the study team under contract with the Louisiana Department of Natural Resources. The CWPPRA Steering Committee provided oversight and comments during the course of the study.

CWPPRA Steering Committee Members:

Steve Gammill, Study Manager – Louisiana Department of Natural Resources
Steve Mathies, Steering Committee Chairman – U.S. Army Corps of Engineers
Gerry Bodin – U.S. Fish and Wildlife Service
Sue Hawes - U.S. Army Corps of Engineers
Britt Paul – Natural Resources Conservation Service
Jeanne Peckham – U.S. Environmental Protection Agency
Ric Ruebsamen – National Marine Fisheries Service

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1.0. INTRODUCTION

This report contains the final evaluation and recommendation of the Barrier Shoreline Feasibility Study team for the Phase 1 study area. The focus of this report is the associated benefits and costs of two alternatives for shoreline restoration in South-central Louisiana. This section contains a description of the study authority and purpose, and the Phase 1 study area.

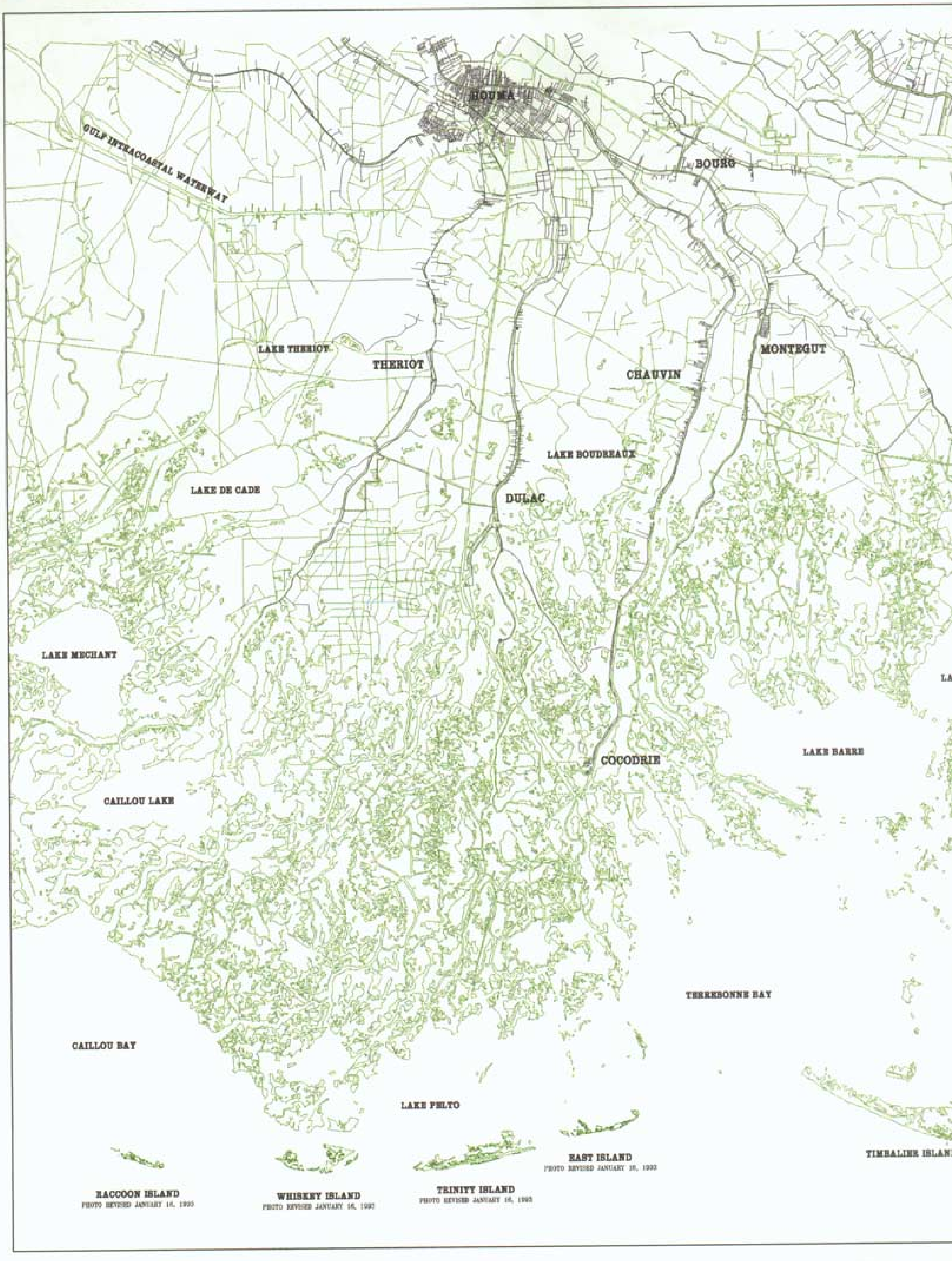
1.1. Study Authority

This study was authorized by the Coastal Wetlands Planning and Protection Act (CWPPRA, PL 101-696) Task Force in early 1995. It was authorized in response to a request by the State of Louisiana for a comprehensive evaluation of shoreline protection methods and needs in coastal Louisiana. The study is managed by the State of Louisiana through the Department of Natural Resources (LA DNR). LA DNR issued a Request for Proposals in March of 1995, and T. Baker Smith & Sons, Inc. was awarded the contract in June 1995.

1.2. Purpose and Scope

The study purpose is to assess and quantify wetland loss problems linked to the barrier formations along the Louisiana coast. The study team was charged to identify solutions to these problems, attach an estimated cost to these solutions, and determine the barrier configuration which best protects Louisiana's significant coastal resources from salt water intrusion, storm surges, wind/wave action, and oil spills. These resources include but are not limited to oil and gas production and exploration facilities, the Strategic Petroleum Reserve, oil and gas pipelines, navigable waterways, and fragile estuarine and island habitats. The scope of the study includes consideration of all management options along the Louisiana barrier shoreline during a 30-year period.

The study area includes the barrier shoreline of coastal Louisiana from Texas to Mississippi. The study was divided into three sub-areas, which were to be addressed in separate phases. The Phase 1 area is from the Atchafalaya River to the Mississippi River. The Phase 2 area covers the Chenier Plain in Vermilion and Cameron Parishes and the Phase 3 area is the Chandeleur Islands. This report discusses the Phase 1 study area from the Atchafalaya River east to the Mississippi River. The Phase 1 barrier shoreline stretches from the western end of Isles Dernieres (Raccoon Point) to Sandy Point in Plaquemines Parish (Figure 1-1).



HOUMA
GULF INTRACOASTAL WATERWAY
BOURG
LAKE THERIOT
THERIOT
MONTEGUT
CHAUVIN
LAKE BOUDREAUX
LAKE DE CADE
DULAC
LAKE MECHANT
COCODRIE
LAKE BARRE
CAILLOU LAKE
TERREBONNE BAY
CAILLOU BAY
LAKE PELTO
EAST ISLAND
PHOTO REVISED JANUARY 16, 1993
TIMBALIER ISLAN
RACCOON ISLAND
PHOTO REVISED JANUARY 16, 1993
WHISKEY ISLAND
PHOTO REVISED JANUARY 16, 1993
TRINITY ISLAND
PHOTO REVISED JANUARY 16, 1993

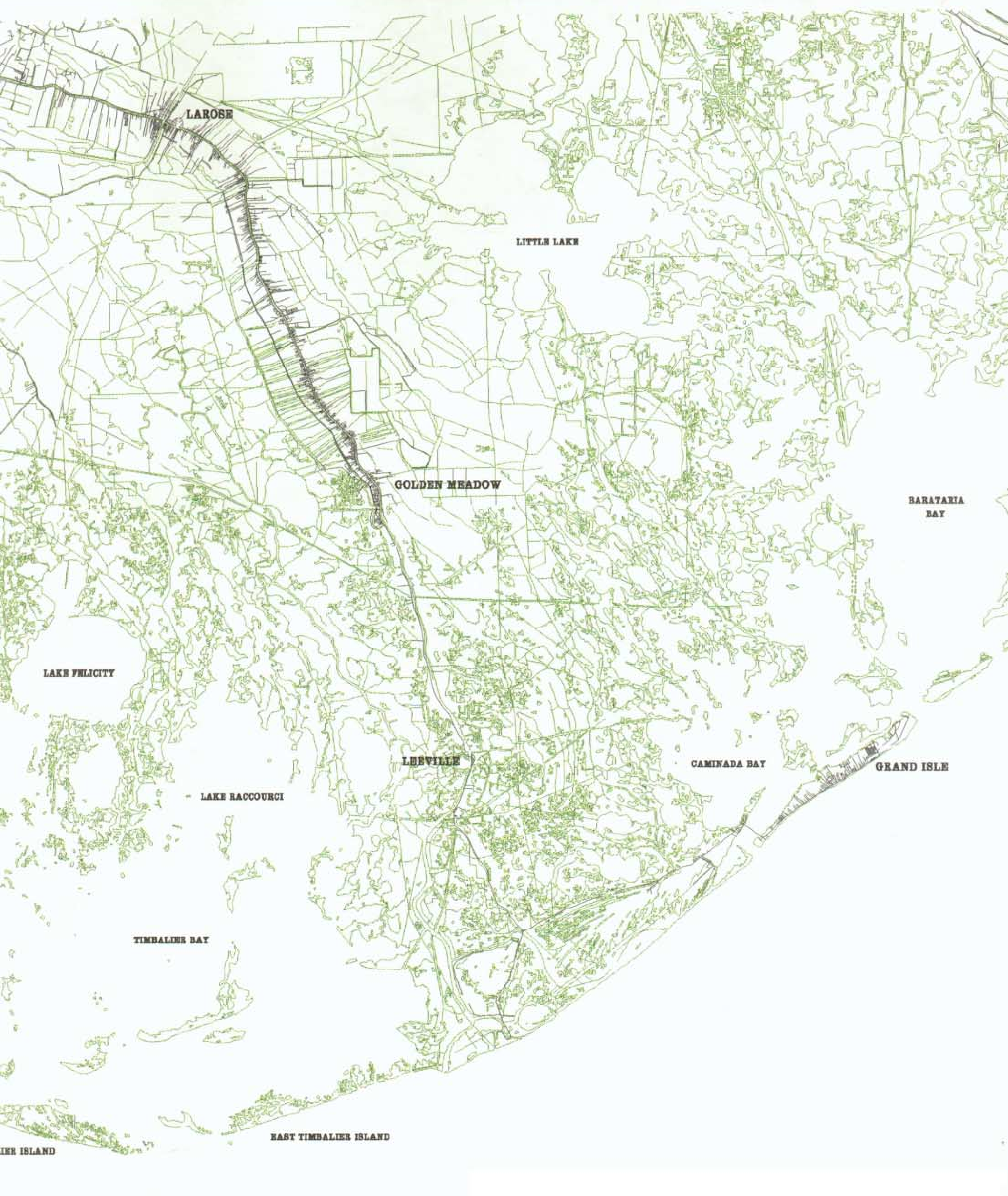
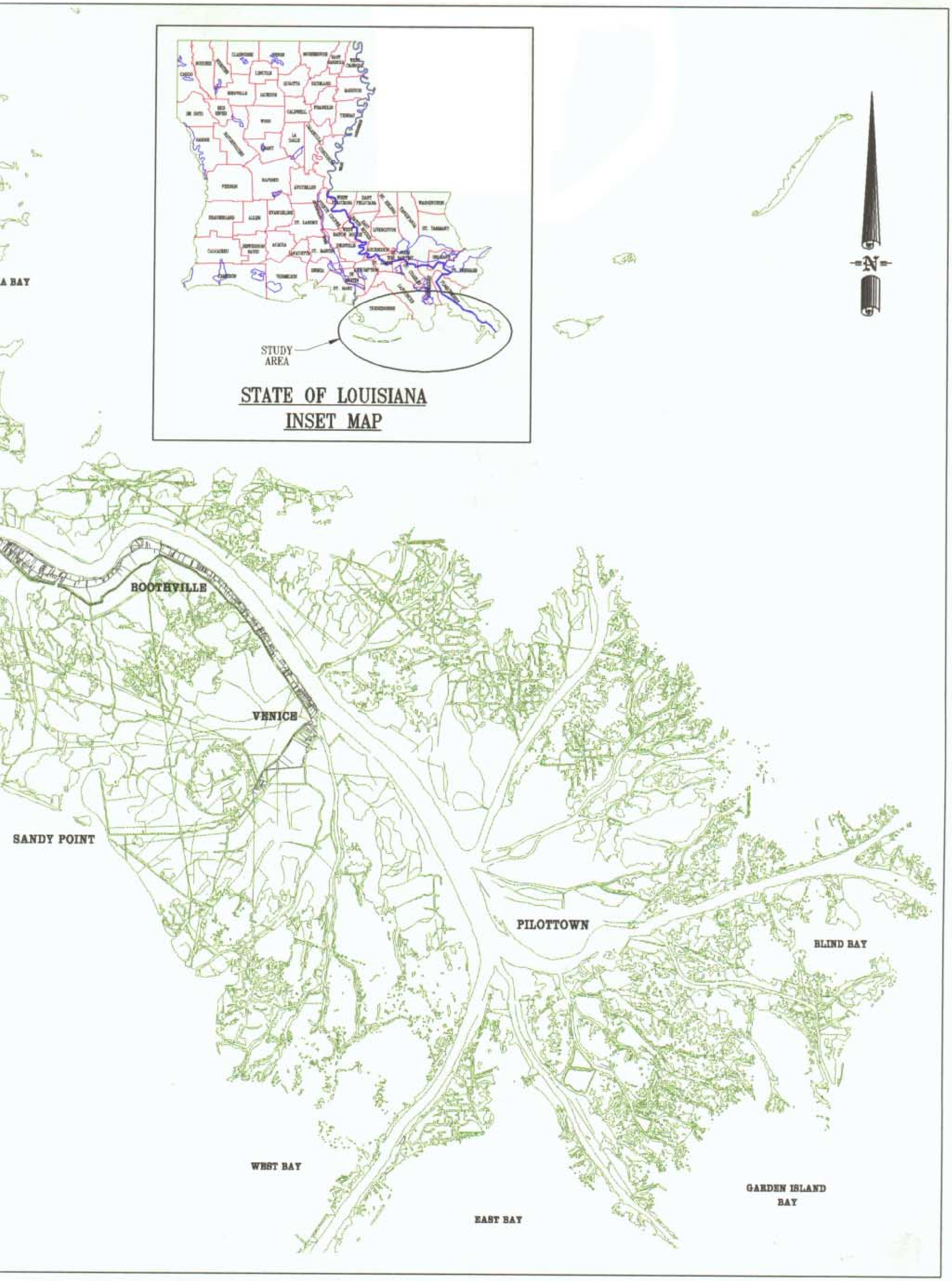


Figure 1-1. Barrier Shoreline Study Area - Phase 1


PORT SULPHUR
CALIFORNIA BAY
BAY
BURAS
BOOTHVILLE
VENICE
SANDY POINT
GULF OF MEXICO
WEST BAY
STUDY AREA
STATE



STUDY AREA
STATE OF LOUISIANA
INSET MAP
N
A BAY
BOOTHVILLE
VENICE
SANDY POINT
PILOTTOWN
BLIND BAY
WEST BAY
GARDEN ISLAND BAY
EAST BAY

2.0. EXISTING CONDITIONS

This section provides an overview of the existing physical conditions and resources within the Barrier Shoreline Phase 1 study area. These conditions and resources will be used to estimate future without project conditions, as well as benefits provided by barrier shoreline restoration alternatives. Section 2.1 describes the zone of economic and environmental analysis within the study area. Section 2.2 discusses the physical conditions within the study area. The diverse environmental and economic resources within the study area are described in Sections 2.3 and 2.4 respectively. This section is based on information previously reported in the Step C – Assessment of Resource Status and Trends, Step D – Quantitative Inventory and Assessment of Physical Conditions and Parameters, Step E – Inventory and Assessment of Existing Environmental Resource Conditions, and Step F – Inventory and Assessment of Existing Economic Resource Conditions reports. For more detailed information, please refer to those reports.

2.1. Introduction

The barrier islands and shoreline in the Phase 1 study area are part of a natural system of interlinked morphologic features and physical processes. Several of these parameters and processes were identified by the study team as potentially impacting environmental and economic resources in the study area. These parameters and processes include: topography and bathymetry, wave characteristics, tidal conditions, hurricane-induced flooding, and salinity. These physical parameters are discussed in Section 2.2. An initial assessment was made with respect to the areal influence of each of these parameters by members of the project team to determine the limits of the zone of economic and environmental analysis. A hurricane storm surge was determined to be the most invasive of these five parameters and was therefore used to define the zone of economic and environmental analysis.

The hurricane surge elevation selected was the water level associated with the 100-year hurricane-induced flooding event. This water level determines the maximum extent of the influence of waves, circulation, and sediment transport. It also determines the area within which infrastructure will be subjected to severe environmental forces. The zone of environmental and economic analysis is shown on Figure 2-1. The zone represents the water and land areas having a one- percent annual risk of being flooded due to hurricane surges (Suhayda, et. al., 1993). The eastern boundary of the environmental and economic analysis zone is west of the Mississippi River.

In the Barataria Basin, the zone extends northward of Lac Des Allemands and passes southward to Lake Boeuf. It encompasses the leveed areas of Terrebonne and Lafourche Parishes and extends westward from Donaldsonville to the Atchafalaya River eastern guide levee.

2.2. Existing Physical Conditions

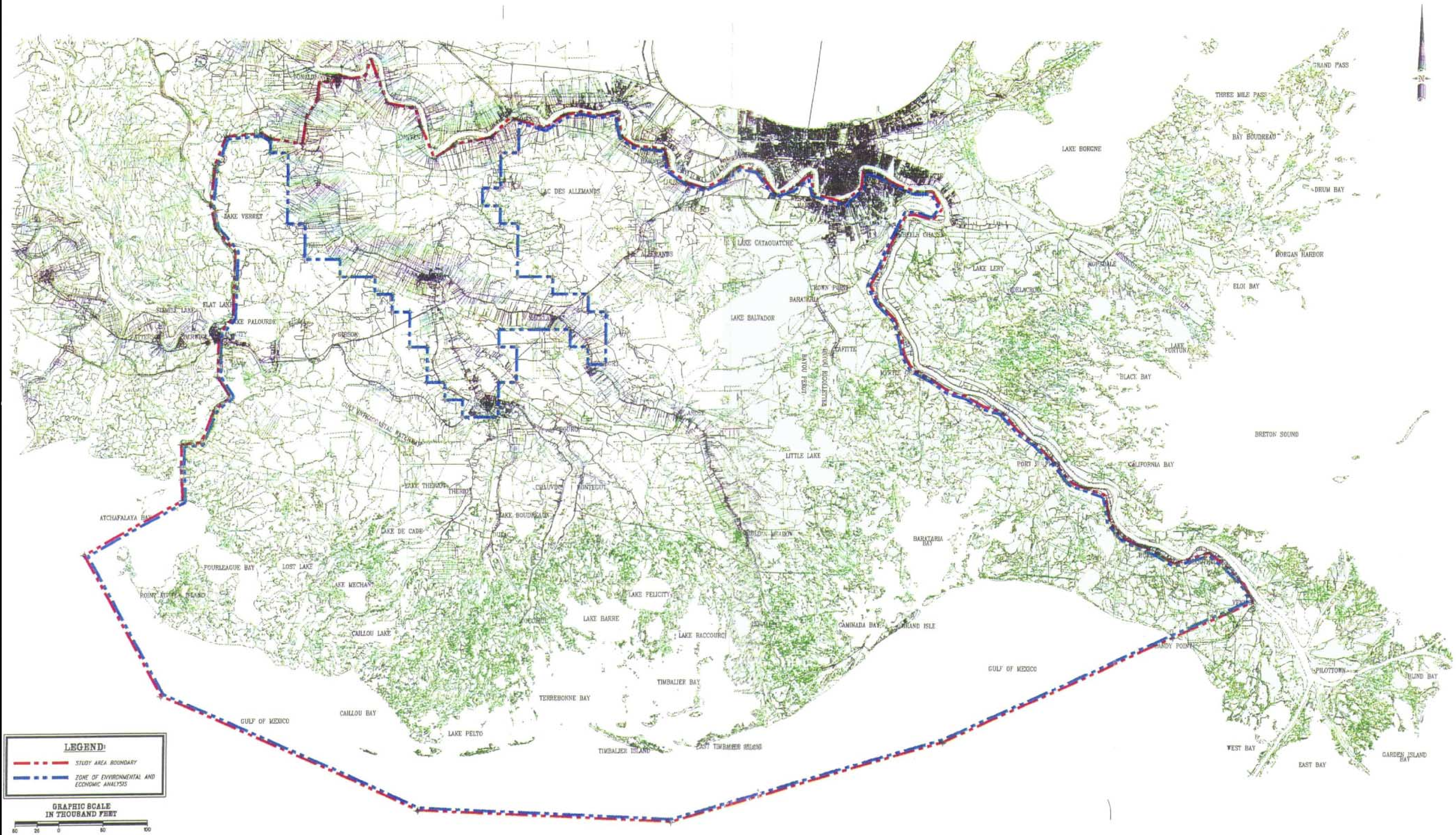
In this section, general physical and hydrologic conditions of the study area are discussed. The study team focused on these parameters which affected, or were affected by, the barrier shoreline. This section includes a discussion of topography, bathymetry, waves, tides, flood events, and salinity.

2.2.1. Topography

Barrier Islands

Louisiana's barrier shorelines have undergone landward migration, area loss, and island narrowing as a result of a complex interaction among subsidence, sea level rise, storm impacts, wave processes, inadequate sediment supply, and intense human disturbance (McBride and Byrnes, 1995; McBride et al., 1992). Consequently, the structural continuity of the barrier shoreline weakens as the barrier islands narrow, fragment, and finally disappear. Storm processes (e.g., washover, island breaching) and in-place deterioration (subsidence-driven vertical movement), as well as longshore sediment transport, control barrier shoreline evolution along the Mississippi River Deltaic Plain. In the Phase 1 study area, the outer shoreline consists of four barrier systems: (1) Isles Dernieres, (2) Timbalier Islands, (3) Caminada-Moreau Headland, and (4) Plaquemines Shoreline. Table 2-1 contains the historical shoreline change and area change rates for these systems.

Figure 2-1. Zone of Environmental and Economic Analysis.



The Isles Dernieres barrier islands (Raccoon Island, Whiskey Island, Trinity Island, East Isle, and Wine Island) are highly dynamic and experiences erosion on both the gulf and bay side shorelines. These islands are low in elevation and are overwashed frequently. The continual narrowing of the island between the gulf and bay shorelines has allowed overwashed sediments to be lost to the bays. The result is that the Isles Dernieres chain is one of the most rapidly eroding barrier shorelines in the United States (Williams *et al*. 1992).

Table 2-1. Barrier Shoreline Change Rates 1887 – 1988 (Williams *et al* 1992).

	Shoreline Change		Area Change
	Bay	Gulf	
Isles Dernieres	-2.0 ft/yr	-36.4 ft/yr	-6,623 acres
Timbalier Islands	38.4 ft/yr	-49.9 ft/yr	-2,217 acres
Caminada-Moreau Headland	N/A	-43.6 ft/yr	N/A
Grand Isle	-3.3 ft/yr	-3.0 ft/yr	-605 acres
Plaquemines Shoreline	1.3 ft/yr	-18.0 ft/yr	N/A

The Timbalier Islands consists of Timbalier and East Timbalier Islands. Timbalier Island is dominated by wind and wave processes. Meanwhile, East Timbalier Island is an overwash dominated island with a detached revetment/breakwater located seaward of the existing island.

The Caminada-Moreau Headland is unique to the Phase 1 study area in that it is an attached headland and does not contain a bay shoreline. The Headland has experienced some of the highest rates of shoreline erosion on the Louisiana coastline (Table 2-1). Another difference from the barrier islands is that the Headland consists of cohesive deltaic sediments and a sandy ridge that have generally been transported laterally or offshore (Williams *et al.* 1992).

Grand Isle has one of the smallest erosion rates along the Louisiana coastline and is unique in that it is the only populated island in the Phase 1 study area. Grand Isle has been affected by construction of several shoreline protection measures using breakwaters and jetties. Since 1954, Grand Isle has received in excess of 2.0 million cubic yards of beach fill (Gravens and Rosati 1994).

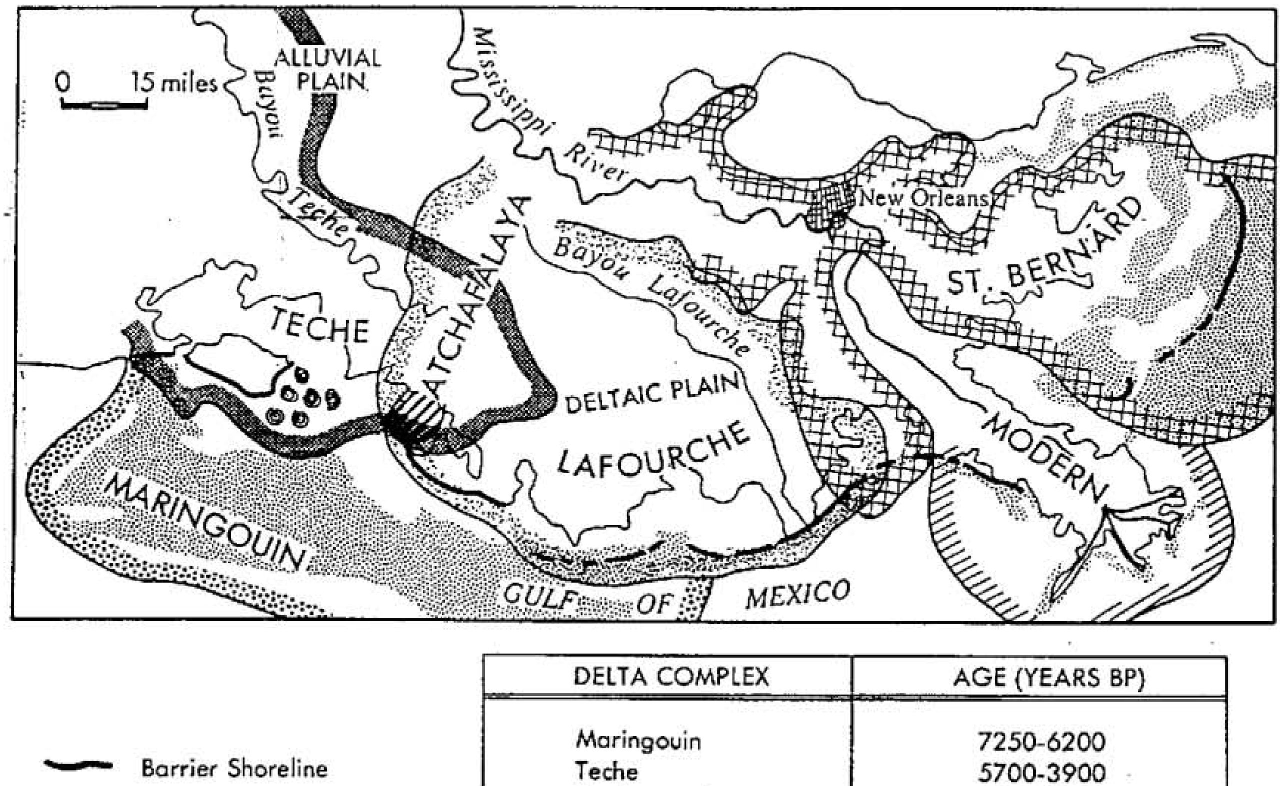
The Plaquemines Shoreline extends from the Grande Terre Islands to Sandy Point, encompassing 30-miles of narrow islands. The Plaquemines shoreline consists of narrow, low-lying, and highly segmented islands. The Plaquemines sub-area has experienced severe coastal erosion due to lack of sediment, subsidence, storms, and human impacts (Williams *et al.* 1992).

Wetlands

Over the past 7,000 years, six major delta complexes have created the present Mississippi River delta plain (Figure 2-2). The result of this long period of deltaic sedimentation is a vast expanse of marshlands separated by active and abandoned distributary channels. As the focus of sedimentation shifted, destructive processes (e.g., shoreline erosion and subsidence) began in the abandoned delta resulting in land loss. However, land loss was more than offset by land gain occurring at the new site of deposition. Since the early 1900s, the trend of land building has reversed and the Louisiana coastal zone is losing hundreds of square miles of wetlands. Britsch and Kemp (1990) conducted a detailed land loss study for the coastal zone of Louisiana to document trends in change for the period 1932 to 1983 (later updated by Britsch and Dunbar [1993] to 1990). Wetland habitat types and Land loss rates in the study area are discussed in more detail in Section 2.3.1.

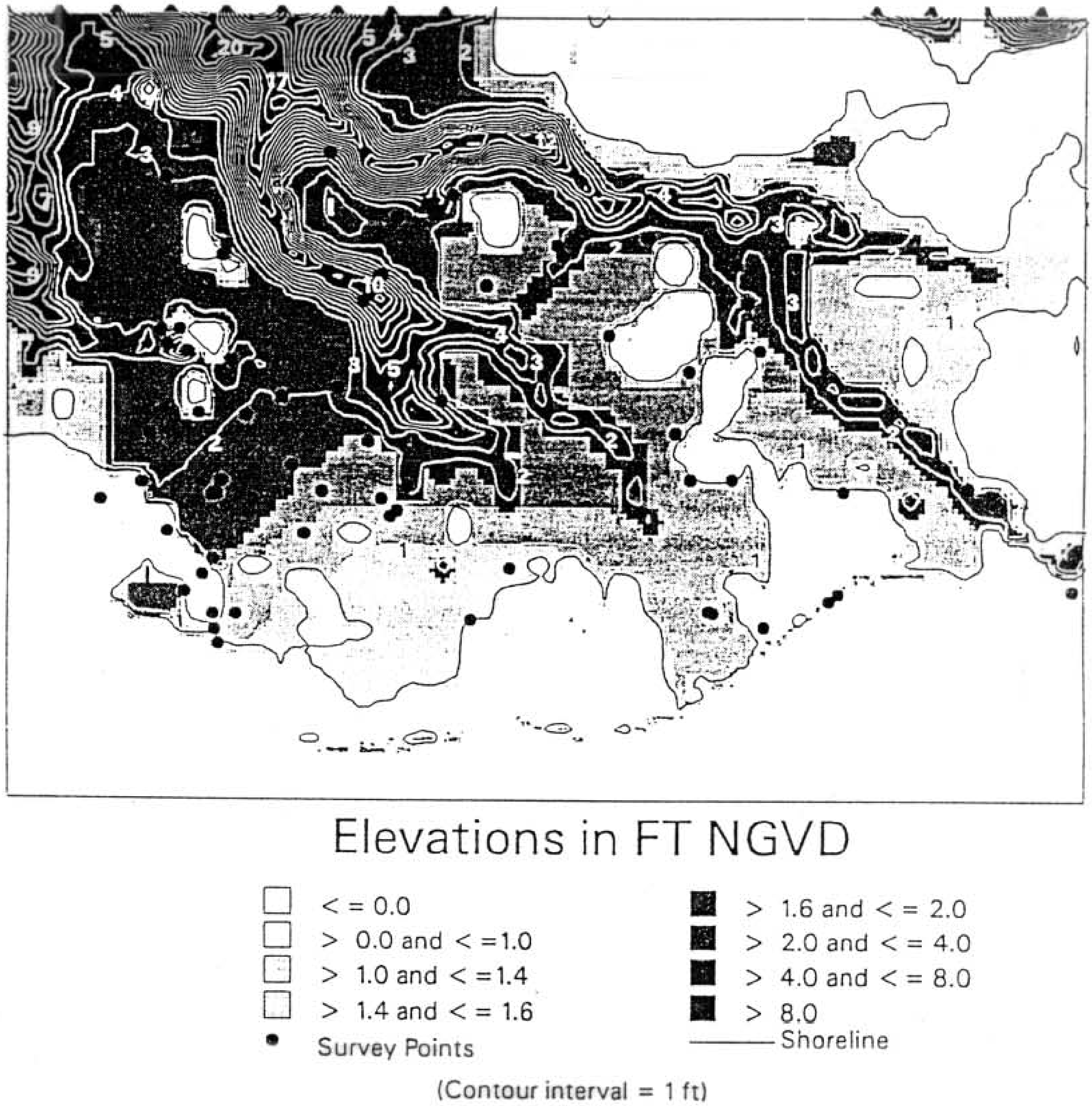
A recent survey of wetland elevation and topography in the study area was conducted by the Barataria/Terrebonne National Estuaries Program (Alawady and Al-Taha 1995). Field crews from several state and federal agencies collected data at 81 sites. Data were referenced to the National Geodetic Vertical Datum of 1929 and the North American Datum of 1927. A contour map of the study area, based upon this data, is shown in Figure 2-3.

Figure 2-2. The Holocene Mississippi River delta plain comprised of six major delta complexes; two are currently active, the Atchafalaya and Modern, and four are abandoned, the Maringouin, Teche, St. Bernard, and Lafourche (from Frazier, 1967).



DELTA COMPLEX	AGE (YEARS BP)
Maringouin	7250-6200
Teche	5700-3900
St. Bernard	4600-1800
Lafourche	3500-400
Modern	Active
Atchafalaya	Active

Figure 2-3. BTNEP Topographic Data (Alawady and Khaled, 1995).



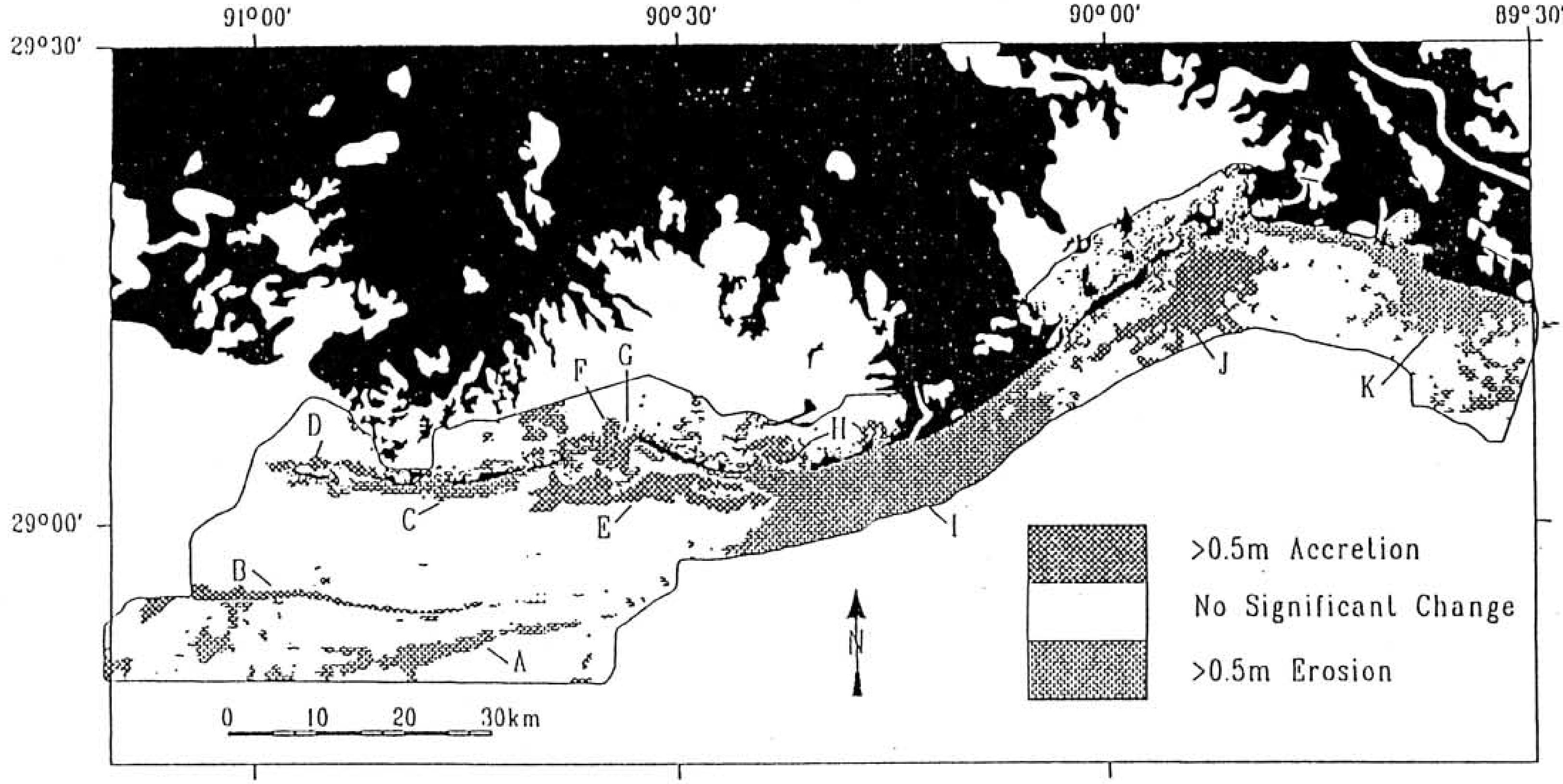
2.2.2. Bathymetry

Hydrographic surveys of regional nearshore morphology provide a direct source of data for quantifying changes in seafloor elevation. Jaffe *et al*. (1989) and List *et al*. (1991, 1994) discuss bathymetric changes over the past 100 years for an area seaward of the barrier islands along the Mississippi River Delta Plain. These data provide information on regional sediment transport patterns and its relationship to shoreline change.

The patterns of erosion and accretion shown in Figure 2-4 represent seafloor changes that occurred between the 1930s and the 1980s. Overall, List *et al*. (1991, 1994) observed only 35% as much deposition (383 x 10^6 cy) as erosion (109 x 10^7 cy) throughout the study area. This may suggest that large depositional volumes were not identified because of transport beyond the limit of the 1980s survey. However, an examination of sediment cores indicates that the eroding deltaic headlands contain only about 30% sand-sized material, whereas the areas of deposition shown in Figure 2-4 are primarily composed of sand. Therefore, it is reasonable to believe the patterns of erosion and accretion represent a largely balanced “sand” system, with eroded fine-grained material dispersed or removed from the study area.

Overall, the patterns of erosion and accretion in the eastern 3/4 of the study area appear to be following a simple shoreline-straightening model (erosion at headlands and deposition in embayments). However, most sediment movement occurred in water depths outside the littoral zone, emphasizing the importance of shoreface processes in coastal evolution.

Figure 2-4. Bathymetric change between the 1930s and 1980s surface grids, corrected for relative sea level rise to yield the patterns of erosion and accretion. Letters indicate areas of erosion or accretion referred to in the text.



2.2.3. Wave Characteristics

Wave statistics (annual and monthly averages of wave height, period and direction, occurrence of extreme event, etc.) were collected and evaluated from three sources: (1) the Wave Information Study (WIS) of U.S. Army Corps of Engineers (USACE); (2) the National Oceanic and Atmospheric Administration (NOAA)'s National Data Buoy Center (NDBC) and (3) the Louisiana-Texas Shelf Physical Oceanography Program (LATEX) station 16 (Hubertz and Brooks 1989; Abel and Tracy 1989; downloaded from National Oceanographic Data Center (NODC)'s World Wide Web site (www.nodc.noaa.gov); unpublished, courtesy of Dr. Steven F. DiMarco of Texas A&M University). A summary of these three sources is shown in Table 2-2.

Table 2-2. Phase 1 Study Area Offshore Wave Climate Data.

Sources	Latitude (N)	Longitude (W)	Water depth (ft)	Mean wave height (ft)	Wave Period (sec)
WIS Stations (18, 19, 20, 21)	28.5°	90.0° to 91.5°	151	3.3 (±0.7)	4.5 to 6.0
NDBC 42001	25.9°	89.9°	10,500	2.6 to 4.6	4.3 to 4.9
LATEX 16	28.9°	90.5°	69	1.0 to 4.3	5.5 to 6.0

The maximum wave heights from three of the four WIS stations exceeded 16.4 feet, and the wave peak period associated with the largest wave exceeded 11 seconds. The predominant wave directions were from the southeast. Also, the directions for the average and largest waves were mostly from the southeast.

2.2.4. Astronomical Tides

The astronomical tides in the Gulf of Mexico offshore of the study area are diurnal with an average range of about 1-foot (Marmer 1954; Zetler and Hansen 1970). Nearshore tides have an average range that slightly increases from east to west across the study area. The tidal range varies from a low of about 0.40 feet to a high of about 2.1 feet over a fortnightly cycle. These ranges represent variations about mean sea level.

The astronomical tides penetrate well into the coastal wetlands of the study area. The tide in Bayou Barataria at Barataria is about 0.40 feet and is about 0.20 feet in Lake Salvador. The tide in Lake Salvador lags the tide at Grand Isle by about 10 hours. Meanwhile, tidal amplitude in the Houma Navigation Canal near Dulac is about 0.08 feet.

2.2.5. Flood Event Characteristics

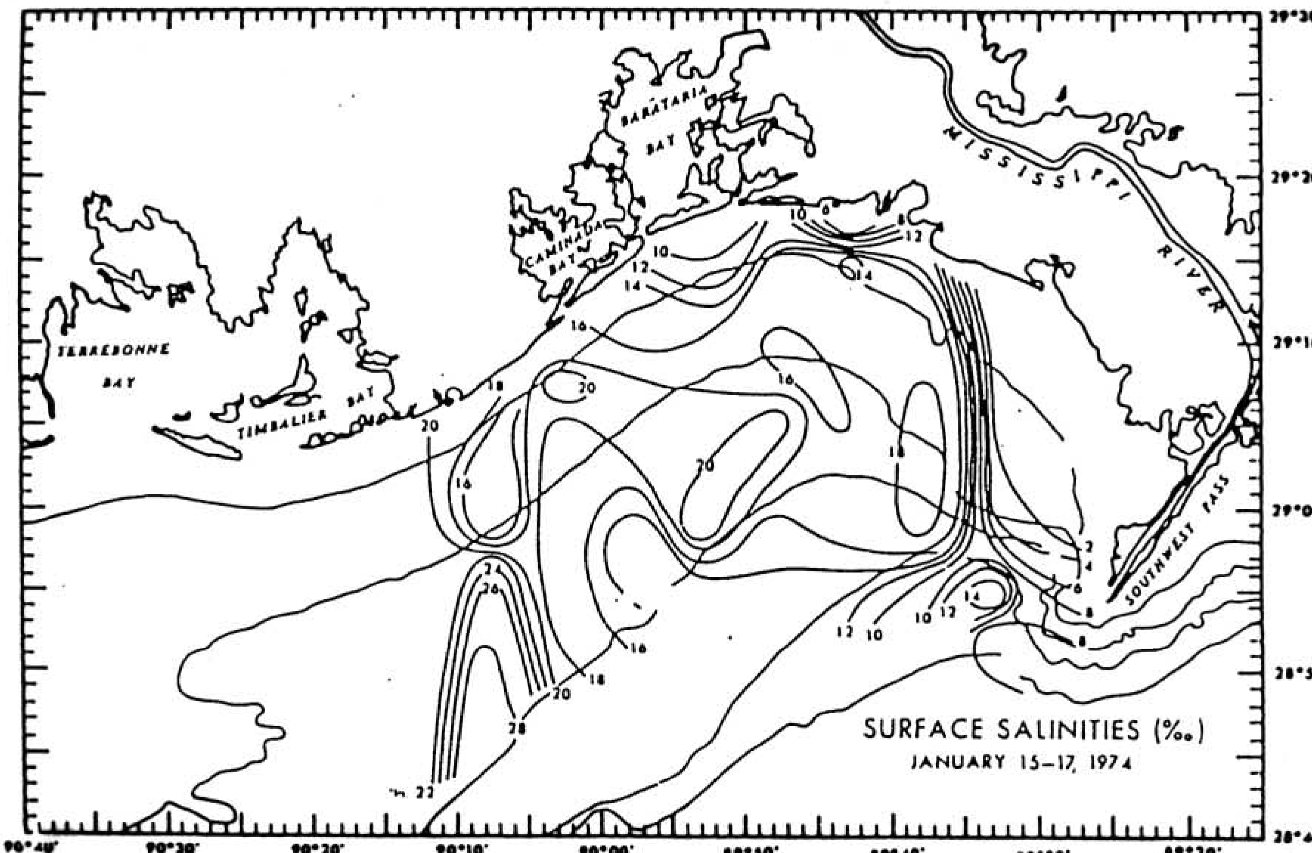
There are several sources of flooding for the study area including run-off, hurricanes, tidal action, backwater and combinations of these events. The most important source of flooding, in terms of impact to resources, is hurricanes. For this study, hurricane-flooding data were generated using the Federal Emergency Management (FEMA) storm surge model and hurricane storm statistics to generate the water level statistics. Results indicate that hurricane flooding affects essentially all locations in coastal Louisiana.

The north/south variations in the 100-year elevations indicate, as expected, that the highest flood elevations occur at the coastline. However, the area of next highest flooding is at the northern edge of the coastal zone, where elevations can reach 7.9 to 9.8 feet. The lowest 100-year flood elevations occur in the midsection of the coastal area due to the lack of land barriers that tend to promote surge buildup. A few sites at the northern edge of the coastal zone experience flooding only during extreme storms. The 50-year flood levels are generally 2.0 to 3.0 feet less than the 100-year levels. Other flood levels, 10 and 25 year, are generally 4.9 and 6.9 feet less than the 100-year elevations, though many locations show different relationships. Generally, these flood levels are considered to be conservative, where the actual flood elevation may be 1.0 foot higher than the predicted flood elevation. The methods used to estimate the water level probability are discussed in the Step D report (LADNR, 1998d)

2.2.6. Salinity

The nearshore variations in water salinity are illustrated in Figure 2-5. The data shows a band of low salinity waters (< 12 ppt) along the coast. These brackish waters are the result of freshwater discharge from bays to the north and from recirculated Mississippi River water. Thus, they undergo seasonal variation as the freshwater supply to the area changes.

Figure 2-5. Surface Salinities (ppt) in the bight west of the Mississippi Delta, (Murray, S.P., 1976).



The volume of salt water entering the wetlands of the study area is termed the tidal prism. The tidal prism is the amount of water brought into and removed from the study area bays during an average tidal cycle. Tidal prism estimates for both Barataria Bay and Terrebonne/Timbalier Bay have been made based upon water level data from several stations in the study area (Wiseman and Swenson 1989). The Barataria Bay tidal prism was 7.8 billion cubic feet, while the Terrebonne/Timbalier Bay tidal prism was about 18 billion cubic feet. The flushing times of the estuaries were estimated to be about 1 to 2 months.

2.3. Environmental Resources

The environmental resources in the study area include various types of flora and fauna that are ecologically important. Change in habitat over time is the primary condition that influences these resources.

2.3.1. Habitat Changes

Coastal marshes in the study area have been gradually following converting to open water. Fuller *et al.* (1995) reported that of the available habitat data for the Barataria basin in 1956, about 39% of the area was classified open water (429,000 acres) and 48% (528,000 acres) was classified marsh, the remaining being agriculture, pasture and developed. In 1978, approximately 49% (538,000 acres) of the area was open water. In 1978, marsh had decreased to 36% (388,000 acres) of the area. Fresh marsh accounted for 5% of the area (decrease of 6,400 acres per year) and non-fresh 31%. In 1988/90, marsh has decreased to 28% (307,000 acres) of the area. In 1988/90, fresh marsh slightly increased to about 6% of the area (an increase of 1,300 acres per year) and non-fresh marsh decreased to 22% of the area (a decrease of about 8,320 acres). Chabreck and Linscombe (1982) have also documented a shift in salinity zones of the wetlands. These data are summarized in Table 2-3.

TABLE 2-3. Area (mi^2) and Annual Habitat Change Based on Available Data for the Barataria Basin for 1956, 1978 and 1988/90 (Fuller et al. 1995).

Habitat		Year		Average Annual Change	
	1956	1978	1988/90	56-78	78-88/90
Water	670	841	974	7.75	11.11
Marsh	825	606	480	-9.94	-10.55
Fresh Marsh		79	105		2.13
Nonfresh Marsh		527	375		-12.68
Forested Wetlands*	118	125	123	0.34	-0.23
Agriculture/Pasture	53	55	59	0.07	0.38
Developed	36	78	72	1.91	-0.44
Other**	10	7	4	-0.12	-0.28
TOTAL	1,712	1,712	1,712		

***** Includes Forest, Swamp, Shrub/Scrub; ****** Includes Shore, Inert, Beach, Upland Barren, Other

Fuller *et al.* (1995) reported the available habitat data for the Terrebonne basin (Table 2-4) which indicates in 1956 approximately 44% (607,000 acres) of the area was open water, 50% (684,000 acres) in marsh and 5% was forested wetlands. By 1978, marsh area decreased to 38% (529,000 acres) with 12% classified as fresh marsh and 26% non-fresh marsh. By 1988/90, marsh was further decreased to 33% (456,300 acres), with 12% classified as fresh marsh (decrease of 128 acres per year) and 21% classified as non-fresh marsh (decrease of 5,760 acres per year).

TABLE 2-4. Area (mi^2) and Annual Habitat Change Based on Available Data for the Terrebonne Basin for 1956, 1978 and 1988/90 (Fuller et al. 1995).

Habitat		Year		Average Annual Change	
	1956	1978	1988/90	56-78	78-88/90
Water	949	1,158	1,283	9.53	10.42
Marsh	1,069	827	714	10.97	-9.49
Fresh Marsh		260	259		-0.15
Nonfresh Marsh		567	455		-9.33
Forested Wetlands*	113	136	122	1.03	-1.20
Agriculture/Pasture	20	25	30	0.23	0.42
Developed	4	11	11	0.31	-0.06
Other**	8	4	4	-0.17	-0.01
TOTAL	2,163	2,161	2,164		

***** Includes Forest, Swamp, Shrub/Scrub; ****** Includes Shore, Inert, Beach, Upland Barren, Other

2.3.2. Flora

This significant flora are discussed within the following coastal environments:

1. **Coastal Marsh -** Includes the wetlands along the coast of Louisiana that are influenced by alternate floods and ebbs of tides.

2. **Cypress-Tupelo Swamp -** Includes the freshwater woody wetlands that exhibit standing water for most, if not all, of the growing season and are dominated by cypress (*Taxodium distichum*) and gum/tupelo (*Nyssa aquatica*).

3. **Bottomland Hardwoods -** Includes the tracts of riparian wetlands that are occasionally flooded by the adjacent rivers, streams, and higher parts of interdistributary basins.

4. **Natural Levees/Cheniers/Uplands -** Includes the natural ridges, high lands, levees, and uplands in the study area.

5. **Estuarine/Marine/Open Waters -** Includes all open water in the study area which support no emergent vegetation.

6. **Barrier Islands -** Includes the barrier islands and headlands in the Gulf of Mexico between the Atchafalaya and the Mississippi River.

The species composition and distribution of flora in each coastal environment is primarily dependent on salinity and elevation. Elevation is a controlling factor in determining species in areas adjacent to larger coastal streams where slightly elevated natural levees allow less flood-tolerant species to grow. Table 2-5 provides a list of some of the dominant species of flora in each of the six major environments. Table 2-6 shows the percentage cover of the dominant plant species in major marsh zones of the Louisiana coast.

TABLE 2-5. List of Some of the Dominant Species of Flora in Major Environments (based on Clark and Berforado 1981, Conner and Day 1976, Resource Management Group, Inc. 1992, Chabreck and Linscombe 1982, Montz 1977, Chabreck 1971)

Major Environment	Aquatic	Terrestrial
Coastal Marsh		No Significant Terrestrial Flora Identified in this Environment (See Table 2-1)
Salt	*Distichlis spicata* (Seashore Saltgrass) *Juncus roemerianus* (Needlegrass Rush) *Spartina alterniflora* (Saltmarsh Cordgrass)	
Brackish/Intermediate	*Eleocharis parvula* (Small Spikerush) *Ruppia maritima* (Widgeon-Grass) *Scirpus olneyi* (Three-Cornered Grass) *Scirpus robustus* (Alkali Bulrush) *Spartina patens* (Saltmeadow Cordgrass) *Bacopa monnieri* (Coastal Water-Hyssop) *Cyperus odoratus* (Rusty Flatsedge) *Echinochloa walteri* (Coast Cockspur) *Paspalum vaginatum* (Seashore Paspalum) *Phragmites australis* (Common Reed)	
Fresh	*Alternanthera philoxeroides* (Alligator Weed) *Eleocharis* sp. (Spikerush) *Hydrocotyl umbellata* (Many-Flower Penny-Wort) *Panicum hemitomon* (Maiden-Cane) *Sagittaria falcata* (Coastal Arrow-Head)	
Cypress/Tupelo Swamp		
Dominant Canopy Trees	*Taxodium distichum* (Bald Cypress) *Nyssa aquatica* (Water Tupelo)	
Sub-Dominant Trees	*Acer rubrum* var. *Drummondii* (Drummond Red Maple)	*Froxinus Tomentosa* (Pumpkin Ash)
Shrubs	*Cephalanthus occidentalis* (Buttonbush) *Salix nigra* (Black Willow)	
Herbs and Aquatic Vegetation	*Lemna minor* (Duckweed) *Spirodella polyrhiza* (Duckweed) *Riccia* Sp.	
	Limmobium spongia (Common Frog's Bit)	
Bottomland Hardwoods		
Dominant Canopy Trees	*Quercus* spp. (Oaks) *Liquidambar styraciflua* (Sweet Gum) *Carya aquaticas* (Water Hickory) *Celtis laevigata* (Sugarberry)	*Quercus* spp. (Oaks)
Sub-Dominant Trees	*Ulmus* spp. (Elms) *Acer rubrum* (Red Maple)	
Shrubs	*Cornus drummondii (*Rough-Leak Dogwood) *Planera aquatica* (Water Elm) *Salix nigra* (Black Willow)	*Crataegus* spp. (Hawthorn)

TABLE 2-5. (Continued) List of Some of the Dominant Species of Flora in the Study Area (based on Clark and Berfurado 1981, Conner and Day 1976, Resource Management Group, Inc. 1992, Chabreck and Linscombe 1982, Montz 1977, Chabreck 1971)

Major Environment	Aquatic	Terrestrial
Natural Levees/Chenieres/Uplands		
Trees	*Fraxinus pennsylvanica* var. *lanceolata* (Green Ash) *Celtis laevigata* (Hackberry)	*Populus deltoides* (Cottonwood) *Liquidambar styraciflua* (Redgum) *Gleditsia triacanthos* (Honeylocust) *Quercus* spp. (Oaks) *Ulmus americana* (American Elm) *Ulmus alata* (Winged Elm) *Ulmus crassifolia* (Cedar Elm) *Carya illinoensis* (Pecan) *Diospyros virginiana* (Persimmon)
Shrubs	*Iva frutescens* (Marsh Elder) *Baccharis Halmifolia* (Groundselbush)	
Estuarine/Maine/Open Waters		No Significant Terrestrial Flora Identified in this Environment (See Table 2-1)
Salt	*Halodule beaudettei* (Shoalgrass) *Ruppia maritima* (Widgeongrass) *Ulva* sp. (Sea Lettuce) *Enteromorpha* sp. (Green Algae) *Polysiphonia* sp. (Red Algae)	
Brackish/Intermediate	*Ruppia maritima* (Wideongrass) *Myriophyllum spicatum* (Eurasian watermilfoil) *Chara vulgaris* (Muskgrass) *Najas quadulupensis* (Southern Naiad)	
Fresh	*Lemna minor* (Common Duckweed) *Myriophyllum spicatum* (Eurasian watermilfoil) *Chara vulgaris* (Muskgrass) *Ceratophyllum demersum* (Coontail)	
Barrier Islands		
Beach Forefront	*Sesuvium portulacastrum* (Beach Purslane) *Cakile geniculata* (Sea Rocket)	*Ipomoea stolonifera* (Beach Morning Glory)
Beach Crest	*Spartina patens* (Wiregrass) *Distichlis spicata* (Salt Grass)	*Fimbristylis castanea* (Sandrush)
Sand	*Batis maritima* (Saltwort) *Salicornia bigelovii* (Glasswort)	
Landward Marsh	*Spartina alterniflora* (Smooth Cordgrass) *Avicennia germinans* (Black Mangrove)	

Table 2-6. Percentage Cover of Plant Species in Terrebonne and Barataria Marsh Zones of the Louisiana Coast (Chabreck 1972)

	BARATARIA				TERREBONNE			
Species	**Salt**	**Brackish**	**Intermediate**	**Fresh**	**Salt**	**Brackish**	**Intermediate**	**Fresh**
Alternanthera philoxeroides	0	0	0	3.43	0	0	0	2.42
Aster sp.	0	0	0	0	0	0	1.12	0
Avicennia nitida	0	0	0	0	1.52	0	0	0
Bacopa monnieri	0	0	23.97	1.82	0	0	3.72	2.73
Batis maritima	3.08	0	0	0	6.58	0	0	0
Cyperus odoratus	0	0	5.34	3.21	0	2.31	2.98	1.92
Decodon verticillatus	0	0	0	1.16	0	0	0	1.1
Distichlis spicata	10.05	28.96	3.05	0	11.66	13.09	1.86	0
Dryopteris thelypteris	0	0	0	0	0	0	0	1.43
Echinochloa walteri	0	0	0	2.15	0	0	2.6	0
Eichornia crassipes	0	0	0	1.99	0	0	0	0
Eleocharis parvula	0	5.49	0	0	0	0	0	0
Eleocharis sp.	0	1.4	2.29	12.31	0	1.93	1.27	18.03
Hydrocotyle umbellata	0	0	0	0	0	0	0	4.32
Ipomoea sagittata	0	0	1.53	0	0	0	1.12	0
Juncus roemerianus	14.9	3.26	0	0	3.69	0	0	0
Leptochloa fascicularis	0	0	0	0	0	0	9.23	0
Najas quadalunpensis	0	0	0	0	0	0	3.35	0
Osmunda regalis	0	0	0	0	0	0	1.49	0
Panicum hemitomon	0	0	0	41.35	0	0	4.09	42.17
Paspalum vaginatum	0	0	0	0	0	0	2.98	0
Phragmites communis	0	0	0	0	0	0	1.49	0
Pluchea comphorata	0	0	16.79	0	0	0	3.12	1.19
Polygonum sp.	0	0	0	1.6	0	0	0	0
Sagittaria falcata	0	0	3.82	17.42	0	0	2.45	7.67
Salicornia virginica	1.19	0	0	0	0	0	0	0
Scirpus olneyi	0	2.26	0	1.48	0	6.57	7.07	0
Scirpus validus	0	0	0	0	0	1.5	0	0
Spartina alterniflora	62.79	9.03	0	0	67.73	2.08	0	0
Spartina cynosuroides	0	0	0	0	0	1.13	0	0
Spartina patens	7.77	45.84	41.99	0	6.81	63.39	34.23	1.22
Typha spp.	0	0	0	2.59	0	0	5.95	1.58
Vigna repens	0	0	0	1.16	0	4.08	7.07	1.04
Zizaniopsis miliaceae	0	0	0	1.36	0	0	0	3.18
Other species	0.22	3.76	1.22	6.97	2.01	3.92	2.81	10
Total	100	100	100	100	100	100	100	100
Total Number of Species	7	7	9	15	7	10	20	14

TABLE 2-7. Net Change in the Size of Vegetative Type in Louisiana Coastal Marsh from 1968 to 1978 (Chabreck and Linscombe 1982)

	Size of Type* (mi2)		Change	
Vegetative Types	**1968****	**1978**	**Sq. Mi.**	**Percent**
Saline	1,455	1,585	+130	+8.9
Brackish	2,203	2,060	+ 37	+1.8
Intermediate	1,072	1,044	- 28	-2.6
Fresh	2,031	1,892	-139	-6.8

***** Includes Natural Marshes and Associated Water Bodies

Chabreck and Linscombe (1982) documented the shift in vegetative zones for the entire Louisiana coastal marsh. Table 2-7 provides the net change in size from 1968 to 1978 of the vegetative type in the Louisiana coastal marsh. Tables 2-6 and 2-7 together provide an assessment of change in species distribution through time.

The vegetative resources of barrier shoreline, coastal marsh and open water environments are considered to be those most susceptible to alterations as a result of changes in barrier shoreline configuration. Although the floral resources of cypress-tupelo swamps, bottomland hardwoods and upland areas may be impacted, little information could be obtained upon which an assessment of changes in those resources could be based.

2.3.3. Fauna

This section discusses some primary fauna in the six major environments. To facilitate identification of individual species, these functional groups are again divided into subgroups, and major species are listed for each subgroup listed in Table 2-8.

The selection of major species within subgroups is very similar to that found in Condrey *et al.* (1995), since selection criteria in both cases are similar and the study areas for the Phase I Barrier Shoreline Feasibility Study and the Barataria-Terrebonne National Estuary Program (BTENP) closely correspond. Condrey *et al.* (*1995*) provides the most updated information on inventory and assessment of fauna in the Barataria-Terrebonne estuary. This study frequently refers to data provided in that document.

Table 2-9 correlates major species (as listed in Table 2-8) with major environments depending on their relative abundance and preferred habitat. In Table 2-8, each species in each of the subgroups has been assigned a number, which has been included in Table 2-9. For this reason, Table 2-9 should be read in conjunction with Table 2-8.

TABLE 2-8. List of Major Species in the Barrier Island Phase 1 Study Area

Functional Group	Subgroup	Major Species
Wildlife	Terrestrial	(1) Nutria, (2) Common Muskrat, (3) North American Mink, (4) Northern Raccoon, (5) Louisiana Black Bear
	Aquatic	(1) Nearctic River Otter, (2) Common Muskrat
Avian	Seabirds	(1) Black Skimmer, (2) Sandwich Tern, (3) Royal Tern, (4) Least Tern, (5) Brown Pelicans, (6) Laughing Gull
	Wading Birds	(1) Snowy Egret, (2) Tri-Colored Heron, (3) Reddish Egret, (4) Black-Crowned Night Heron, (5) White Ibis, (6) Great Blue Herons, (7) Great Egret, (8) Little Blue Heron, (9) Cattle egret
	Waterfowl	(1) Lesser Scaup, (2) Greater Scaup, (3) Snow Goose, (4) Mallard, (5) Northern Pintail, (6) Blue-winged Teal, (7) Green-winged Teal, (8) American Widgeon, (9) Northern Shoveler, (10) Gadwall, (11) Mottled Duck, (12) Wood Duck
	Other Wetland Birds	(1) American White Pelican, (2) Seaside Sparrow, (3) Double Crested Cormorant, (4) Yellow Crowned Night Heron, (5) Least Bittern, (6) American Bittern, (7) American Coot, (8) Belted Kingfisher
	Raptors	(1) Bald Eagle, (2) Northern Harrier, (3) Red-Shouldered Hawk, (4) Red Tailed Hawk, (5) Barn Owl, (6) Barred Owl
	Shore Birds	(1) Piping Plover, (2) Semipalmated Sandpiper, (3) Western Sandpiper, (4) Common Snipe, (5) American Woodcock, (6) Least Sandpiper
	Other Resident Birds	(1) Wild Turkey, (2) Mourning Dove, (3) Red-Bellied Woodpecker, (4) Downy Woodpecker, (5) Pileated Woodpecker, (6) American Crow, (7) Carolina Chickadee, (8) Tufted Titmouse, (9) Carolina Wren, (10) Blue-Gray Gnatcher, (11) Northern Mockingbird, (12) Loggerhead Shrike, (13) Northern Cardinal, (14) Rufous-Sided Towhee, (15) Eastern Meadowlark
	Other Migrating Birds	(1) Yellow-Billed Cuckoo, (2) Tree Swallow, (3) House Wren, (4) Ruby-Crowned Kinglet, (5) American Robin, (6) Brown Thrasher, (7) Orange-Crowned Warbler, (8) Black-Throated Green Warbler, (9) Blackburnian Warbler, (10) Cerulean Warbler, (11) Prothonotary Warbler, (12) Ovenbird, (13) Blue Grosbeak, (14) Indigo Bunting, (15) American Goldfinch
Nekton	Invertebrates	(1) Brown Shrimp, (2) White Shrimp, (3) Pink Shrimp, (4) Seabob Shrimp, (5) Blue Crab
	Freshwater Fish	(1) Blue Catfish, (2) Channel Catfish, (3) Largemouth Bass, (4) Bluegill, (5) Black Crappie, (6) White Crappie
	Estuarine Fish	(1) Gulf Killifish, (2) Longnose Killifish, (3) Inland Silversides, (4) Naked Goby, (5) Darter Goby
	Estuarine/ Marine Fish/Mammals	(1) Atlantic Croaker, (2) Bay Anchovy, (3) Black Drum, (4) Gulf Menhaden, (5) Red Drum, (6) Sand Seatrout, (7) Spotted Seatrout, (8) Southern Flounder, (9) Spot, (10) Striped Mullet (11) Bottle-Nosed Dolphin
	Reptiles	(1) Loggerheads, (2) Snapping Turtle, (3) Green Turtle, (4) Alligator Snapping Turtle, (5) Hawksbill, (6) Leatherbacks, (7) Kemp's Ridley, (8) Diamond-Backed Terrapin, (9) American Alligator
Infauna		(1) Hardshell Clam
		(1) Macrofauna, (2) Meiofauna
Epifauna	Mollusks	(1) Oyster, (2) Stone Crab, (3) Red Swamp Crawfish
Zooplankton	Vertebrates	(1) Larval Fish
	Invertebrates	(1) Shrimp/Crab, (2) Permanent Zooplankton

TABLE 2-9. Occurrence of the Major Species in the Major Environments

Functional Group	Subgroup	Major Environments					
		Coastal Marsh	Cypress -Tupelo Swamp	Bottom land Hard woods	Natural Levees/ Cheniers/Uplands	Estuarine/ Marine/ Open Waters	Barrier Islands
Wildlife	Terrestrial	1,2,3,4	4	4,5	4,5	-	4
	Aquatic	1,2	1,2,3	-	-	-	-
Avian	Seabirds	6	-	-	-	-	1,2,3,4,5,6
	Wading Birds	1,2,3,4,5, 6,7,8	1,2,3,4, 5,6,7,8,9	9	7,9	-	2,3,4,7
	Waterfowl	3,4,5,6,7,8,9, 10,11	12	4,12	-	1,2	-
	Other Wetland Birds	1,2,3,4,5,6,7,8	3,4	-	-	-	-
	Raptors	2	1,5,6	1,2,3,4,5,6	2,3,4,5	-	-
	Shore Birds	2,3,4	-	5	5	-	1,6
	Other Resident Birds	-	1,3,10	1,2,3,4,5,6,7, 8,9,10,11,12, 13,14	2,4,6,7,11,12,13, 14,15	-	-
	Other Migrating Birds	-	2,8,10, 11,12	1,2,4,5,7,8,9, 10,11,12,13, 14	1,3,4,5,6,7,14,15	-	1,2,3,4,5,6,7, 8,9,10,11,12, 13,14,15
Nekton	Invertebrates	1,2,5	-	-	-	1,2,3,4,5	1,2,3,4,5
	Freshwater Fish	1,3	3,4,5,6	-	-	1	-
	Estuarine Fish	1,3,4	-	-	-	1,2,3,4,5	1,2,3,4,5
	Estuarine/ Marine Fish	1,2,3,4,5,6,7,8, 9,10	-	-	-	1,2,3,4,5,6, 7,8,9,10,11	1,2,3,4,5,6,7, 8,9,10
	Reptiles	2,4,9	2,4,9	-	-	2,4,7,8,9	1,3,5,6,7,8
Infauna		**	**	-	-	**	**
Epifauna	Mollusks	1	3	-	-	1	1
Zooplankton	Vertebrates	1	1	-	-	1	1
	Invertebrates	1,2	2	-	-	1,2	1,2

** Infauna are located throughout these major environments.

2.3.3.1. Wildlife

The Barataria-Terrebonne estuary hosts 48 species of undomesticated mammals representing 19 families. The Common Muskrat, Nutria, Northern Raccoon, North American Mink, Nearctic River Otter, and the Louisiana Black Bear are considered among the significant species in this region. Exploitation of wildlife resources in coastal Louisiana was among the earliest economic activities practiced by early settlers in Louisiana. Fur and hide trades flourished in this region replete with alligators, mink, raccoon, and various fur-bearing animals. More than 40% of wild fur harvested in the United States now comes from Louisiana's wetlands (McKenzie *et al.* 1995). Parallel to commercial interests, hunting for recreational purposes has been favored by Louisiana residents since the early days. Louisiana hunters pursue such game as White-tailed Deer, rabbits, and squirrels.

2.3.3.2. Birds

There are 353 species of birds representing 16 orders and 45 families have been recorded in the study area. Of this number, 178 are reported to be currently common to abundant, at least periodically, in the study area and 69 are residents. These include:

- Seabirds
- Wadingbirds
- Waterfowl
- Other Wetland Birds
- Raptors
- Shore Birds
- Other Resident Birds
- Other Migratory Birds.

A number of species, including the Passenger Pigeon and the Carolina Parakeet, are possibly extinct, or likely to be extinct, in the study area because of loss of habitat associated with deforestation, saltwater intrusion, human development, overharvest and coastal erosion.

Beaches, dunes, and low-lying vegetation are important, almost irreplaceable, nesting sites for seabirds (Pelicans, Gulls, Terns, and Skimmers). The close proximity of these sites to the fertile waters of the Gulf and area bays increases their habitat value since foraging time is reduced and nesting success is increased. As habitat continues to be lost, nesting birds may crowd into the few remaining sites, making them more vulnerable to disease, lowered food availability and predation, or they may locate alternate sites where nesting success is reduced.

Another important habitat feature of the barrier islands relates to Neotropical migrants. The islands in the study area lie in the flight path of many Neotropical migratory birds. These birds breed in or north of the study area and winter in the Caribbean, Central America, and South America.

2.3.3.3. Nekton

Nekton are animals that spend most of their lives in water and swim freely. This group includes invertebrates, freshwater fish, estuarine fish, estuarine/marine fish and reptiles. Louisiana is the second largest producer of seafood in the United States and is a leader in the production of shrimp, blue crabs, oyster, crawfish, catfish, black drum, sea trout, and mullet (McKenzie *et al.* 1995). Table 2-10 provides total commercial fisheries landings by parish in the Barataria-Terrebonne Estuary Systems (BTES) during the period between 1979 and 1992. Table 2-11 provides the species-specific data on total landings during the same period.

The penaeid shrimp fisheries, especially the white and brown shrimp, are commercial mainstays of the Louisiana seafood industry. In addition to White Shrimp and Brown Shrimp, fishermen harvest smaller amounts of Pink Shrimp and Seabob. Beyond commercial importance, the species group is of significant trophic importance as a food source for many estuarine finfish.

The Blue Crab is habitat ranges found from the offshore waters in the Gulf of Mexico to the inland tidal freshwater marshes of Louisiana. The Blue Crab exemplifies the coupling of the marine and freshwater ecosystems that sustain Louisiana's aquatic productivity.

TABLE 2-10. Total Commercial Landings by Barataria-Terrebonne National Estuary (BTES) Parishes, Louisiana, 1979-1992 (from McKenzie *et al.* 1995)

Parish	Five Year Average 1979-1983	Five Year Average 1984-1988	Four Year Average 1989-1992	Five Year Average 1979-1983	Five Year Average 1984-1988	Four Year Average 1989-1992
	Thousand Pounds			Thousand Dollars ($)		
Ascension	24	338	436	8	156	210
Assumption	2,905	6,334	4,780	1,292	2,738	2,519
Iberville	1,346	1,116	3,044	419	417	1,483
Jefferson	17,802	25,494	20,392	25,539	30,774	24,151
Lafourche	15,812	23,526	23,804	20,763	32,758	30,009
Plaquemines	284,498	324,199	282,132	35,459	61,073	60,009
Point Coupee	0	0	68	0	0	37
St. Charles	1,086	1,363	2,316	424	534	853
St. James	0	109	525	0	43	219
St. John	0	0	412	0	0	213
St. Mary	175,957	64,378	114,848	12,690	11,475	15,286
Terrebonne	252,943	328,570	157,776	49,110	66,813	57,808
West Baton Rouge	0	0	2	0	0	2
BTES Total	752,373	775,368	610,535	145,704	206,782	193,682
State Total	1,554,511	1,715,534	1,132,578	218,184	296,962	276,187
% BTES of Total	48.4	45.2	53.9	66.8	69.6	70.1

Compiled from the National Marine Fishery Service Database by Louisiana Department of Wildlife and Fisheries, Marine Fishery and Socioeconomic Section

TABLE 2-11. Total Louisiana Commercial Landings by Species, 1979-1992 (from McKenzie *et al.* 1995)

Species	Five Year Average 1979-1983	Five Year Average 1984-1988	Four Year Average 1989-1992	Five Year Average 1979-1983	Five Year Average 1984-1988	Four Year Average 1989-1992
	Thousand Pounds			Thousand Dollars ($)		
Finfish						
BTES Total	659,861	637,916	483,307	31,272	9,464	12,042
State Total	1,428,480	1,527,952	957,921	65,351	11,350	15,011
% BTES of Total	46.2	41.7	50.6	47.9	83.6	80.2
Shellfish						
BTES Total	92,513	137,452	127,228	114,432	159,350	144,606
State Total	126,031	187,582	174,657	152.633	211,457	196,715
% BTES of Total	73.4	73.3	72.8	74.9	75.4	73.5
Shrimp						
BTES Total	70,419	69,378	78,394	98,785	123,009	105,418
State Total	89,626	118,120	103,234	129,359	163,718	142,534
% BTES of Total	78.4	75.7	75.9	76.4	75.1	74.0
Crab						
BTES Total	12,264	30,124	31,186	3,442	10,234	12,568
State Total	18,657	39,503	43,993	5,271	13,771	18,749
% BTES of Total	65.8	76.3	70.9	65.3	74.3	67.0
Other Shellfish						
BTES Total	2,572	6,538	10,317	1,216	21,478	21,351
State Total	7,626	16,712	18,378	3,610	28,400	28,846
% BTES of Total	33.7	39.1	56.1	33.7	75.6	74.0

Compiled from the Louisiana Department of Wildlife and Fisheries Licensing Database, Socioeconomic Section.
The figures reflect neither the magnitude of unreported landings or the origin of the harvest.
Recorded landings and their corresponding values include both the westbank as well as the east bank of Plaquemines Parish.

Estuarine fishes are permanent members of the estuarine community, completing their entire life cycle within the study area estuaries. As a group, they span a wide range of ecological conditions, ranging from freshwater to high salinity including marsh edge, creeks, and meanders.

Estuarine/marine fishes include: Bay Anchovy, Spotted Seatrout, Gulf Menhaden, Striped Mullet, Atlantic Croaker, Spot, Red Drum, Black Drum, and Sand Seatrout. As a group, these species are among the most numerous in the study area estuaries, but abundance varies greatly from season to season due to their migratory life cycle.

Twenty-one species of turtles; six species of lizards, anoles and skinks; 23 species of snakes; and one species of crocodilians have been identified in the Barataria-Terrebonne estuary. Many turtles are on the threatened or endangered species list and efforts are being made to preserve their existence.

Direct harvest, loss, and degradation of nesting habitat, historically, has resulted in the depletion of all commercially important reptiles in coastal Louisiana. The comeback of the American Alligator represents a true success story in which management measures implemented by the State of Louisiana and the U.S. Fish and Wildlife Service reversed the declining population trend in a short period. The alligator is now commercially harvested in Louisiana (Table 2-12).

TABLE 2-12. Reported Commercial Harvest of Wild Alligators by Barataria-Terrebonne National Estuary Parish, 1989-1992 Average (from McKenzie *et al.* 1995)

Parishes	Tags Issued	Tags Used	Average Size (Feet)	Average Price/Feet	Total Value
Ascension	129	124	7.05	$41.00	$ 35,842.20
Assumption	270	250	7.45	$41.00	$ 76,362.50
Iberville	497	459	6.83	$41.00	$ 128,533.77
Jefferson	487	182	7.48	$41.00	$ 147,819.76
Lafourche	2,469	2,456	7.35	$41.00	$ 740,115.60
Plaquemines	997	986	7.37	$41.00	$ 297,939.62
Pointe Coupe	105	86	7.89	$41.00	$ 27,820.14
St. Charles	1,119	1,114	7.14	$41.00	$ 326,112.36
St. James	225	244	7.02	$41.00	$ 70,228.08
St. John	552	544	7.57	$41.00	$ 168,841.28
St. Mary	1,561	1,547	7.39	$41.00	$ 468,725.53
Terrebonne	4,423	4,377	7.71	$41.00	$1,383,613.47
West Baton Rouge	51	43	7.27	$41.00	$ 12,817.01
BTES Total	12,885	12,712	7.35	$41.00	$3,884,771.32
State Total	25,363	24,573	7.30	$41.00	$7,315,892.28
% BTES of Total	50.8%	51.7%			53.1%

Compiled from a National Marine Fishery Service Database, Louisiana Department of Wildlife and Fisheries, Marine Fisheries and Socioeconomic Section

2.3.3.4. Infauna

Infauna are ecologically important organisms, such as clams, that live within the substrate. They are critical links in the food web, making nutrients regenerated in the soil available to epifaunal and pelagic organisms that feed on them. Condrey *et al.* (1995) summarized information on the macroinfauna of Barataria and Terrebonne estuaries, noting how little study has actually been done. They reported on Spring-Summer declines in infaunal abundance, suggesting that it may be a natural phenomenon. They also recommended permanent monitoring stations be established for long-term data about infuanal population dynamics and abundance. The main group of macroinfauna are polychaetes, nemerteans, crustaceans and mollusks. The rangia clam is probably the best known of the Phase 1 area infaunal species.

2.3.3.5. Epifauna

Similar to Epifauna, they are critical links in the food web, making nutrients regenerated in the sediment available to pelagic organisms that feed on them, particularly fish. Condrey *et al.* (1995) summarized information on several of the dominant species of epifauna including penaeid shrimp, crabs, eastern oyster and crawfish. (Note: Some of these species have been classified as nekton invertebrates in this study. Many organisms can fit into either category based on their environment throughout their life cycle.) The young of these species, particularly abundant in the estuarine nursery areas, are heavily preyed upon by many species.

2.3.3.6. Zooplankton

Zooplankton are aquatic animals that cannot actively swim. They are a significant resource both as prey and as a predator. Zooplankton are placed into two functional groups: 1) holoplankton - forms that remain as plankton for all life history stages and 2) meroplankton - forms that are plankton only part of their life, usually in the early stages of their life history. This last group includes many important vertebrates and invertebrates such as fish, crabs, shrimps and oysters that start life as plankton, but with growth acquire the ability to swim or settle out of the water column. There is no section of the aquatic habitat in the Phase 1 study area that does not have large populations, perhaps only temporarily, of zooplankton. There is no data to support an estimate of the abundance of these species.

2.3.3.7. Threatened and Endangered Species

A list of threatened and endangered species in Louisiana is found in Table 2-13. Of the 27 vertebrates listed, 17 are found in the Barataria- Terrebonne system (Condrey, 1995; USFWS, 1995). Of these, turtles and birds are predicted to be most impacted by the restoration and/or loss of the Barrier Islands. Five of the seven turtle species listed in Table 2-13 have historically visited and foraged in the Phase 1 study area barrier islands. The National Research Council (1990) report documented no sea turtle breeding presently in the Phase 1 study area. The Kemp's Ridley Sea turtle, and the Green and Loggerhead turtles occur in the Phase 1 study area.

Seven bird species are included on the threatened and endangered list that pertains to the Phase 1 study area. Those that would be directly impacted by the Barrier Islands are the Brown Pelican, the Piping Plover, and the Least Tern. These species use the Barrier Islands for nesting and foraging.

It should be noted that all species included on the threatened and endangered list are added and removed periodically. No prediction has been made as to the future status of these and other species on the Threatened and Endangered List.

Table 2-13. Species Listed as Threatened (T) or Endangered (E) in Louisiana, 1995[1] (Condrey, *et al.*, 1995 and U. S. Fish and Wildlife Service, 1995).

Common Name	Scientific Name	Federal Status	State Status
Plants			
Earthfruit	*Geocarpon minimum*	T	*
Louisiana Quillwort	*Isoetes louisianensis*	E	*
Invertebrates			
American Burying Beetle	*Nicrophorus americanus*	E	E
Inflated Heelsplitter	*Potamilus inflatus*	T	T
Louisiana Pearlshell	*Margaritifera hembeli*	T	E
Fish			
Pallid Sturgeon	*Scaphirhynchus albus*	E	E
Gulf Sturgeon	*Acipenser oxyrhynchus desotoi*	T	T
Reptiles			
Green Sea Turtle	*Chelonia mydas*	T/E	T
Hawksbill Sea Turtle	*Eretmochelys imbricata*	E	E
Kemp's Ridley Sea Turtle	*Lepidochelys kempii*	E	E
Leatherback Sea Turtle	*Dermochelys coriacea*	E	E
Loggerhead Sea Turtle	*Caretta caretta*	T	T
Gopher Tortoise	*Gopherus polyphemus*	T	T
Ringed Sawback Turtle	*Graptemys oculifera*	T	T
Birds			
Brown Pelican	*Pelecanus occidentalis*	E	E
Bald Eagle	*Haliaeetus leucocephalus*	T	E
Peregrine Falcon	*Falco peregrinus*	E	T/E
Attwater's Greater Prairie Chicken**	*Tympanuchus cupido attwateri*	E	E
Whooping Crane**	*Grus americana*	E	E
Eskimo Curlew**	*Numenius borealis*	E	E
Piping Plover	*Charadrius melodus*	T/E	T/E
Interior Least Tern	*Sterna antillarum athalassos*	E	E
Ivory-billed Woodpecker**	*Campephilus principalis*	E	E
Red-Cockaded Woodpecker	*Picoides borealis*	E	E
Bachman's Warbler**	*Vermivora bachmanii*	E	E
Mammals			
Manatee	*Trichechus manatus*	E	E
Blue Whale	*Balaenoptera musculus*	E	E
Finback Whale	*Balaenoptera physalus*	E	E
Sei Whale	*Balaenoptera borealis*	E	E
Sperm Whale	*Physeter macrocephalus* (= *catodon*)	E	E
Red Wolf**	*Canis rufus*	E	*
Black Bear	*Ursus americanus luteolus*	T	T
Florida Panther**	*Felis concolor coryi*	E	E

* Unlisted
** Extinct or nearly extinct in Louisiana
[1] Louisiana Heritage Program

2.4. Economic Resources

Originally, the south Louisiana economy was small-scale subsistence driven. With time, this economy became more large-scale money and entrepreneurial oriented. Agricultural products (sugarcane, cattle and other crops) sulfur, oil and natural gas, fresh- and saltwater fisheries and the region's trapping resources developed in response to national and international market demands. The regional economic mainstay, therefore, revolves around a market that is national and international in scope.

Each community acquired their own distinctive employment identity, from agricultural nodal points to oil and gas support centers to ports and seafood processing centers. The economy has benefited from the abundant renewable and nonrenewable resource base.

2.4.1. Renewable Resources

The region's renewable resources include agriculture, seafood, and fur-bearers. Although land is being lost to open water at an alarming rate, the region's water bottoms continue to sustain a large inland fishing fleet.

The region's agriculture industry has been vital to the area's economy since Colonial times. Sugarcane is evident throughout the region. Cattle graze the fresh water marshes and along the natural levees and within forced drainage sites. Trapping and alligator harvests also help sustain the region's renewable resource base.

2.4.1.1. Agriculture

In the study area, field crops, including sugarcane, soybeans, field corn and hay are major income-producing commodities. Truck farms specializing in vegetables, potatoes and tomatoes are also important, as well as orange orchards and livestock herds. Specialty crops—including tobacco, shallots, nursery items, Spanish moss (*Dendropogon usneodies*) and crawfish, turtle and alligator farming—are relatively new additions to the inventory of farm activity. The major product trends are related to a number of variables—amount of land used for agricultural purposes, consolidation into large corporate holdings, high production costs, capital requirements, market conditions, rising costs, and other factors—that have a direct impact on the farming/agricultural community.

South Louisiana's favorable climate and fertile alluvial soils allow almost every crop indigenous to the Western Hemisphere to be raised in the coastal zone. Throughout the region's history, agricultural activities have occupied an important position.

Development of a process for granulating sugar in 1794 allowed sugarcane to become a commercial crop in Louisiana. With establishment of the industry, indigo production was abandoned in favor of sugarcane (Hansen, 1971; Taggart and Simon, 1957; Sitterson, 1953).

The pattern of land use in the study area has intense competition between sugarcane and industrial activity. While industry is a welcome addition to the local economy, a great deal of prime agricultural land has been converted to other uses. Land-use competition from hydrocarbon development, in the form of oil and natural gas wells, pipeline pumping stations, and natural gas processing plants has increased. Others are growing soybeans and other row crops on land that is normally fallow. Others are simply getting out of the business, selling their surface rights, but keeping their subsurface holdings—a trend that started in the early 1980's and continues today.

Two important technological innovations have had a direct influence on livestock production's dramatic gains in the post World War II era. First, animal husbandry and scientific breeding applications helped to develop an animal stock that is particularly well suited to the study area's ecological conditions. Second, reclamation techniques converted unused wetlands to prime pasturage. Consequently, small-scale reclamation endeavors were quite successful and ideally suited for livestock, encouraging marsh dwellers to drain and reclaim areas for use as pasture. This they did by extending the boundary of the natural levees into the swamps and marshes by reclaiming these tracts through forced drainage projects involving pumps, canals, and large engineered levees.

Many individuals in the study area have other primary occupations but maintain a small cattle herd as well. Cattle raising is a cash-and-carry business with strong cultural connections, serving in many ways as a link to the past. With current changes in the sugar business, many landowners are turning to the cattle industry for additional income.

2.4.1.2. Commercial Fisheries

Five of the ten largest commercial fishing ports by weight of landings are in Louisiana—Empire-Venice, Cameron, Intracoastal City, Dulac-Chauvin and Morgan City-Berwick. In 1991, they collectively processed nearly 1 billion pounds. The catch at Dulac-Chauvin and Empire-Venice was valued at nearly $100 million.

Shrimp

Louisiana's estuaries are acknowledged world leaders in shrimp production (McKenzie *et al.* 1995). Shrimp have been a source of income and a basic food item in Louisiana since the Colonial period. Two species make up most of the harvest, white and brown shrimp. Post-larvae of these species enter Louisiana's estuaries from the gulf and spend several months in the estuarine nursery areas as they metamorphose into juveniles and grow. These species migrate offshore into gulf waters where they spawn. Therefore, the economic viability of the shrimp fishery is estuary dependent. Table 2-14 provides the data on the shrimp licenses issued in Louisiana's Delta Plain.

TABLE 2-14. Shrimp Licenses Issued in Louisiana's Delta Plain (From Louisiana Summary Agriculture and Natural Resources 1991; and Roberts and Pawlyk 1986; Personal communication with LDFW, 1996)

Parish	1976	1980	1985	1991	1995
Iberia	368	562	462	600	350
Jefferson	1,699	2,829	2,988	1,673	3,188
Lafourche	1,045	1,612	1,702	2,025	2,529
Plaquemines	698	1,022	869	1,185	1,721
St. Bernard	742	1,092	1,199	1,051	1,346
St. Mary	459	622	517	115	658
Terrebonne	1,862	2,688	2,494	3,407	3,810
Total	6,873	10,427	10,231	10,056	13,602

Industry growth and expansion resulted in shrimp becoming Louisiana's most valuable fishery. The catch is second only to menhaden in quantity, but first in dollar value. Louisiana's commercial shrimp landings vary from 10 million to 20 million pounds annually. Twenty to 25% of the shrimp processed in the United States are caught in Louisiana (McKenzie *et al.* 1995).

Oysters

Louisiana is second only to Maryland in the production of oyster. The five primary oyster-producing parishes in Louisiana are Plaquemines, St. Bernard, Terrebonne, Jefferson and Lafourche. The combined oyster acreage in these parishes is greater than 500,000 acres. Plaquemines and St. Bernard are the most important oyster producing parishes, since they often account for more than 80 % of the state's harvest. Table 2-15 provides the yield comparison for oyster production in Louisiana from 1880 to 1991.

TABLE 2-15. Yield Comparisons for the Production of Oysters in Louisiana (LDNR 1998c)

	1880	1991
Bushels	295,000	734,981
Value	$118,000	$13,964,639
Price/bushel	$0.40	$19.00

Menhaden

Menhaden (*Brevoortia patronus*) or "pogie" are one of the oldest fisheries in the Gulf of Mexico. Among Louisiana's commercial fishery, menhaden yield the greatest biomass and has been the principal contributor to making Louisiana a national leader in fisheries production. In 1880, less than 1,000 pounds were landed. Although considerable variability exists in the catch record, landings have steadily increased since the 1950's. In 1971, more than 1.6 billion pounds of menhaden passed through Gulf of Mexico ports. This amounted to nearly 75% of the United States' harvest. Since this record catch, landings from the Gulf of Mexico have exceeded or approached 1 billion pounds annually. From 1980 to 1991, the menhaden catch has decreased from 1.3 billion pounds to 1.0 billion pounds annually. Most of these fish are harvested in the waters that fringe the Louisiana coast; specifically in and around the Mississippi delta (LDNR 1998c).

Crabs

Crabbing is an activity that is not only important to commercial fishermen, but also is enjoyed by a large number of recreational sportsmen. While crabbing is a year-round activity, periods of concentrated efforts correspond to the summer and spring shrimp season. In both periods, fishermen harvest hard- and soft-shelled blue crabs (*Callinectes sapidus*) which is the dominant crab in the fishery.

The overall number of crabs landed has doubled from 1979 to 1993. Blue crabs occupy many different habitats, but the greatest numbers are caught in periods of low salinity and temperature. The crab industry has increased noticeably in recent years and the resource may be approaching the limit of sustainable yields. Competition is intense and catch per effort has been reduced (LDNR 1998c).

2.4.1.3. Trapping Resources

Trapping in Louisiana's subtropical marshes was limited until the 1800's when alligator (*Alligator mississippiensis*), mink (*Mustela vison*), otter (*Lutra canadensis*) and raccoon (*Procyon lotor*) were recognized as valuable hide-and fur-bearing animals. Louisiana's marshes became North America's preeminent fur producing region. In the early 20th century, Louisiana's annual harvest was greater than Alaska and Canada combined.

In less than 30 years nutria supplanted muskrat to become the principal animal trapped. In the 1961-1962 season, nutria surpassed the muskrat in number of pelts sold. It has maintained the lead, but in the marshes, there is ample range to graze and both have done well. Nutria prefer fresh water marshes, but with increased densities will encroach upon the muskrat's brackish water habitat. Although competition exists between both rodents, the end result has been an abundant fur harvest.

Although present throughout the state, the greatest concentration of *Alligator mississippiensis* is within the fresh to slightly brackish habitats. Muskrat, nutria, rabbits (*Sylvilangus aquaticu***s**), rails (*Rallus longirostris saturatus*) and waterfowl feed in these marsh zones and naturally attract the omnivorous predator. Since the 1800’s, the alligator has been hunted commercially in Louisiana. That changed in 1962, when alligator hunting was terminated in order to protect the reptile. To assist further in this management effort, the alligator was placed in 1966 on the Federal list of rare and endangered species and was protected under the Endangered Species

Act of 1973. In the 1980's, amendments were made to the Lacy Act, to prohibit the interstate shipment of illegally taken alligators, thereby curtailing bootlegging. This protective legislation, along with habitat preservation, allowed the reptile to make a dramatic recovery (Nichols, *et al.*, 1976).

2.4.2. Nonrenewable Resources

Nonrenewable resources in the study area include oil, natural gas, and sulfur. Exploration for and production of these mineral resources has had a major economic impact on the study area in the last 50 years.

<u>Oil and Gas</u>

The first producing oil well was completed in Louisiana in 1901. Exploration for oil and the associated natural gas in the study area wetlands was troublesome because it required boats, barges, and port facilities (Franks and Lambert 1982). These necessities were not available until the 1930s (Davis and Place, 1983). By 1955, the industry had expanded offshore, with 40 offshore rigs in operation (Davis and Place, 1983).

Virtually every community with direct access to the Gulf of Mexico became a logistic support site for oil and gas industry (McKenzie *et al*, 1993). The vast army of support personnel became an important part of the area's employment structure, and businesses throughout the coastal zone support the industry (McKenzie and Davis, 1994).

Consequently, within Louisiana, there has been rapid economic development and expansion during the past 75 years (Centaur Associates, Inc., 1986). Much of this growth has been associated with hydrocarbon development. The oil and gas industry has served the economy well. In Louisiana, approximately $2.4 billion was paid by offshore producing companies to vendors and contracts in 165 different communities in 47 parishes in support of the offshore industry during 1992. This is nearly the equivalent of $1,000 for every person living in the state. Nearly 4000 vendors are involved (McKenzie and Davis, 1994). The Louisiana-based vendors employ approximately 55,000 people to support the offshore industry alone, with additional jobs available to support the industry's onshore component. Further, more than 30,000 individuals are employed offshore. There are also currently 18 refineries operating in the state, with all but one located in South Louisiana (Table 2-16).

Table 2-16. Louisiana Refinery Operations in 1993* (LDNR 1998c)

American International Refinery	Kerr-McGee Refining Corporation
Atlas Processing Company	Marathon Oil Company
British Petroleum Oil Company	Mobile Oil Corporation
Calcasieu Refining Company	Murphy Oil USA
Calument Lubricants Company	Phibro Refining Incorporated, Krotz Springs
Canal Refining Company	Phibro Refining Incorporated, St. Rose
CITGO Petroleum Corporation	Placid Refining Company
Conoco, Incorporated	Shell Oil Company
Exxon Company	Star Enterprise

*(With few exceptions, each of these refineries require pipeline-derived oil and/or natural gas. Without these products the refineries ability to meet their production quotes will be severely impacted).

Sulfur

The sulfur mined in the study area is associated with salt domes. Commercially viable salt domes are rare; less than 10% of the domes fringing the Gulf of Mexico contain recoverable sulfur (Cunningham, 1935). Sulfur is mined both inshore and offshore; many of the inshore mines have been depleted, but the offshore Main Pass, Block 299, mine is new (Davis 1992; Hall 1990).

2.4.3. Demographics

Population has increased by 36% in the study area over the 40-year period, consistent with the growth in population in Louisiana of 36%. All Parishes, except for Orleans Parish, have grown over the 40 year period (1950-1990) with Jefferson Parish having the greatest increase of 77% (Table 2-17).

TABLE 2-17. Population in the Study Area

Location	1950	1960	1970	1980	1990	Diff. 1990 – 1950	% Diff
Ascension	22,387	27,927	37,086	50,068	58,214	35,827	62%
Assumption	17,278	17,991	19,654	22,084	22,753	5,475	24%
Jefferson	103,873	208,769	338,229	454,592	448,306	344,433	77%
Lafourche	42,209	55,381	68,941	82,483	85,860	43,651	51%
Plaquemines	14,239	22,545	25,225	26,049	25,575	11,336	44%
St. Charles	13,363	21,219	29,550	37,259	42,437	29,074	69%
St. James	15,334	18,369	19,733	21,495	20,879	5,545	27%
St. John	14,861	18,439	23,813	31,924	39,996	25,135	63%
St. Mary	35,848	48,833	60,752	64,253	58,086	22,238	38%

Terrebonne	43,328	60,771	76,049	94,393	96,982	53,654	55%
Orleans	570,445	627,525	593,471	557,927	496,938	-73,507	-15%
Study Area	893,165	1,127,769	1,292,503	1,442,527	1,396,026	502,861	36%
Louisiana	2,683,516	3,257,022	3,644,637	4,206,312	4,219,973	1,536,457	36%

Source: Louisiana Almanac 1992-93

Employment in the study area is primarily in Services (165,804), Retail Trade (112,380), and Manufacturing (60,416). These industries dominate the 1990 employment in the study area, representing more than 68% of the total. These figures are compatible with those reported for the state (Table 2-18).

TABLE 2-18. Employment by Business Sector: 1990

Location	Agricultural Services	Mining	Contract Construction	Manufac.	Trans. and Other Public Utilities	Wholesale Trade	Retail Trade	Finance Insurance Real Estate	Services	Unclassified
Ascension	60	175	2,115	5,317	1,195	602	3,579	652	2,869	22
Assumption	0	10	411	411	138	240	596	133	397	10
Jefferson	573	1,665	9,787	18,302	13,750	16,489	46,209	12,343	54,055	405
Lafourche	89	285	773	1,764	4,028	889	3,880	942	3,114	87
Plaquemines	50	1,678	1,515	2,224	1,677	787	1,565	361	2,005	22
St. Charles	22	60	753	4,408	1,948	1,191	1,763	215	3,110	10
St. James	10	60	175	2,625	506	235	677	267	681	10
St. John	60	60	323	2,449	579	569	1,861	469	1,885	10
St. Mary	51	1,500	1,614	4,120	3,583	1,263	3,490	690	3,510	30
Terrebonne	127	3,917	1,714	2,879	2,553	2,720	8,054	1,333	6,462	71
Orleans	274	6,774	6,095	15,917	20,656	9,156	40,706	16,250	87,716	487
Total Study Area	1,316	16,184	25,275	60,416	50,613	34,141	112,380	33,655	165,804	1,164
Louisiana	5,526	55,780	92,824	176,993	100,772	83,921	288,285	81,377	381,935	3,806

Source: U. S. Department of Commerce, County Business Patterns

In 1989, the real per capita income for the eleven-parish study area averaged $10,645 compared to the state average of $11,207 when adjusted to 1990 dollars. Within the study area the real per capita incomes varied from a low of $8,500 in Assumption Parish to a high of $13,500 thousand in Jefferson Parish.

2.4.4. Recreational Opportunities

The recreational environments of the study area consist primarily of freshwater lakes, estuarine bays, and marshlands. Except where parks or other public facilities have been developed, use of freshwater swamps is generally restricted to crawfishing, deer hunting, waterfowl hunting, small game hunting, sport fishing, and recreational boating. Waterfowl hunting during the fall season is extremely popular in the lakes and bayous of fresh and brackish water environments. Where waters of the study area become more saline in nature, the more popular recreational activities are crabbing, shrimping, and salt-water fishing. The wetland areas of Louisiana are utilized at a relatively intense rate because of their accessibility and because they are free of high user fees and other use inhibiting factors.

The parishes of Orleans and Jefferson are currently receiving intense in-state recreation and tourist use pressure. In many localities, there is a finite amount of available shoreline property for meeting the increased demands of the nearby urban population center. Grande Isle in Jefferson Parish provides beaches, boat launches, surf fishing, historic sites, and scenic areas.

In Louisiana's marshlands, there are 10,220 seasonally occupied recreational dwellings and camps. These camps provide sportsmen with a summer site for fishing and boating and a winter base for waterfowl hunting and trapping. Four parishes in the study area contain the majority of the camps in Louisiana: Terrebonne (2,074), Jefferson (1,724), Plaquemines (1,090), and Orleans (1,051). These 5,939 units account for 58 percent of the total camp structures and reflect the significance of camp-based recreation there. Jefferson Parish has the largest number (1,410) of camps with highway access (Gary and Davis, 1979).

Louisiana's coastal marshes provide outdoor enthusiasts with year-round recreational opportunities. In fall and winter, hunters, trappers, and fishermen harvest ducks, muskrat, nutria, alligator, and numerous fresh- and salt-water fish. In contrast, spring is the season to shrimp, crab, crawfish and fish for spotted seatrout, largemouth bass, and red snapper. From the beginning of spring until the first cold front moves through the area, fishing and boating are principal elements in the use cycle.

Many of the parishes in the study area are home to properties owned or leased by the Louisiana Department of Wildlife and Fisheries for public use or wildlife management areas. These areas include: the Atchafalaya Delta in St. Mary Parish; the Attakapas area, a portion of which is in St. Mary Parish; Bohemia area in Plaquemines Parish; Manchac area in St. John Parish; Pass-a-Loutre area in Plaquemines Parish; Pointe-au-Chien in Terrebonne Parish; Salvador area in

St. Charles Parish and Wisner area in Lafourche Parish. These parishes offered recreational activities for many types of hunting and fishing to the public.

There are many state parks and commemorative areas in the study area parishes and one national park. Available visitation statistics reveal that the facility at Grand Isle registered the largest number of visitors with 415,764 visitors in the 1977 - 1978 reporting period. E. D. White in Lafourche Parish registered 2,797 visitors.

Much of the tourist trade within the study area falls within Orleans Parish. The City of New Orleans is a cultural and festive attraction, and because of its hotel/motel accommodations, convention facilities, French Quarter attractions, and other tourist services, the city clearly dominates the regional tourist market. Smaller communities outside of Orleans Parish, especially those that offer resource-based activities like hunting and fishing, compete less successfully for a share of tourist traffic.

3.0. FUTURE WITHOUT-PROJECT CONDITIONS

This section provides a forecast of future conditions in the Phase 1 Study Area that are projected to occur if no additional coastal restoration projects are built beyond the CWPPRA projects approved at the time of this study and the Davis Pond Freshwater Diversion Project. The impacts of these projects were based on the land loss reduction benefits provided by the CWPPRA Feasibility Study Steering Committee. The future without project conditions will be used as the basis for comparing barrier shoreline alternatives.

The driving force of the resource impacts will be the changes in hydrologic conditions associated with barrier island and wetland losses. The estimation procedure is to select those potential impacts that are both important and quantifiable, and are physically tied to the changes that would result from land losses along the barrier shoreline and interior wetlands. A detailed discussion of the methodology and results for the future without project conditions is found in Step G - Forecasted Trends in Physical and Hydrological Conditions, Step H - Forecasted Trends in Environmental Resource Conditions, and Step H - Forecasted Trends in Economic Resource Conditions.

3.1. Physical Conditions

The method used to predict future land losses is discussed in Steps G and Step H reports (LDNR g and h.i.). The procedure is to modify certain areas of the LANDSAT image based on projected land loss rates for those areas using historical data.

For no-action in 30-years, the land loss projections indicate enhanced fragmentation of the marsh. Marsh areas near bays retain a greater density of land, but further inland, open water and land are about equal. For no-action in 100-years, many of the present marsh areas are mostly open water. At this point, the wetland areas surrounding Terrebonne and Barataria bays are scattered fragments of land located within large areas of open water. Some areas of the western Terrebonne marshes retain a greater percentage of land than water; however, these areas are considerably reduced in size and are surrounded by large bodies of open water as well. The boundary of Terrebonne Bay has expanded northward nearly to the Intracoastal Waterway and Barataria Bay extends northward almost to Bayou Perot and Bayou Rigolets. The corridor of land surrounding Bayou Lafourche is nearly gone.

The Phase 1 Study Area no-action projections for 30- and 100-years show the largest land loss for fresh-, saline-, brackish-, and intermediate marshes. In all, 144,879 acres (226 mi^2) and 332,947 acres (520 mi^2) of these four habitat types are predicted to be lost in 30- and 100-years respectively. The habitat changes are shown in Table 3-1. These losses, shown as the percent change in Table 3-2 , include the benefits provided by all authorized CWPPRA projects through 1996 as well as the Davis Pond Diversion.

Table 3-1. Acres of habitats for present and future projections[1]

	1990	30-year projection	100-year projection
Water	1,212,848	1,388,745	1,625,428
AB floating	11,004	5,140	3,086
AB Submerged	10,285	4,068	2,257
Fresh marsh	376,008	321,419	260,852
Intermediate marsh	109,144	92,393	73,124
Brackish marsh	192,711	158,450	116,785
Saline marsh	226,818	187,540	120,973
Cypress forest	157,530	155,704	136,098
Bottomland forest	147,611	144,312	134,885
Upland forest	16,081	15,112	13,441
Dead forest	351	231	125
Bottomland scrub	57,467	53,604	44,846
Upland scrub	12,599	9,058	5,918
Shore/flat	1,984	1,288	858
AG/pasture	179,693	176,414	173,541
Upland barren	674	600	548
Developed	73,283	72,080	70,801
Other	96	29	17
TOTAL	**2,786,187**	**2,786,187**	**2,783,583**

[1]Projected acres for No-action did not include portions of the Phase I study area, which were later added to the habitats discussed in Section 6.

Table 3-2. Percent habitat change from 1990.

% change from 1990	30-year projection	100-year projection
Water	13.27	32.14
Fresh marsh	-14.52	-30.63
Intermediate	-15.35	-33.00
Brackish	-17.78	-39.40
Saline marsh	-17.32	-46.67
Wetland forest	-2.48	-12.90

In all, the future without project impact landscape is projected to have a total of 175,897 acres (275 mi^2) of land converted to water in 30-years. In 100-years, 412,580 acres (645 mi^2) of land will be converted to open water. Maps illustrating the present and future landscape of the study area are shown in Figures 3-1, 3-2, and 3-3.

3.2. Hydrologic Conditions

The hydrologic variables that the study team considered were tidal levels (daily), salinity, hurricane surge, and waves. Changes to other processes, such as wind and rain, were not considered because changes t the barrier shoreline would not impact these processes.

3.2.1. Tides

Assessments of the effects of barrier shoreline alternatives on average water level conditions were made by running the hydrologic model with average tides. A tidal amplitude of 0.66 feet for the Gulf of Mexico for a period of 84 hours was used.

Typically, wind has a significant effect on water levels, currents, and salinity in the estuary. However, wind was not included in the tidal simulations in order to determine effects on water level associated only with changes to the barrier islands and inlets under the no-action conditions.

The no-action simulations show that a slight change in tidal amplitude and flooding in the future will occur as a result of wetland and barrier island loss. Although some change is detectable in the water level fluctuations, the magnitude of the change, and the amplitude of the variation in water level, is usually small. Areas flooded by average tidal movement generally increase for future conditions. Table 3-3. shows the general changes in flooding predicted for the future without project conditions.

Table 3-3. Changes in water level for future projections. X = no change or not flooded. V = flooded and/or change in water level.

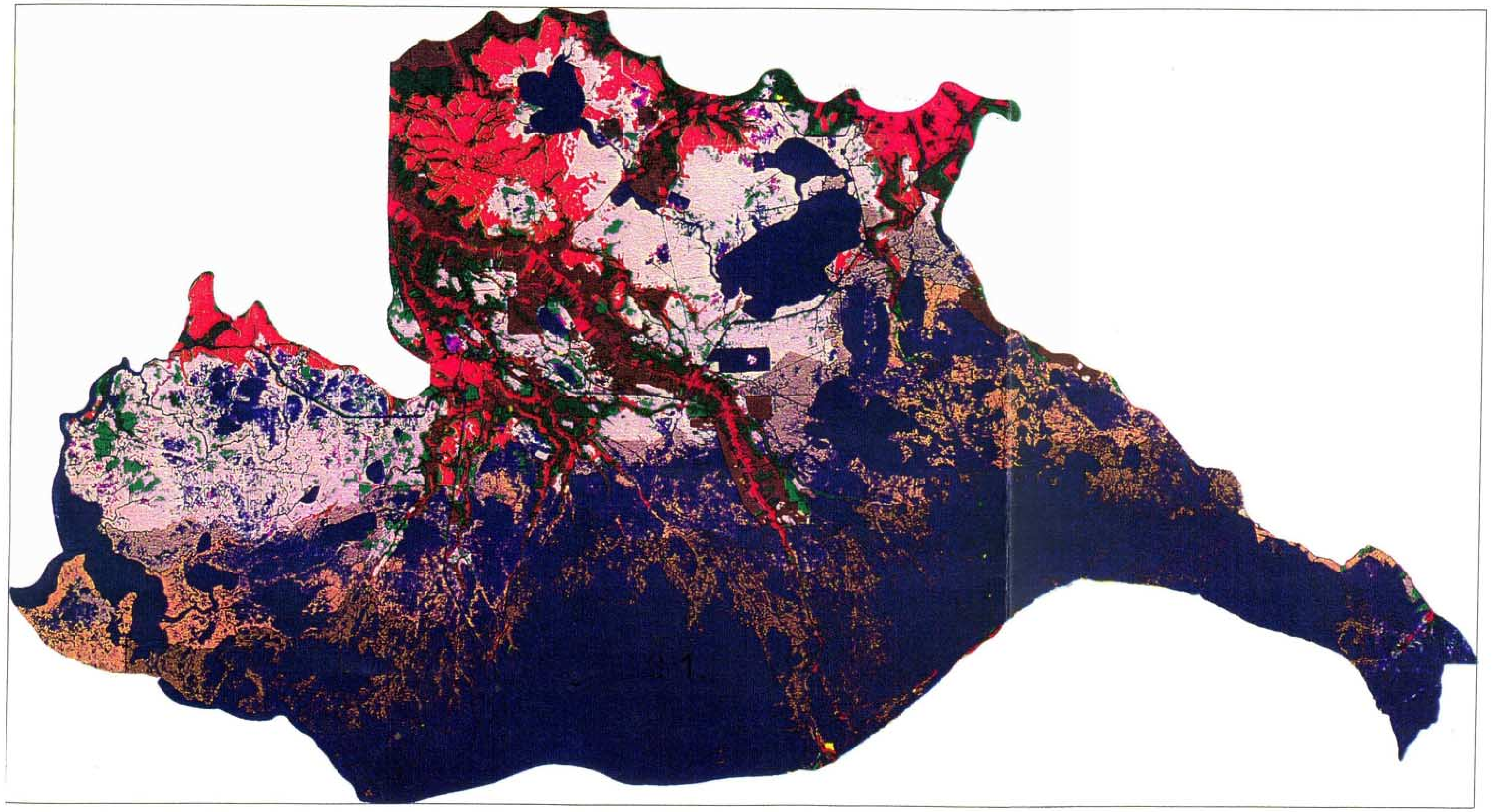
Station Name	Present	Water Level – 30-years	Water Level - 100-years	Type of Change
Venice	X	V	V	X→V
Port Sulphur	X	X	V	X→V
St. Mary's Point	V	V	V	NONE - V
Lafitte	X	X	X	NONE -X
Bayou Perot (S)	V	V	V	NONE - V
Lake Salvador	V	V	V	NONE - V
Leeville	V	X	V	X→V
Golden Meadow	X	X	X	NONE -X
Bully Camp	X	X	V	X→V
Caillou Island	V	V	V	NONE - V
Lac des Allemands	V	V	V	NONE - V
Madison Canal	X	X	X	NONE -X
Cocodrie	X	X	V	X→V
Falgout Canal[1]	X	V	X	NONE -X
HNC at GIWW	X	X	X	NONE -X
Minors Canal	X	X	V	X→V
Sister Lake	X	V	V	X→V
Jug Lake	X	V	V	X→V
Lost Lake	X	X	X	NONE -X
Bayou Penchant (W)	X	X	X	NONE -X
Amelia	X	X	X	NONE -X

[1] Although water levels at Falgout Canal vary at the 30-year projection the flooding level for that scenario is less that 2 hours per cycle and may be within the error of the projection technique, especially as no flooding is identified for the 100-year projection.

3.2.2. Salinity

Salinity impact assessments were made by running the hydrologic model for various wetland and barrier shoreline configurations. The model was run to simulate a 90-day period of tidal conditions. Wind driven currents were not included in the simulations in order to determine only the effects of changes to the barrier islands and inlet under no-action. The no-action wetland configurations for present, 30-, and 100-years were used. Davis Pond diversion runs were made for both operational and non-operational periods. When operating, the diversion was assumed to be operating at 8,000-cfs for the entire 90-day period of the simulation.

Figure 3-1. Present Coastal Habitat Image.

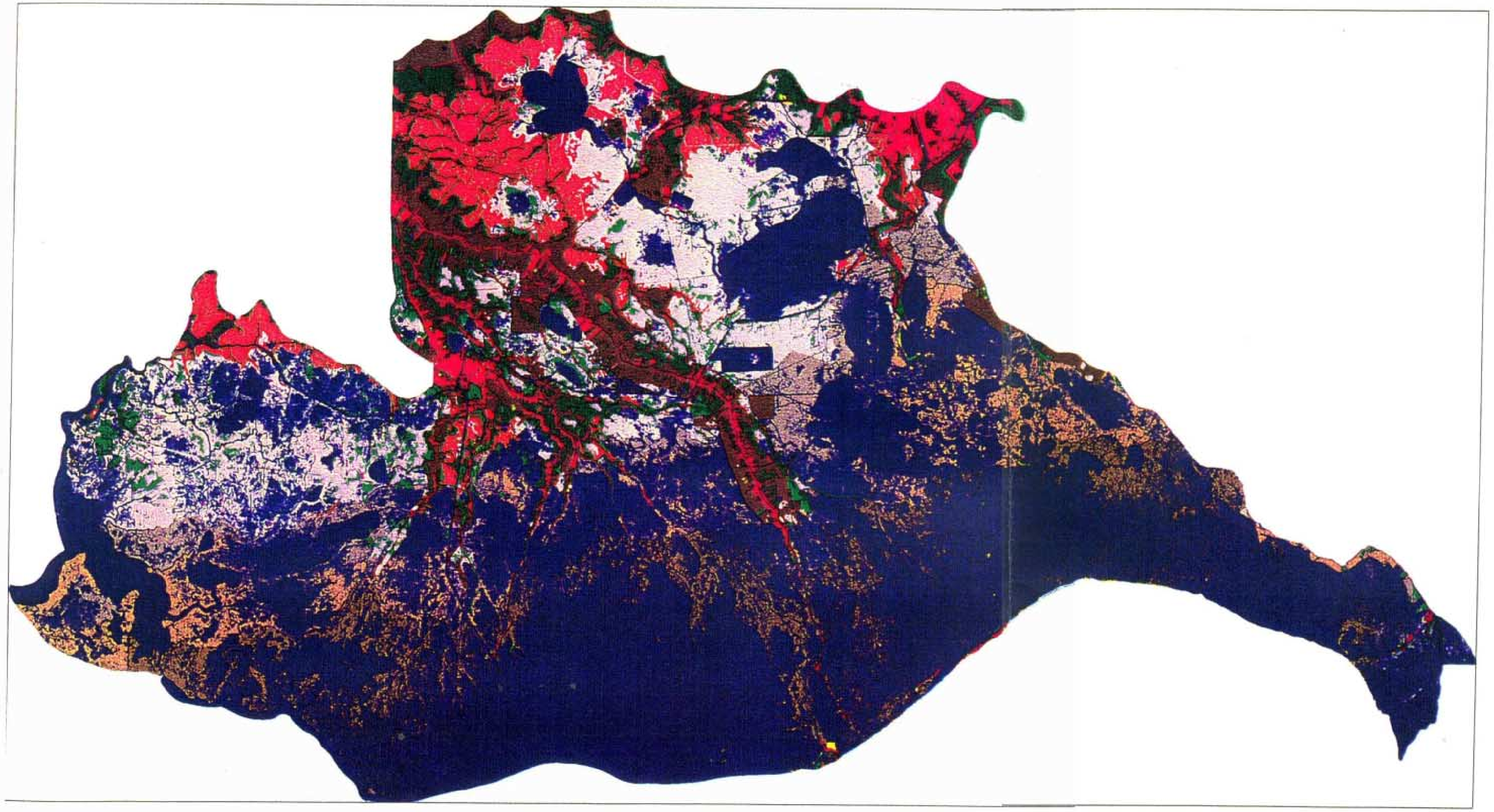


Habitat	Area (Acres)
Water------------:	1212848
AB Floating-------:	11004
AB Submerged------:	10285
Fresh Marsh-------:	376008
Intermediate Marsh:	109144
Brackish Marsh----:	192711
Saline Marsh------:	226818
Cypress Forest----:	157530
Bottomland Forest-:	147611
Upland Forest-----:	16081
Dead Forest-------:	351
Bottomland Shrub--:	57467
Upland Shrub------:	12599
Shore/Flat-------:	1984
AG/Pasture-------:	179693
Upland Barren-----:	674
Developed--------:	73283
Other Land--------:	96

Prepared by NSEL/LWRRI/LSU
November 13, 1996

Note: Projected acres for No-action did not include portions of the Phase 1 Study Area which were later added to the habitats discussed in Section 6.

Figure 3-2. 30-Year Projection of Coastal Habitats.

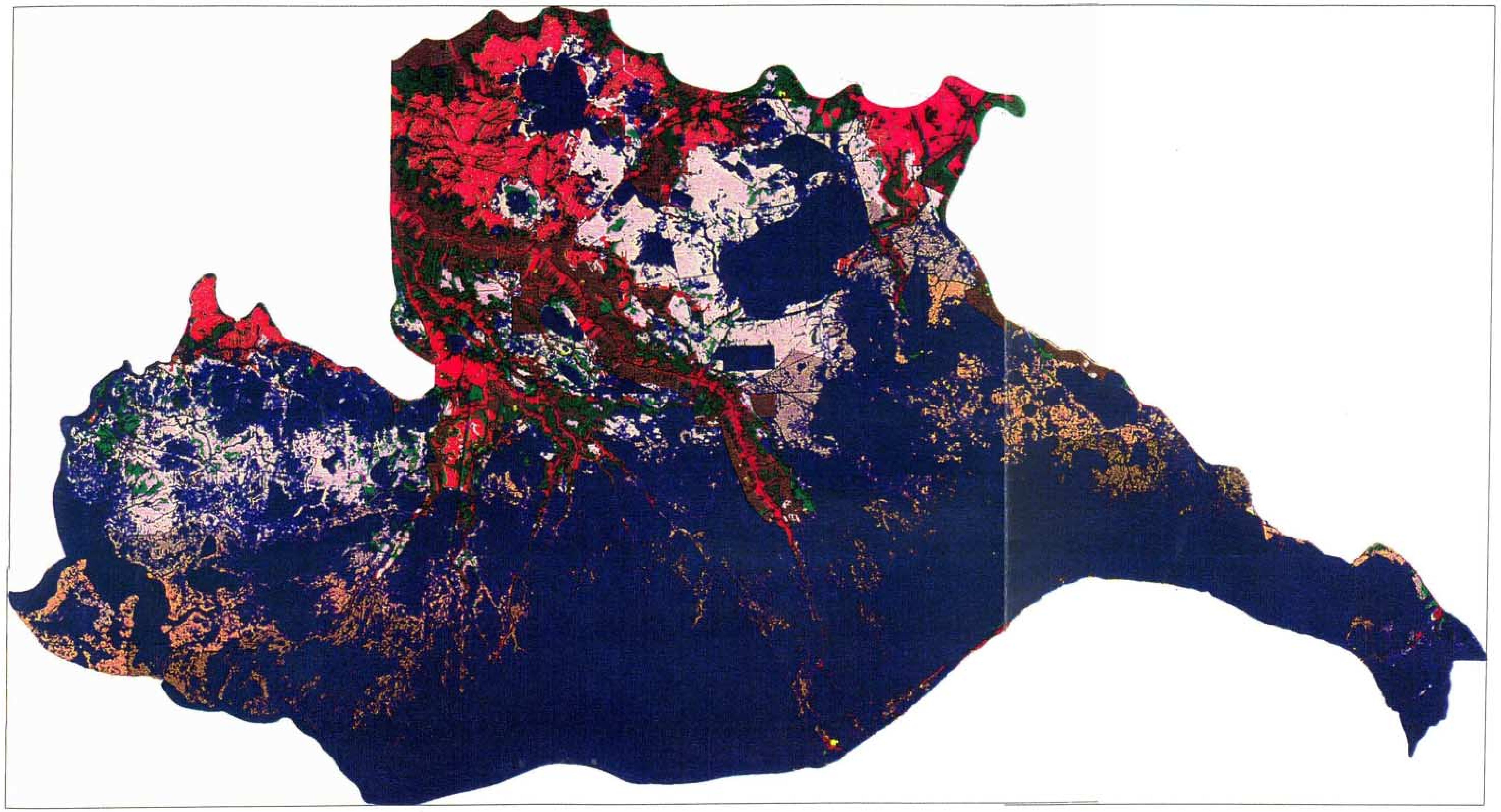


Habitat	Area (Acres)
Water	1388745
AB Floating	5140
AB Submerged	4068
Fresh Marsh	321419
Intermediate Marsh	92393
Brackish Marsh	158450
Saline Marsh	187540
Cypress Forest	155704
Bottomland Forest	144312
Upland Forest	15112
Dead Forest	231
Bottomland Shrub	53604
Upland Shrub	9058
Shore/Flat	1288
AG/Pasture	176414
Upland Barren	600
Developed	72080
Other Land	29

Prepared by NSEL/LWRRI/LSU
November 13, 1996

Note: Projected acres for No-action did not include portions of the Phase I Study Area which were later added to the habitats discussed in Section 6.

Figure 3-3. 100-Year Projection of Coastal Habitats



Note: Projected acres for No-action did not include portions of the Phase 1 Study Area which were later added to the habitats discussed in Section 6.

Habitat	Area (Acres)
Water------------:	1625428
AB Floating-------:	3086
AB Submerged------:	2257
Fresh Marsh-------:	260852
Intermediate Marsh:	73124
Brackish Marsh----:	116785
Saline Marsh------:	120973
Cypress Forest----:	136098
Bottomland Forest-:	134885
Upland Forest-----:	13441
Dead Forest-------:	125
Bottomland Shrub--:	44846
Upland Shrub------:	5918
Shore/Flat-------:	858
AG/Pasture-------:	173541
Upland Barren-----:	548
Developed--------:	70801
Other Land--------:	17

Prepared by NSEL/LWRRI/LSU

The Davis Pond diversion has a major effect on the salinity in the Barataria Bay portion of the study area. Comparisons of the salinity results for the various conditions indicate that mean salinities for the future without project conditions will increase in the areas of the basins where land loss occurred by about 1 ppt. Salinities on the eastern side of Barataria Bay are not strongly influenced by the diversion.

For no-action in 30-years, the marshes in the Little Lake and Bayou Perot/Rigolettes area are subjected to salinity variations over a year from effectively fresh to at least 3 ppt. With Davis Pond, decreased salinities occur on the western side of Barataria Bay and the 3 ppt isohaline extends to the back of the barrier shoreline. For no-action in 100-years, the central Barataria Basin has opened considerably with the loss of marshes between Little Lake and the bay constrictions at the north end of Bayou Perot preventing much exchange with Lake Salvador.

3.2.3. Hurricane Surge

Assessments of the future without project on extreme hydrologic conditions were made by running the hydrologic model described in Step B with a Category 5 hurricane. This condition represents the greatest hydrologic threat to the natural and economic resources in the study area. Hurricane simulations for the future without project conditions included all barrier island and wetland loss predicted in 30-, and 100-years.

Storms propagating along two paths were simulated in the modeling. The first hurricane path, Track 1, is shown in Figure 3-4 and had a forward direction along longitude 90W degrees 30 minutes. The largest storm surge associated with Track 1 was in the Barataria basin. Track 2, shown in Figure 3-5, had a forward direction along longitude 91W degrees 30 minutes. The largest storm surge associated with Track 2 is in the Terrebonne basin.

The no-action projections indicate that the islands are already degraded and that there will be a slight increase in maximum hurricane flood elevation due to the future loss of the barrier islands and the coastal wetlands. Tables 3-4 and 3-5 contain the average maximum flood elevations at selected locations for the track 1 and track 2 storms, respectively. This increase was generally less than 10%. The general result of the simulations is that the future loss of barriers and wetlands will increase maximum flood elevations in the study area by no more than about 10 to 20%. This results from the fact that the islands and wetlands are currently in an advanced state of degradation and since little of these features are present in 1993, their continued loss has little effect on a storm surge of this magnitude.

Table 3-4. Average[*] maximum flood elevation for the Track 1 Category 5 hurricane (feet) under future without project conditions

Location	Surge elevation (feet)
Bully Camp	5.90
Caillou Island	4.60
Cocodrie	3.80
Golden Meadow	5.90
Lafitte	9.00
Lake Salvador	3.95
Leeville	6.90
Port Sulphur	10.80
St. Mary's Point	7.90
South Bayou Perot	6.60
Venice	4.40

* Average of present, 30- and 100-year

Table 3-5. Average[*] maximum flood elevation for the Track 2 Category 5 hurricane (feet) under future without project conditions

Location	Surge elevation (feet)
Amelia	8.70
Bully Camp	10.65
Bayou Penchant	8.00
Cocodrie	9.50
Falgout Canal	9.85
Golden Meadow	5.40
Houma Navigation Canal	11.15
Jug Lake	11.00
Lafitte	5.90
Lac des Allemands	7.55
Lake Salvador	6.05
Leeville	5.10
Lost Lake	9.85
Madison Canal	8.85
Minor's Canal	11.30
Port Sulphur	5.10
Sister Lake	11.30
South Bayou Perot	5.10

* Average of present, 30- and 100-year

3.2.4. Waves

The future without project wave climate modeling for the study area was divided into Areas 1, 2 and 3, shown in Figure 3-6. Under no-action, all changes in wave height, primarily increases, are due to the transformation of the subaerial mass of the barrier islands and mainland beaches (*e.g.,* Caminada-Moreau headland) to subaqueous shoals or deepening of the offshore profile.

For the 30-year forecast in Area 1, which comprises the Isles Dernieres, the transformation of Raccoon Island to a shoal system results in the largest increase in average southerly wave height from 1.0 feet to 3.3 feet in Caillou Bay for fair-weather conditions. Similar increases are noted in Lake Pelto in areas where the islands had previously existed. The spatially averaged range of wave heights in Lake Pelto and Caillou Bay is 0.4 to 0.6 feet. For the 100-year forecasts, the largest wave height increase reaches 3.3 feet and covers a significantly greater area of Lake Pelto. The entire area from Lake Pelto to Caillou Bay is transformed to an open marine environment with spatially averaged wave heights ranging from 0.5 to 1.3 feet. Thus, the adjacent fringing marshes will experience increases in wave energy.

Significant increases in wave energy occur in Area 2, which encompasses the Timbalier Islands and western margin of the Caminada-Moreau Headland, for the 30 and 100-year forecasts. A 3.3 feet wave-height increase is predicted at the east end of East Timbalier Island, under fair-weather conditions. Along most of the Timbalier Islands and the Caminada Moreau Headland, wave heights increase between 0.7 to 2.6 feet due to an increase in water depth in the nearshore resulting from projected shoreline erosion and a landward shift in the beach profile. Landward of the western flank of Timbalier Island, a significant decrease in wave height of up to 2.6 feet is predicted due to the westward progradation of the island in the 30-year scenario. The 30-year no-action mean wave height throughout Area 2 is 0.3 to 0.6 feet. More dramatic increases in wave heights are predicted for the 100-year scenario due to the projected total loss of the barrier islands. Immediately landward, an increase of wave height of up to 2.6 feet is predicted for fair-weather conditions. The spatially averaged wave height in 100-years ranges from 0.5 to 1.4 feet.

Figure 3-4. Maximum Water Level Elevation (Present, No-Action, Track 1)

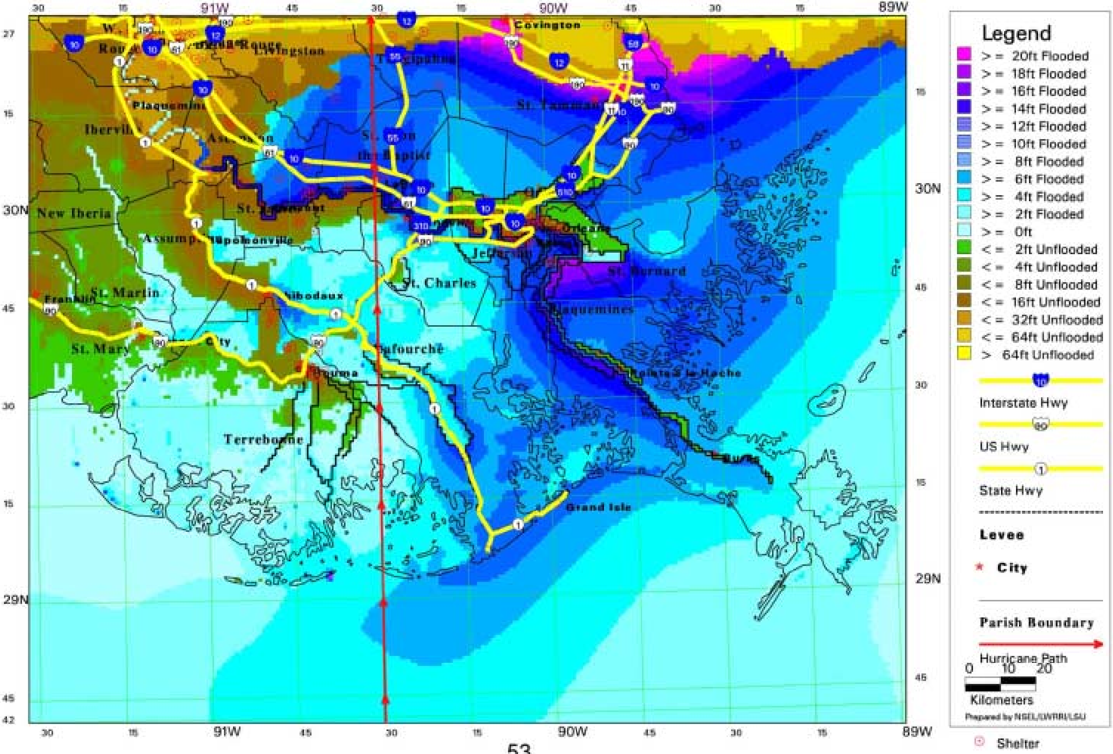


Figure 3-5. Maximum Water Level Elevation (Present, No-Action, Track 2)

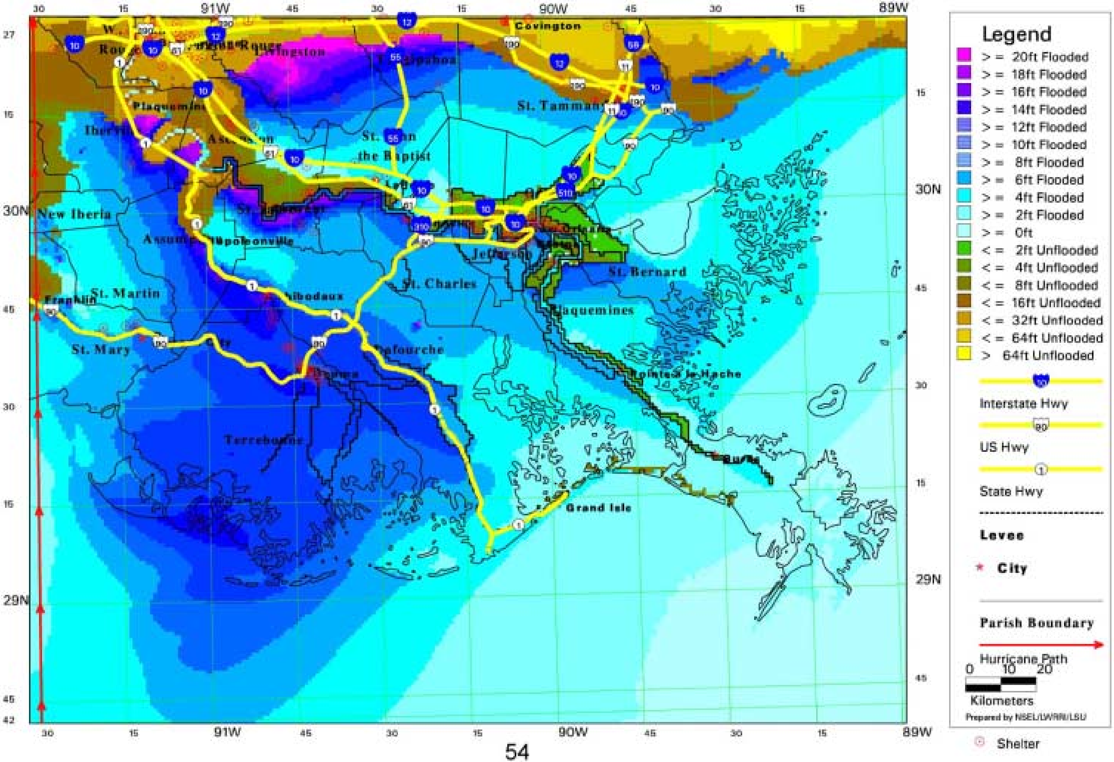
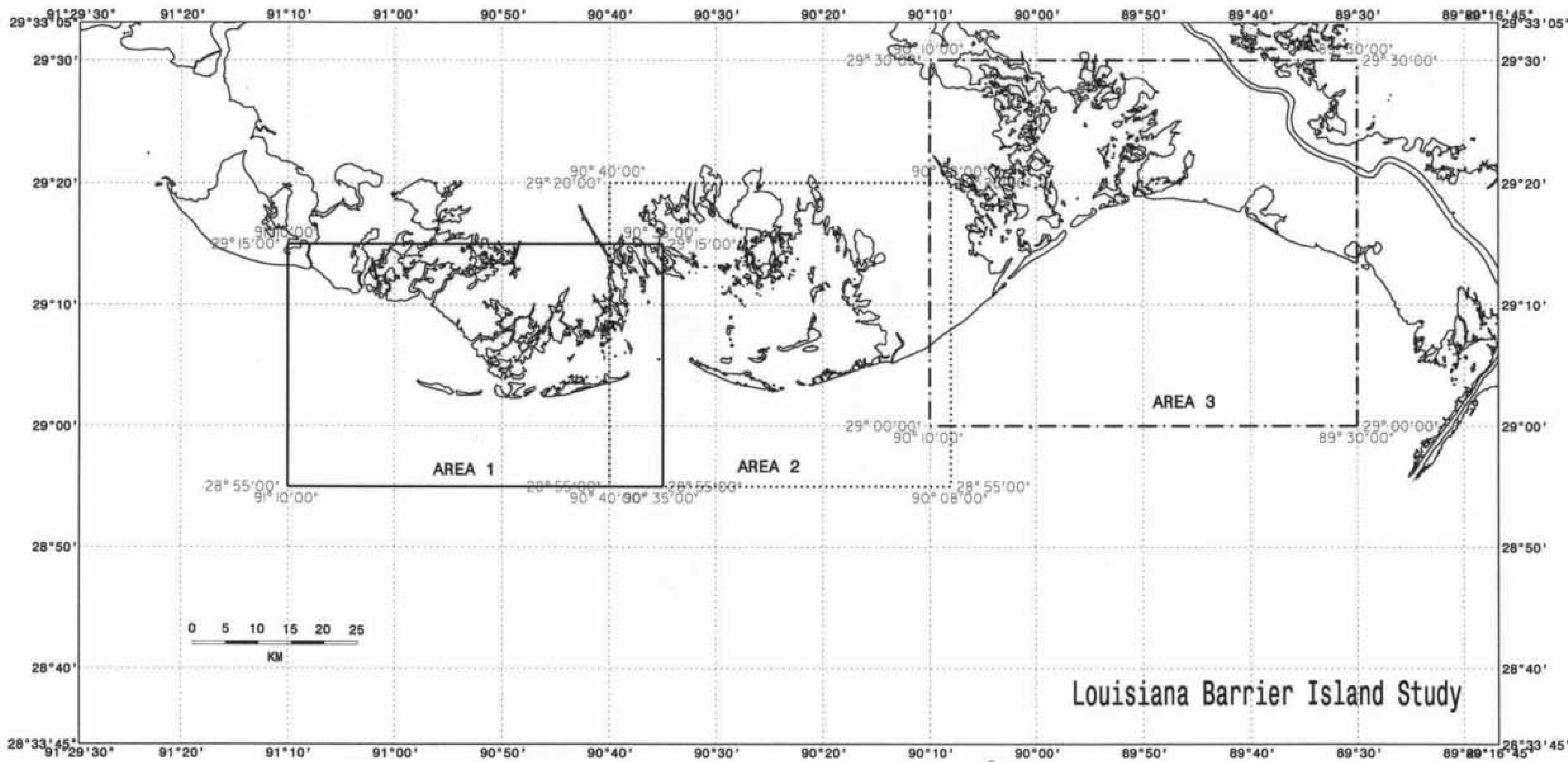


Figure 3-6. Base Map of Phase 1 Study Area, Louisiana Barrier Shoreline Feasibility Study



The general wave climate changes in Area 3 for both 30 and 100-year scenarios are much less dramatic than those for Areas 1 and 2. This is primarily due to smaller projected shoreline change. The predicted wave-height changes are concentrated along Gulf shorelines where an increase in wave height is predicted due to the projected retreat of the Caminada-Moreau headland and a restoration project on Grand Isle. The average wave height in Area 3 ranges from 0.2 to 0.4 feet. No significant changes in wave conditions are predicted in Barataria Bay due to the continued protection afforded by the barrier islands.

In general, the present barrier shoreline provides substantial protection by reducing wave height. This is especially true for areas immediately landward of the barriers. The no-action model runs demonstrate that the present degraded barrier islands have a substantial influence on marsh shorelines by blocking the Gulf waves from entering the back-barrier bays. The future loss of the barrier shoreline results in substantial increases in wave energy in Terrebonne Bay, Lake Pelto and Caillou Bay.

3.3. Environmental Resources

As described in Section 3-1, the no-action projections for 30- and 100-years show the largest land loss for fresh-, saline-, brackish-, and intermediate marshes. In all, 144,879 acres (226 mi^2) and 332,947 acres (520 mi^2) of these four habitat types are predicted to be lost in 30- and 100-years respectively. With the conversion of wetland habitat to open water, important habitat values, including feeding areas and predator refuges, would be greatly diminished or lost entirely.

Water level fluctuations are projected to vary throughout the study area as the land loss occurs in the future. In general, the water levels changes are not ecologically significant. The changes in landscape will likely produce some alterations in salinity patterns within the bay marsh systems. However, none of these changes is considered to be of sufficient magnitude to result in habitat shifts in the emergent marsh areas.

Changes to the faunal communities are assumed to be associated with the amount of habitat of a certain type rather than a change in habitat type. The projected loss of the barrier islands is significant to many species of birds that utilize the islands either as nesting areas (e.g., shorebirds, seabirds), or as stop-over habitat for songbirds and other trans-Gulf migratory birds. In addition, high-energy beach habitat that currently serves as a nursery ground for many species of fish that have no alternate nursery habitat is projected to be lost. The loss of the barrier island marsh will eliminate nursery habitat for many species of young-of-the-year estuarine marine fish and macroinvertibrates that move inland to mainland marshes.

Saline marsh north of the barrier islands is projected to lose 17% and 47% of the total acreage in the Barataria and Terrebonne estuaries over the 30- and 100-year time spans. These marshes are already fragmented, so the marsh will undergo a major transition to open water. Much of the function of these saline marshes could be lost, particularly as feeding and predator refuge areas for juveniles. This function would be greatly diminished in the small remaining fragments of saline marsh in the system as the rivulets and meanders expand to open water. With close to half of the total acreage lost, any potential enhancement from edge heterogeneity will most likely have come and gone. Estuarine residents such as gobies and killifish will have lost much of their lower bay habitat. Estuarine/marine transitory migrants such as penaeid shrimp, spotted seatrout, and red drum use the saline marsh as nursery areas and this function could be greatly impaired. Overall, secondary fishery production in saline marsh will greatly decline. Fewer marine species enter the estuary to use saline marsh, so this group will not be as severely impacted.

The dynamics of biological use of brackish marsh can be very similar to that of saline marsh. The projected fragmentation of this marsh will probably result in some loss of its nursery function, but may enhance its use by birds as feeding areas due to the more open nature of the marsh. The slight increase in projected salinity and depth will probably have few biological consequences. Loss of 40% of this habitat as shown in the 100-year projection could be devastating to local muskrat populations who prefer brackish marsh as a food source.

Intermediate marshes remain relatively stable in the Barataria basin, presumably because of the influence of the Davis Pond diversion. There is no predicted increase in salinity here. Changes there are largely increases in the size of existing open water bodies rather than widespread fragmentation. Within Terrebonne, intermediate marshes in both the west and east become more fragmented. There is a projected change in salinity of approximately 1 ppt in these areas with the prevailing salinity still less than 3 ppt. The projected loss over 100-years of one-third of this habitat is cause for serious concern since conservation efforts elsewhere in North America to stabilize and enhance waterfowl populations could fail from lack of wintering acreage along coastal Louisiana. Intermediate marsh is often important habitat for seasonal estuarine-marine fish and macroinvertebrates penetrating farther inland, and the cumulative impact of large losses of saline, brackish, and intermediate marsh acreage almost certainly would result in population decline of these species. Increased fragmentation of the intermediate marsh in the Terrebonne system could be detrimental to species of fish such as sunfish and killifish that prefer protected edge habitats, with loss of spawning areas for many of these nest-building sunfish a distinct possibility.

There is a large difference between Barataria, with Davis Pond, and Terrebonne. In Barataria, fresh marshes remain relatively stable and open water bodies will remain fresh. New small ponds are projected to be shallow and isolated. In the Terrebonne Basin, already fragmented areas of western Terrebonne marshes coalesce to form large bodies of open water. Tidally influenced fresh marsh can be important habitat for young of certain seasonal estuarine-marine species that normally use the upper reaches of estuaries as preferred nursery/refuge habitat. These species would lose habitat, particularly in Terrebonne Basin, where a greater percent of freshwater marsh is predicted to be lost, but this may be difficult to document in the overall population along coastal Louisiana. Although there is a projected 30% loss of freshwater marsh, over 250,000 acres will remain in the two systems, but this is far short of the projected acreage of the North American Waterfowl Management Plan (MRCWI-GCJV 1990) that has the objective of “providing, through preservation, restoration, creation, and enhancement approximately 509,000 acres of fresh marsh” in the Mississippi Deltaic Plain Region. The creation of new small, shallow ponds within the marsh may provide valuable habitat for spawning and nesting for amphibians and certain fishes (sunfish and bass). These ponds may serve as feeding stations for many birds and small amphibians.

3.4. Economic Resources

The economic impacts of the future without project storm tidal surge flooding regimes and projected losses to the barrier shoreline and wetlands were compared to current conditions. Economic resources that were analyzed include commercial and recreational fishing; increased hurricane surge flooding for residential, commercial, and industrial infrastructure; agriculture; water supply; and roads.

3.4.1. Commercial and Recreational Fishing

In order to estimate the impact on commercial fishing incomes, an assumption was made that fishing effort will remain constant in spite of reduced stock. As discussed in Step H (LDNR 1998 h.ii), an estimate of the present value of losing one acre of wetlands today would result in future fisheries losses between $41.50 and $58.30 per acre. Recall that annual wetlands losses under no-action were projected to be 4,828 acres per year for the first 30-years, and 2,686 acres per year for the remaining 70 years. Using the 8.25% discount rate, the present value losses range from $2.319 million to $3.258 million.

As described in the Step H report (LDNR 1998 h.ii), recreational interests would presumably value a 50% reduction in catch or bag at $92. Estimated wetland loss over the 100-year period is 37% of the current wetland area. Translating this, a reduction in catch or bag would be valued at $68.08 per year per user. The present value of these recreational losses range from $7.48 million to $8.20 million.

3.4.2. Hurricane Flooding

In estimating the increased damages due to hurricane flooding, the storm of record was modeled (Category 5 Hurricane - winds greater than 155 mph) on two tracks. Expected flood damages to residential, commercial, industrial and public structures, as well as to roads, were estimated. Damage costs for the future without project conditions were then compared to costs of similar storm probabilities under current conditions of barrier island and wetland configurations. Lesser storms would also yield economic implications for the different project alternatives. For this reason alone, the cost differences should be viewed as the minimal projected cost.

As shown in Table 3-6, the predicted total damages from the 90.5W prototype Category 5 storm occurring in 100-years under the no-action plan, using median depths, are $939 million. This can be compared to the $862 million in damages for an identical storm under Current Conditions. In other words, a no-action plan would result in $77 million more damages from a storm in 100-years than the same storm occurring currently.

The predicted total damages from the 91.5W prototype Category 5 storm occurring in 100-years under the no-action plan, using median depths, are $879 million, compared to $787 million in damages for an identical storm under Current Conditions. This results in $92 million more damages from a storm in 100-years than the same storm occurring currently.

The increases in damages is attributable to the fact that the hydrologic modeling, which is the basis for this estimate, takes into consideration the deterioration of the barrier islands and wetlands over this 100-year period. The analysis shows that although the flooding damages associated with the 90.5W track are higher than the 91.5W track, damages increase by a greater amount with the 91.5W track.

3.4.3. Other Economic Resources

There may be other economic costs associated with no-action compared to current conditions including oil and gas infrastructure, highway and street maintenance costs, water supply, and agricultural crop flood damage.

3.4.3.1. Oil and Gas Infrastructure

As discussed in Section 3.1, tremendous loss of the barrier islands is projected under the future without project conditions. The loss of the islands could be sufficient within 30-50 years to require reburial of all pipelines using the islands as an anchor point. Therefore, all 60 lines would need to be reburied in 30-years, 60-years and again in 90-years. This reburial cost would be $1.2 million each time it occurs. In addition, of the pipelines located in the marsh, 750 miles of line will have to be replaced over the next 100-years as wetlands convert from marsh to open water. This amounts to 7.5 miles per year, or $369,600 in reburial cost per year. Combined, pipeline reburial for future without project conditions has a present value cost of $4.6 million.

Table 3-6. Predicted Median Flood Damage Costs to Structures from Category 5 Hurricanes, Under Current Conditions and No-Action

	Current Condition	No-Action	Current Condition	No-Action
	TRACK 1 (90.5°W)		TRACK 2 (91.5°W)	
Parish	Present	100-years	Present	100-years
	$1000's	$1000's	$1000's	$1000's
Ascension	$ 6,117	$ 6,117	$ 17,670	$ 18,187
Assumption	$ 495	$ 495	$ 22,061	$ 24,287
Jefferson	$ 346,814	$ 387,280	$ 235,284	$ 282,847
Lafourche	$ 53,211	$ 71,901	$ 119,266	$ 131,458
Orleans	$ 253,488	$ 256,995	$ 91,402	$ 95,779
Plaquemines	$ 35,165	$ 36,195	$ 20,102	$ 31,318
St Charles	$ 52,246	$ 54,153	$ 33,006	$ 38,766
St James	$ 17,870	$ 17,870	$ 8,100	$ 8,951
St John	$ 64,403	$ 64,403	$ 29,226	$ 29,716
St Mary	$ 12,017	$ 12,017	$ 46,403	$ 46,403
Terrebonne	$ 20,535	$ 31,746	$ 165,116	$ 171,149
TOTAL	$ 862,361	$ 939,173	$ 787,636	$ 878,862

There are roughly 340 oil and gas fields and nearly 19,000 wells in the study area, with 270 fields and over 17,000 wells located in the five parishes adjacent to the barrier islands (LDNR 1998f). Wells and associated structures in open waters lying landward of the barrier islands may be subject to substantial increased storm risk in the absence of those protective islands. The cost to construct a platform in unprotected waters is at least double the cost for platforms in protected waters. Based on the number of new wells installed in the 1980's and the cost to build larger platforms due to the loss of the barrier islands and wetlands, the present value of these increased costs is $0.269 million over the 30-year period and $0.296 million over the 100-year period.

3.4.3.2. Highway and Street Maintenance

Increased flooding may impact road and street maintenance expenses. A total of 371 miles of roads and streets are at greater risk of flood related damages from the prototype storms under no-action than under Current Conditions. It was assumed that road mileage at risk increases linearly over time. The per mile cost used in this analysis is resurfacing rural two lane asphalt roads at $100,000 per mile (high) and the cost of simply resealing two lanes is only $40,000 per mile (low) (LDNR 1998f). Therefore, the storm related cost for the future without project conditions ranges from $4.5 to $11.1 million in 30-years and $14.8 to $37.1 million in 100-years.

3.4.3.3. Water Supply

The no-action condition presumes that indeterminate levels of saltwater intrusion in the future will require new investment in water treatment plants and equipment in Terrebonne and Lafourche Parishes (USACE 1997). These upgrades are planned under no-action while they are not under current conditions. The construction costs of these upgrades would equal $98 million. The timing of the need depends upon the rate of increased salinity intrusion into the study area. The USACE study cited the 1996 Terrebonne Parish Master Plan prediction that existing facilities would not meet demands by 2003. Therefore, it is assumed that the upgrade would be necessary in 10-years resulting in an upgrade cost of $44.355 million, with annualized costs over the 30-year period of $4.033 million per year and annualized costs over the 100-year period of $3.661 million per year. A one-time replacement cost is assumed, so the present value of costs over the 30-year period are the same as costs over the 100-year period.

3.4.3.4. Agricultural Crop Flood Damages

Flooding effects on agriculture crops will come directly from water damage due to submersion and flow, and, in the end, to increased soil salinity from saltwater flooding. Increased flood damages to agricultural crops could be due to two effects: inundation of previously unflooded lands, and longer inundation periods. No data on length of flooding under the various project alternatives was available. Only 148 acres of present agricultural area are projected to be newly flooded due to the Category 5 storm surge. Therefore, the impacts to agricultural crops are considered negligible. No data was available on the long-term impacts of increased soil salinities. This prediction is considered minimal (least damage) at best.

3.4.4. Total Costs

The non-storm related increased costs for the future without project conditions compared to current conditions is shown in Table 3-7. This includes commercial and recreational fishing, pipeline reburials, and increased costs to install new oil and gas wells. This table shows the present and annualized values of these costs, for 30- and 100-year periods using the U.S. Army Corps of Engineers 8.25% discount rate.

The future without project imposes non-storm costs that range from $12.2 to $13.4 million higher in a 30-year period than compared to Current Conditions. The annualized increase in costs over this 30-year period range from $1.1 to $1.2 million per year. Over a 100-year period, these costs range from $14.7 to $16.4 million higher under the future without project compared to Current Conditions, with annualized cost increases of $1.2 to $1.35 million per year.

Table 3-7. A Summary of Non-Storm Cost Increases to the Study Area of the Future Without Project Conditions Compared to Current Conditions ($ millions)

	No-Action		No-Action	
	30 Years	30 Years	100 Years	100 Years
	Low	High	Low	High
Present Value	$12.2	$13.4	$14.7	$16.4
Annualized Value	$1.1	$1.2	$1.2	$1.4

The estimated damage increase for a Category 5 Hurricane making landfall in the study area compared to present conditions is shown in Table 3-8. The increases are due to the projected loss of the barrier shoreline and wetlands in 30- and 100-years.

Table 3-8. Storm Damage Increases for Category 5 Storms Occurring in for the Future Without Project Conditions Compared to Current Conditions($ millions)

	90.5W Storm		91.5W Storm	
	Low	High	Low	High
Damage increase in **30-years** for the future without project	$27.5	$34.1	$31.9	$38.5
Damage increase in **100-years** for the future without project	$92	$114	$106	$128

4.0. PROBLEM IDENTIFICATION

In this section, the problems, needs, and opportunities associated with the Phase 1 barrier shoreline are described. Identification of problems, needs, and opportunities ensures the study team is properly orientated to the study area and focused on its unique aspects.

The Phase 1 barrier shoreline acts as a buffer for coastal marshes and communities, dissipating much of the wave action from the Gulf of Mexico (USACE 1984; LDNR 1998g). This barrier shoreline also play a role in determining the basin hydrology, socio-economic prosperity, and cultural diversity of coastal Louisiana, and help maintain a diversity of plants and animal life in the unique ecosystem of coastal wetlands.

For the purpose of defining the specific problems, needs, and opportunities in the Phase 1 study area, the resources were categorized under three major groups: environmental, socio-economic, and engineering. Economic and social resources are discussed together as socio-economic resources due to their interdependency.

4.1. Existing Problems and Needs

Environmental problems identified in the Phase 1 study area associated with the barrier shoreline include the continued loss of habitat for migratory fishes, macro-invertebrates and macro-crustaceans, and birds. Many of the economically important species harvested in Louisiana are taken from the larger bays where they occur as sub-adults. These larger bays are separated from the open Gulf by the barrier shoreline. In addition, island ponds and streams are important as spawning and feeding areas for many resident species. Shore birds, wading birds, migratory songbirds and other avian species use the barrier shoreline for breeding, nesting, feeding, and resting areas. Additionally, greater wave activity in the bays associated with barrier shoreline loss may increase turbidity. The increased turbidity may negatively impact submerged aquatic vegetation as well as fisheries that rely on water clarity for feeding. A description of the particular species which occur in the Phase 1 area is contained in Section 3 and in the Step E - Assessment of Resource Status and Trends and Step E – Inventory and Assessment of Environmental Resource Status and Trends reports.

The primary need associated with environmental resources in the study area is the provision of sustainable habitat for various biological species. The retention of the barrier shoreline will provide this sustainable habitat. To retain the barrier shoreline, the primary need is for the introduction of sediment into the system.

Continued loss of the barrier shoreline may expose additional socio-economic resources to storm damage and hurricane flooding. As these infrastructure nodal points are exposed to greater risk, the cost to society both in terms of actual expenditure, and in terms of the quality of life, will increase. Another problem is the public investment necessary for shoreline restoration. Society must be willing to support such a commitment of public funds.

Socio-economic needs include political support for the investment necessary to restore the shoreline. It is also necessary that the local, state, and national economy be protected from the detrimental effects of shoreline loss in the Phase 1 study area.

Engineering problems in the study area include the instability of the gulf and bay shoreline and frequent overwashing of the dunes. Additionally, borrow material availability for use in shoreline stabilization is an issue, and requires careful consideration of the short and long term impacts.

Engineering needs in the Phase 1 study area include the need to increase the height and width of the islands to prevent frequent overwash and reduce the number and size of inlets. The primary engineering need is to add sediment to the barrier shoreline and to retain as much of the material as possible on or near the islands. Height also is needed to prevent storm surge.

4.2. Existing Opportunities

Environmental opportunities for the study area barrier shoreline include the continued existence of the shoreline, i.e. it has not completely eroded. Indigenous species remain in the area and utilize the habitats on both the shoreline and those protected by the shoreline. The opportunity is to improve and enhance this habitat before it totally disappears. The socio-economic opportunity exists to improve or enhance eco-tourism and recreational business ventures by stabilizing the shoreline. In addition, commercial fishing and trapping activities can be sustained or maintained by improving the appropriate habitats. To the extent that barrier shoreline restoration reduces exposure to extreme events such as hurricanes, economic development may occur in a more stable setting. Engineering opportunities associated with barrier shoreline restoration include retention of the material in the littoral zone by closing inlets and the use of hard structures, vegetative planting, and sand fencing to stabilize the shoreline.