Hurricane Protection, Louisiana

Section 905(b) of the Water Resources Development Act of 1986 Analysis

1. STUDY AUTHORITY

The study was authorized by a resolution adopted by the Committee on Transportation and Infrastructure of the United States House of Representatives on April 22, 1999. This resolution reads as follows.

> Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the reports of the Chief of Engineers on Lake Pontchartrain, Louisiana, published as House Document 231, 89th Congress, 1st Session: on the Mississippi River Delta at and below New Orleans, Louisiana, published as House Document 550, 87th Congress, 2nd Session: and on Grand Isle and Vicinity, Louisiana, published as House Document 134, 89th Congress 1st Session and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at the present time, to provide a higher level of hurricane protection for category 4 or 5 storms.

The 2001 Energy and Water Appropriations Act included $100,000 added by Congress, to initiate a General Investigations reconnaissance study specifically for the Hurricane Protection, Louisiana area. This study was initiated in March 2001.

2. STUDY PURPOSE

The purpose of this reconnaissance study is to make a determination whether planning of projects to reduce hurricane storm damages in the study area should proceed further based on a preliminary appraisal of the Federal interest. This study focused on the investigation of structural means of reducing flood damages.

3. LOCATION OF PROJECT

The Hurricane Protection, Louisiana study area is located in Southeast Louisiana and includes portions of the parishes of St. Tammany, St. John the Baptist, Lafourche, St. Charles, Jefferson, Orleans, St. Bernard, Tangipahoa, Terrebonne, St. Mary, and Plaquemines (Plate 1). The study area is located between the Atchafalya River and the Pearl River and includes all of the parishes located along the southeast coast of Louisiana and surrounding Lake Pontchartain.

Included in the study area are five existing authorized hurricane protection projects plus three hurricane studies that are in various stages of the study process. The existing authorized projects are Lake Pontchartrain, Louisiana and Vicinity, New Orleans to Venice, Louisiana, West Bank and Vicinity, Louisiana, Larose to Golden Meadow, Louisiana, and Grand Isle and Vicinity, Louisiana. Ongoing studies include Morganza to the Gulf Feasibility Study, Lake Pontchartrain West shore Feasibility Study, and Donaldsonville to the Gulf Reconnaissance Study.

The study area is comprised of a wide range of land types including highly urbanized areas, industrial areas, agricultural lands, and large areas of coastal wetlands. Numerous communities exist in the study area dominated by the Greater New Orleans metropolitan area. Major international port facilities are located along the deep draft navigation channel of the Mississippi River and the Mississippi River Gulf Outlet and a high volume of shallow draft traffic exists along numerous shallow draft waterways in the study area. In addition, four interstate highways, an international airport, and six mainline railroads serve the area.

The study area is subject to rainfall, tidal and hurricane flooding resulting in structural, agricultural, and environmental damages. Flood damages are aggravated by the relatively flat terrain and in some cases large urbanized areas at or below sea level.

The study area is located in the 1st, 2nd, and 3rd Congressional Districts, which are currently represented by David Vitter, William Jefferson, and W. J. (Billy) Tauzin, respectively.

4. PRIOR STUDIES, REPORTS, AND EXISTING WATER RESOURCE PROJECTS

A number of studies and reports on water resources development in the study area have been prepared by the U.S. Army Corps of Engineers (USACE), other Federal, state, and local agencies, research institutes, and individuals. Previous Federal and non-Federal studies have established an extensive database for this report. Historical trends and existing conditions were identified to provide insight into future conditions and help isolate the problems. The more relevant studies, reports, and projects are described in the following paragraphs.

STUDIES AND REPORTS

- An Interim Survey Report for Lake Pontchartain, Louisiana and Vicinity dated November 21, 1962 resulted in the authorization of a project which included levees and structural features in St. Charles, Jefferson, Orleans, and St. Bernard Parishes and structural barriers at the entrance to Lake Pontchartran to provide for protection against the standard project hurricane.

- A Reevaluation Study for the Lake Pontchartrain, Louisiana and Vicinity Hurricane Protection project dated July 1984, revised the project plan to construct higher levees around the metropolitan area of New Orleans instead of the structural barriers at the entrance to Lake Pontchartrain.

- A USACE report entitled New Orleans to Venice, Louisiana Hurricane Protection, was published as House Document 550, 87th Congress, 2nd Session. The project provides hurricane protection to developed areas in Plaquemines Parish along the Mississippi River. The locally constructed back levee from City Price to Venice, Louisiana, on the west bank would be brought up to grade. The General Design Memorandum Supplement No. 5, dated October 1983, provides for the creation of 297 acres of marsh in the Delta-Breton National Wildlife Refuge as mitigation for marsh loss caused by the levees.

- USACE prepared a reconnaissance report entitled Donaldsonville to the Gulf of Mexico, Flood Control, Mississippi River and Tributaries in June 2000. The study focused on investigating structural means to reduce flood damages. The study has been completed with a recommendation to proceed to the feasibility phase.

- USACE prepared a feasibility report entitled Morganza, LA to the Gulf of Mexico. This report recommends implementation of flood control measures in Lafourche and Terrebonne Parishes to protect against hurricane storm surges. The study has entered the preconstruction engineering and design phase.

- USACE prepared a reevaluation study entitled Lower Atchafalaya Basin Reevaluation Study. The United States Senate Report to the 1994 Energy and Water Development Act (PL 103-126) dated 28 October 1993 directed the Corps to use available funds to investigate conditions at Wax Lake Outlet, Bayou Black, and other features and recommend any modifications desirable for flood protection, navigation, and environmental management.

- USACE is preparing a feasibility report entitled West Shore-Lake Pontchartain, LA. This study is identifying hurricane protection projects in the St. Chalres Parish and St. John the Baptist Parish area along the western shore of Lake Pontchartrain.

- An initial evaluation study entitled Louisiana Coastal Area, Louisiana, Shore and Barrier Island Erosion, dated September 1984, reports investigative findings which indicate that Louisiana's beaches and barrier islands act as buffers for coastal marshes and communities, absorbing much of the wave action from the Gulf of Mexico. However, most of the shoreline is receding. Continued retreat will expose valuable marshes to direct attack from the gulf. Loss of the marshes would have a severe impact on existing coastal development and fish and wildlife resources important to the state and nation.

- USACE prepared a reconnaissance report on hurricane protection in March 1988. The Louisiana Coastal Area Hurricane Protection Reconnaissance Report investigated the feasibility of providing hurricane protection for coastal Louisiana between the Pearl River on the east and the Sabine River on the west. For this report, concentration was placed on the Barataria Basin portion of the Louisiana Coastal Area. The report recommended proceeding to the feasibility phase to investigate a hurricane protection alternative for the Luling area of St. Charles Parish on the west bank of the Mississippi River.

- The Louisiana Department of Natural Resources contracted with Coastal Environments, Inc., to publish a report entitled Louisiana's Eroding Coastline: Recommendation for Protection in June 1982. The report recognized that future losses of coastal wetlands are unavoidable and will require either retreat of development from the coast or increasingly greater costs of maintaining present levels of flood protection. Areas with erosion problems were identified and ranked according to the severity of the erosion problem. The report recommended development and implementation of a shoreline protection plan and proposed a number of pilot projects using water and sediment diversions, dredged material placement, and planted vegetation as ways to reduce erosion. A study to determine future coastal conditions including changes in shoreline configuration and impacts on developed areas was also recommended. Information produced from this study on erosion and shoreline changes was used in defining problem areas and evaluating alternative plans.

- The U.S. Fish and Wildlife Service (USFWS) produced a report entitled Mississippi Deltaic Plain Region Ecological Characterization. Published in 1980, the report supplies information about the biological, social, and physical parameters in the Mississippi Deltaic Plain region of Louisiana.

- A report sponsored by USFWS, An Ecological Characterization Study of the Chenier Plain Coastal Ecosystem of Louisiana and Texas, was published in 1979. This report also contains information on the biological, social, and physical parameters in the Chenier Plain of Louisiana and Texas.

- The USFWS published the Proceedings of the Conference on Coastal Erosion and Wetland Modification in Louisiana: Causes, Consequences, and Options, edited by D.F. Boesch (1982). The proceedings provided a compendium of information on the natural and man-induced causes of land loss, their impacts on natural resources production and man's use of the area, and possible means of reducing land loss.

- Bayou Chevreuil and Grand Bayou, Louisiana, Continuing Authorities Program Section 205 Preliminary Evaluation was conducted by USACE in March 1993. During this evaluation, nonstructural means of flood protection for structures within the Bayou Chevreuil and Grand Bayou drainage basins were analyzed. Nonstructural flood control measures include temporary closures to impacted structures, ring levees, structure raising, and structure relocation. The preliminary evaluation recommended additional Federal studies on nonstructural flood control measures in the study area.

- The USACE completed the Southeast Louisiana Hurricane Preparedness Study in 1994. The study developed information for state and local officials in developing hurricane evacuation plans for a nine-parish area in southeast Louisiana, including all of the parishes in Hurricane Protection, Louisiana study area, except Terrebone Parish. The information includes estimates of hurricane stages for various categories and forward speeds of hurricanes, of the population and critical facilities vulnerable under each hurricane scenario, of shelter

requirements, and of evacuation times. Information in the report is based on existing conditions (1994) and conditions that would be expected in the immediate future.

EXISTING PROJECTS

- The Lake Pontchartrain, Louisiana, and Vicinity Hurricane Protection project was authorized by the Flood Control Act of 1965. The project provides for the construction of levees, floodwalls, and other structural features to help prevent damage caused by storm surges. Construction of the project is underway and will be completed by 2013. The project provides protection for St. Charles, Jefferson, Orleans, and St. Bernard Parishes against the Standard Project Hurricane.

- The New Orleans to Venice, Louisiana, Hurricane Protection Project, was authorized by the Flood Control Act of 23 October 1962, House Document 550, 87th Congress, 2nd Session, and authorized improvement of existing back levee systems by increasing their height and construction of new levees for the prevention of hurricane flood damage. The project provides 100-year frequency protection from hurricane tidal overflow by increasing the heights of existing back levees and modifying the existing drainage facilities where necessary. This project is approximately 80 percent physically complete and is scheduled for completion in 2017.

- The West Bank and Vicinity, New Orleans, Louisiana, Hurricane Protection Project is located on the west bank of the Mississippi River in the vicinity of New Orleans and in Jefferson, Orleans and Plaquemines parishes. The project initially consisted of three parts: Westwego to Harvey Canal - authorized by the Water Resources Development Act (WRDA) of 1986 (PL 990-662), Lake Cataouatche, and East of Harvey Canal - both authorized by WRDA 96 (PL 104-303). WRDA 99 combined all three parts into a single project under the current name. The project will provide Standard Project Hurricane Protection to residents from storm surges from Lakes Cataouatche and Salvador, and waterways leading to the Gulf of Mexico. This project is approximately 22% physically complete and is scheduled for completion in 2014.

- The Grand Isle and Vicinity (Larose to Vicinity of Golden Meadow) General Design Memorandum was published by USACE in May 1972. The Larose to Golden Meadow Hurricane Protection Project was authorized by Public Law 298, 89th Congress, 1st Session, approved 27 October 1965. This project is authorized to provide 100-year frequency protection against floodwaters by a hurricane utilizing a loop levee approximately 43 miles in length along both banks of Bayou Lafourche from Golden Meadow to Larose. This project is approximately 90 percent physically complete and is scheduled for completion in 2008.

- The Grand Isle and Vicinity, Louisiana, Hurricane Protection project was authorized by Section 204 of the Flood Control Act of 1965. The project provides for the construction of

beach and sand dunes to protect against hurricane driven waves from 50-year frequency storms. The authorized work is complete.

5. PLAN FORMULATION

A. PROBLEM IDENTIFICATION

The Federal objective of water resources project planning is to contribute to national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to the NED are increases in the net value of national output of goods and services, expressed in monetary units.

Although there are five existing hurricane protection projects in the study area, these projects were not designed to protect against Category 4 or 5 storms. In 1998, Hurricane Georges caused great concern in the Southeast Louisiana area and forced the evacuation of hundreds of thousands of people. Although this storm did not strike the study area directly, its close passage made many aware of the potential disastrous impact of a high strength storm. These concerns are increased because of the changes occurring in the coastal parishes of Southeastern Louisiana. These changes include, continued subsidence related to geologic conditions, sea level rise, and the continued loss of coastal wetlands and barrier islands. Based on these factors, efforts were begun to authorize studies to investigate the current level of protection provided by the existing projects and to determine if improvements can be made that would provide protection against Category 4 or 5 hurricanes.

(1) EXISTING CONDITIONS

a. Topography. The topography of the study area is primarily a deltaic plain. The study area is very low in elevation, comprised primarily of sea-level marsh, swamp, and open water, with relief provided by the alluvial ridges of the present and abandoned courses and distributaries of the Mississippi River. The elevation of topographic features within the study area vary from as low as –10 feet NGVD in developed areas which have been leveed off and drained by pumps, to about +25 feet NGVD along the ridges of the Mississippi River. An extensive system of Federal and local levees have been constructed in southern Louisiana to protect against hurricane surge and flooding from the Mississippi River. St. Tammany Parish, located on the north shore of Lake Pontchartrain, has ground elevations of up to +200 feet NGVD.

b. Population. The population of the study area is approximately 1.4 million people. Of that number, over 1 million people currently live within areas protected by existing hurricane protection projects. Because none of these existing hurricane protection projects provide protection against a category 4 or 5 storm, mass evacuations are required when hurricanes threaten the area.

c. Evacuation. The Southeast Louisiana Hurricane Preparedness Report completed by the Corps is 1994 studied evacuation issues in the study area. Under the best of circumstances, emergency managers estimate that 80 to 90 percent of the residents in the vulnerable areas will evacuate prior to the arrival of a storm. This could leave approximately 200,000 people at risk during a storm event. There is great potential for catastrophic loss of life due to a major hurricane storm surge.

d. Climate. The climate of the study area is subtropical. Proximity to the Gulf of Mexico provides a source of abundant moisture and rainfall. The annual mean normal temperature is 69.1°F, with monthly mean temperature normal varying from 82.3°F in July to 52.9°F in January. The annual normal rainfall is about 62 inches. Prevailing wind direction is southerly during much of the year. Tropical storms and hurricanes in the summer produce the highest winds in the area. At Louis Armstrong International Airport the maximum wind speed observed (highest one minute speed) since 1963 was 69 mph, caused by Hurricane Betsy in September 1965. Peak wind speeds can occur from any direction.

e. Tides. Tides along the open coast are diurnal have a mean range or approximately 1 foot under normal conditions. In Lake Pontchartrain the normal tidal range is 0.6 feet. Stream gaging data are available at many stations in the study area. For Lake Pontchartrain the gages at West End, Frenier, Mandeville and Rigolets have the longest period of record.

f. Floods and Storms of Record. Many storms have affected the study area over the last 100 years. Several of the most intense hurricanes that affected the Lake Pontchartrain basin are described briefly in the following paragraphs.

The hurricane of 29 September 1915 had a central pressure of 27.87 inches, an average forward speed of 10 knots, a 94 miles per hour (mph) 5-minute sustained wind velocity, and a extreme wind velocity of 106 mph, based on National Weather Service records. This hurricane approached the study area from the south. Storm tides rose to 10-12 feet along the Mississippi-Louisiana coast. High water marks indicate that the stage at West End rose to 6.1 feet NGVD (National Geodetic Vertical Datum of 1929) and at Frenier to 13 feet NGVD.

The hurricane of 19 September 1947 had a central pressure of 28.57 inches and an average forward speed of 16 knots. The National Weather Service Station at Armstrong International Airport reported a special wind observation of 98 mph from the northeast and gusts to 112 mph. This station estimated the wind velocity to be 110 mph with gusts to 125 mph from the north just before the calm center. The direction of approach of this hurricane was approximately from the southeast. Stages at West End were recorded at 5.5 feet NGVD and on the north shore at Mandeville at 7.0 feet NGVD. Shell Beach experienced a high water elevation of 11.2 feet NGVD.

Hurricane Flossy was a fast moving storm, which passed through the study area on 24 September 1956. Hurricane Flossy had a central pressure of 28.76 inches and an average forward speed of 10 knots. The highest wind velocity was estimated at 90 mph was recorded

near the mouth of the Mississippi River. Flossy approached the mainland from the southwest. A stage of 5.3 feet NGVD was recorded at West End. Other high-water marks reported were: 10.5 feet NGVD at Shell Beach; and 8.4 feet NGVD at the Paris Road Bridge on the GIWW.

On September 9, 1965 Hurricane Betsy, the most destructive storm of record in Louisiana struck the study area from the southeast. Betsy, had a central pressure of 27.79 inches and an average forward speed of about 17 knots. Betsy's maximum-recorded wind speed was 105 mph with gusts estimated to be in excess of 160 mph. On Mississippi River at New Orleans, River Mile 103, the stage rose from a normal of about 4 feet to a crest stage of 12.40 feet, NGVD, on 9 September. At St. Francisville, mile 266 on the Mississippi River, the water rose as much as 8 feet above normal. In Lake Pontchartrain stages reported were: 5.5 feet at West End, 6.5 feet at Mandeville and 12.1 feet at Frenier, all in NGVD. Upstream of this point in the River the surge dropped off rapidly. A stage of 9.3 feet NGVD was recorded at Shell Beach and a high-water mark of 11.6 feet NGVD was established at the junction of the Inner Harbor Navigation Canal and the Mississippi River Gulf Outlet. A stage of 9.2 feet NGVD was recorded at the Paris Road Bridge across the GIWW. In Rigolets and Chef Menteur Passes stages of 9 feet NGVD were measured.

Hurricane Camille, one of the most intense and destructive storms ever, struck the Mississippi Gulf Coast, but severely affected the lower Louisiana delta region. Camille had a central pressure of 26.61 inches and an average forward speed of about 13 knots. This storm made landfall just east of the Louisiana state line on August 18, 1969; a Saffir-Simpson category 5 storm, Camille's maximum winds were estimated at 160 mph with gusts up to 200 mph. Peak stages include 11.1 feet, NGVD, at Shell Beach on 17 August and 10.0 feet, NGVD, at IWW at Paris Road Bridge in the MRGO on 18 August. In Lake Pontchartrain at West End a peak stage of 5.2 feet NGVD was recorded.

Hurricane Juan in October 1985 set several peak stage records due to it's prolonged stay along the Louisiana coast. A minimal category 1 hurricane, Juan moved slowly and erratically along the Louisiana coast for several days. Juan's maximum sustained wind was 86 mph. Record stages set by this storm include: 8.0 feet, NGVD, at Bayou Bienvenue at Floodgate (East) on 28 October; 3.5 feet, NGVD, at Bayou Dupre at Floodgate (west) on 30 October; and 6.9 feet, NGVD on Bayou Terre Aux Boeufs at Delacroix on 28 October. In Lake Pontchartrain the maximum high stages of record were measured at West End, 6.1 feet NGVD, and at Mandeville, 7.6 feet NGVD.

In September 1998, Hurricane Georges skirted the eastern marsh zones of Plaquemines and St. Bernard Parishes before making landfall in Mississippi with maximum sustained winds of 105 mph. At landfall Hurricane Georges had a minimal central pressure of 28.5 inches and a forward speed of approximately 7 mph. Maximum stages for this storm were 9.1 feet, NGVD, on the IWW near Paris Road Bridge, 6.6 feet, NGVD, on the Mississippi River Gulf Outlet at Shell Beach, and 4.6 feet, NGVD, on Bayou Terre Aux Bouefs at Delacroix, all on 27 September. In Lake Pontchartrain at West End the peak recorded stage was 5.5 feet NGVD.

g. Standard Project Hurricane. The Standard Project Hurricane (SPH) is the current storm used in the design of the existing hurricane protection project in the Lake Pontchartrain basin. Many COE design documents for hurricane protection projects along coastal Louisiana describe the derivation of the SPH. The SPH was derived by the National Weather Service from a study of hurricane occurrences over the region of the Gulf of Mexico known as Zone B. The National Weather Service provided isovel patterns, hurricane tracks, pressure profiles, rainfall estimates, frequency data, and various other parameters required for development of the SPH. For Lake Pontchartrain observed storms, which occurred in September of 1915, 1947, 1956, and 1965, with known parameters and effects, were used to establish and verify procedures and relationships for determining hurricane surge heights in the area. The SPH has a frequency of once in 100 years in Zone B, a 400-mile reach in the Gulf of Mexico. The central pressure that corresponds to this frequency is 27.5 inches of mercury; the radius of maximum winds is 30 nautical miles. An average forward speed of from 5 to 11 knots was used for hurricanes critical to the Lake Pontchartrain and Vicinity project area. In Lake Pontchartrain the Zone B frequency was reduced to 20 percent of the frequency along the open coast to reflect the reduced vulnerability of the area to storms, which make landfall outside of a 40-mile radius of the coast near the project area. On the south shore of Lake Pontchartrain the SPH stage is 11.5 feet NGVD; its associated return frequency is once in 300 years.

h. Subsidence and Sea Level Rise. One of the primary causes for the apparent increase in water levels along the coastline is apparent subsidence. Apparent subsidence is defined as the lowering of the land relative to mean sea level. An alternative term is relative sea level rise. The potential exists for confusion when discussing subsidence because geologists use the term subsidence for a particular process. Apparent subsidence involves the relationship between water level and land and includes factors considered to be geologic subsidence as well as hydraulic factors such as the rise in sea level.

Apparent subsidence deals with the relationship between water level and land. It is the difference between water level and land that defines damages in an economic analysis; the incremental change of this difference between the with- and without-project conditions determines the economic feasibility of the project. Capturing the apparent subsidence in the hydraulic and economic analysis results in a more realistic appraisal of the flood problems expected over the life of the project.

Apparent sea level rise was not considered in the feasibility studies that resulted in the authorization of some of the existing hurricane protection projects. In future studies, apparent sea level rise must be considered in the planning, design, and construction of any hurricane protective structure.

(2) EXPECTED FUTURE CONDITIONS

While the Lake Pontchartrain and Vicinity, LA and West Bank and Vicinity, LA projects provide protection for the Standard Project Hurricane, this level of protection cannot protect against slow moving category 3 or higher strength storms. The remaining hurricane protection projects provide much lower levels of protection. In addition, the project area is experiencing

high levels of coastal wetlands losses which is likely increasing the threat from hurricanes. Although coastal restoration projects have been constructed, these have not significantly reversed the current rate of losses. Additional projects have been proposed and are under study to address the coastal land loss problem, but these projects have not moved beyond the study stage at this time. Other conditions that could impact hurricane protection issues are sea level rise and apparent subsidence issues.

(3) PLANNING OBJECTIVES AND CONSTRAINTS

The objective of this study is to determine whether detailed studies are warranted to investigate increased levels of protection against hurricanes in the study area.

(4) PROBLEMS AND OPPORTUNITIES

The near miss of Hurricane George in September 1998 heightened local concerns about the level of hurricane protection in the study area. State and local emergency operations managers have stated that evacuation of all of the approximately 1.4 million people in the project area is not possible in the short amount of time prior to landfall of a major hurricane. It is likely that 250,000 to 300,000 people will be unable to evacuate prior to the storm. Because much of the urban area is below sea level, those individuals not evacuating are at great risk since the American Red Cross and other agencies do not operate shelters in any parishes south of Lake Pontchartrain. This is due to the fact that there are, at present, no structures in the metropolitan area that are certified as a shelter that could withstand a storm surge generated by a category 4 or 5 hurricane. Therefore, emergency planners believe that great loss of life will occur should a major storm strike the area.

In addition, overtopping of the existing protection areas will flood vast areas of the metropolitan area. Analysis of this possibility has projected that unwatering the flooded areas would take many months. With large areas of the metropolitan area flooded for long periods of time, extremely high damages to infrastructure, businesses, and homes can be expected. In addition, severe impacts to the Port of New Orleans, New Orleans International Airport, the major facilities owned by the U. S. Navy, and the NASA facility at Michoud can be expected.

B. ALTERNATIVE PLANS

Alternatives to be studied have been divided into plans for protection east of the Mississippi River and plans for protection west of the Mississippi River. These are two distinct basins and protection alternatives on one side of the river will not benefit the opposite side of the river. Therefore it is possible that two recommended plans could be developed in the feasibility report. In addition, because the scope of the study is extremely large, consideration will be given to the preparation of separate feasibility studies. That decision will be made after completion of the first phase of the feasibility study as described in Section 8. Detailed Design Reports (DDRs) would be required after authorization for major structures. Maps of each alternative are provided at the end of this report (Plates 2 – 12). The following is a listing of proposed alternatives:

EAST OF THE MISSISSIPPI RIVER

Alternative E-1. This alternative would raise all existing Lake Pontchartain and Vicinity levees, floodwalls and structures to provide Category 4 or 5 protection. It would include construction of structures where the outfall canals enter Lake Pontchartrain instead of parallel protection work.

Alternative E-2. This alternative would raise all existing Lake Pontchartain and Vicinity levees, floodwalls and structures to provide Category 4 or 5 protection except for the levees and floodwalls along the IHNC and the GIWW. At the confluence of the GIWW and the MRGO, a navigation structure would be constructed that could be closed when a hurricane approaches. Another structure at Seabrook would also be closed to effectively seal off the IHNC area from the storm surge. This alternative would be identical to Alternative E-1 in all other respects including the construction of structures where the outfall canals enter Lake Pontchartrain instead of parallel protection work.

Alternative E-3. This alternative would be similar to Alternative E-2 in that the existing Lake Pontchartrain & Vicinity levee between the MRL in St. Bernard Parish and the New Orleans East Back Levee would be raised to accommodate a higher level of protection. This would include a structure at the GIWW/MRGO confluence. The remaining levees in Orleans. Jefferson and St. Charles Parishes would be excluded from this alternative. Instead, protection would be provided by a series of levees and structures at the Chef and Rigolets Passes, which would eventually tie-in to high ground in St. Tammany Parish. The new structures would have to be designed to provide for navigation and the passage of normal flows into and out of Lake Pontchartrain. In addition, the structures may have to provide flow out of the lake during a hurricane event to prevent induced damages on the north shore of Lake Pontchartain.

Alternative E-4. This alternative will consider increasing the level of protection for the east bank of the New Orleans to Venice Hurricane Protection project. The current project is authorized to provide 100-year frequency protection. Alternative E-4 will determine if raising the elevation of the existing levees on the east bank is economically justified. A two-stage process would be used to determine if the alternative is viable. In the first stage, elevations would be established for a 200-year frequency storm. Then, recon level analysis of costs and benefits would help us determine if we should proceed to the second stage and if higher levels of protection could be feasible. The second stage would be a normal feasibility analysis using field data and updated economics.

Alternative E-5. This alternative will consider the coastal restoration projects under study by the Louisiana Coastal Area (LCA) project. There are projects proposed that may affect hurricane protection plans in the Lake Pontchartrain Basin and in Plaquemines Parish. We would determine during the term of the feasibility study if these coastal restoration projects will provide storm surge reduction benefits. Since the design costs will be borne by the LCA project, the effort undertaken by the Hurricane Protection, LA Feasibility Study would be limited to determining the impacts of the LCA projects on our study alternatives. If a LCA project

produces surge reductions then we would make a decision as to the impact on our study alternatives. For now, we'll show estimates of costs for H&H Branch to analyze the impact of the LCA projects.

Alternative E-6. This alternative will consider the proposal by LSU to construct an area of refuge within the existing hurricane protection systems in the metropolitan New Orleans area. The area of refuge would be protected from the storm surge caused by a category 5 hurricane. It would be an area where residents who were unable to evacuate could go to avoid impacts caused by the storm surge.

WEST OF THE MISSISSIPPI RIVER

Alternative W-1. This alternative will consider raising all of the authorized West Bank Hurricane Protection levees and structures to provide Category 4 or 5 protection levels.

Alternative W-2. This alternative will consider raising all of the authorized West Bank Hurricane Protection levees and structures to provide Category 4 or 5 protection levels except that a new navigation structure would be constructed on the GIWW (see map). This structure would eliminate the need for raising the levee elevations along the Harvey and Algiers Canals and avoid modifications to the Harvey Canal navigation structure.

Alternative W-3. This alternative will consider increasing the level of protection for the west bank of the New Orleans to Venice Hurricane Protection project (see map). The current project is authorized to provide 100-year frequency protection. Alternative W-3 will determine if raising the elevation of the existing levees on the west bank is economically justified. A two-stage process would be used to determine if the alternative is viable. In the first stage, elevations would be established for a 200-year frequency storm. Then, recon level analysis of costs and benefits would help us determine if we should proceed to the second stage and if higher levels of protection could be feasible. The second stage would be a normal feasibility analysis using field data and updated economics.

Alternative W-4. This alternative will consider increasing the level of protection for the Larose to Golden Meadow Hurricane Protection project. The current project is authorized to provide 100-year frequency protection. Alternative W-4 will determine if raising the elevation of the existing levees is economically justified. A two-stage process would be used to determine if the alternative is viable. In the first stage, elevations would be established for a 200-year frequency storm. Then, recon level analysis of costs and benefits would help us determine if we should proceed to the second stage and if higher levels of protection could be feasible. The second stage would be a normal feasibility analysis using field data and updated economics.

Alternative W-5. This alternative will consider the coastal restoration projects under study by the Louisiana Coastal Area project. There are projects proposed that may impact hurricane protection plans in the Barataria and Terrebonne Basins. We would determine during the term of the feasibility study if these coastal restoration projects will provide storm surge reduction benefits. Since the design costs will be borne by the LCA project, the effort undertaken by the

Hurricane Protection, LA Feasibility Study would be limited to determining the impacts of the LCA projects on our study alternatives. If a LCA project produces surge reductions then we would make a decision as to the impact on our study alternatives. For now, we'll show estimates of costs for H&H Branch to analyze the impact of the LCA projects.

Due to limited resources, efforts in the reconnaissance report were concentrated on one structural plan. This plan provided for an increase in protection for the East Jefferson Basin for a Category 4 storm. The preliminary evaluation of this alternative is contained in Section C.

C. PRELIMINARY EVALUATION OF ALTERNATIVE

(1) EVALUATED IMPROVEMENTS

The New Orleans area, because of its location below sea level and proximity to Lake Pontchartrain, has the potential for catastrophic flooding from a Category 4 or 5 hurricane. Limited resources constrained the scope of the study to analysis of only one basin. Because flooding would result in catastrophic loss of life and property, the East Jefferson Basin was selected for analysis in this study.

The plan considered for this report provides for the increase in elevation of the existing levees and structures protecting the East Jefferson Basin in Jefferson Parish to provide for protection against a Category 4 storm. The higher design elevations were developed as described in section C (2), Design Storm. The features of the plan are shown on Plate 13.

(2) DESIGN STORM

a. Surges

Wind setup can be defined as a rise above normal water level due to the action of wind stress on the water surface. Hurricane storm surge at the open coast includes wind setup, wave setup, a rise in water level due to atmospheric pressure reduction, and thermal expansion of the sea during late summer and early fall. In Lake Pontchartrain wind stress across the enclosed body of water can further raise water levels entering the Lake from the Gulf by creating wave setup on the leeward side of the lake.

The current hurricane protection design is based on the Standard Project Hurricane, a hypothetical hurricane, which is reasonably characteristic of hurricanes that have occurred in the region. Surges from SPH storm were extrapolated from storms that occurred in the area using the relationship between the historic and the hypothetical storm characteristics.

This study uses hypothetical stages developed using the Weather Service's Sea, Lakes, and Overland Surge from Hurricanes (SLOSH) model results. Using the range of central pressures from the Saffir-Simpson scale for hurricanes on different tracks moving at different forward speeds, the SLOSH model predicts storm surge elevations in Lake Pontchartrain. Storm surge elevations vary depending upon the storm track, forward speed, and central pressure. The

SLOSH model uses several straight tracks of approach from westerly through northerly to northeasterly. The forward speeds are: 5 mph (slow); 10 mph (moderate); 15 mph (fast). The SLOSH model uses the 5 Saffir-Simpson Hurricane Categories. See Table 1 for a description of the Saffir-Simpson categories. The SLOSH model results for Category 4 hurricanes affecting the south shore of Lake Pontchartrain show stages that vary from 7.5 to 17.2 feet NGVD. However, since only one stage can be used for design and in the future, more detailed studies will determine the stage and frequency more accurately, an average of these stages, 12.4 feet NGVD, was used for this study.

TABLE 1
SAFFIR-SIMPSON HURRICANE SCALE

SCALE NUMBER	CENTRAL PRESSURE	WINDS MPH
1	28.94	74 – 95
2	28.50 – 28.91	95 – 110
3	27.91 – 28.47	111 – 130
4	27.17 – 27.88	131 – 155
5	<27.17	>155

b. Wave runup

Wave runup accompanies the storm surge. Runup on a protective structure depends on the characteristics of the structure (i.e., shape and surface roughness), the wave characteristics associated with the storm, and the depth of water at the structure. The vertical height to which water from a breaking wave will run up on a given protective structure determines the top elevation to which the structure must be built to prevent wave overtopping. Wave runup on the protective structures was computed using the ACES (Automated Coastal Engineering Systems) computer program. Protective structures exposed to wave runup will be constructed to an elevation that is sufficient to prevent all overflow from the significant-wave and all lesser waves accompanying the design hurricane. Waves larger than the significant wave may overtop the protective structures; but these waves are infrequent and such overtopping will not endanger the security of the structures or cause significant interior flooding. Runup was computed for the significant wave and the required levee height was determined by adding the highest computed runup value to the design stillwater elevation.

c. Frequency estimates

Hurricane stage data gathered along the Louisiana coast over the past 100 years indicate that all localities along the coast are about equally prone to hurricane attack. Using observed stages, frequency relationships were developed for several points along the coast, including in and around Lake Pontchartrain.

The Weather Service has made a generalized study of hurricane frequencies for a 400-

mile zone along the central gulf coast, Zone B, from Cameron, La., to Pensacola, Fla. Frequencies for hurricane central pressure indexes reflect the probability of hurricane recurrence from any direction in the midgulf coastal area. In order to establish frequencies for the localities under study, it was assumed that a hurricane whose track is perpendicular to the coast will ordinarily cause high tides and inundation for a distance of about 50 miles along the coast. Thus, the number of occurrences in the 50-mile sub zone would be 12.5 percent of the number of occurrences in the 400-mile zone, provided that all hurricanes traveled in a direction normal to the coast. However, the usual hurricane track is oblique to the shoreline. The average projection along the coast of this 50-mile swath for the azimuths of 48 Zone B hurricanes is 80 miles. Since this is 1.6 times the width of the normal 50-mile strip affected by a hurricane, the probability of occurrence of any hurricane in the 50-mile sub zone would be 1.6 times the 12.5 percent, or 20 percent of the probability for the entire midgulf Zone B. Thus, 20 percent of the Zone B frequencies were used to represent the central pressure frequencies in the 50-mile sub zone that is critical for Lake Pontchartrain. This analysis was used to develop frequencies of occurrence for the SPH.

The observed frequencies of occurrence of central pressures in Zone B were used to determine the frequency of the category 4 storm stages determined by the SLOSH model. A category 4 storm, which has a central pressure of between 27.2 and 27.9 inches of mercury, has an associated frequency in Zone B of 250-year and 25-year, respectively. These frequencies in turn can be associated with the stages of 17.2 and 7.5 feet determined by the SLOSH model. These Zone B frequencies can be reduced to 20 percent of the number of occurrences based on the previous frequency analysis developed for the SPH. Thus, the frequencies for the stages become 1250-year and 125-year, respectively. Since an average stage of 12.4 feet was to be used for design, a graphical interpolation between the two stages and their associated frequency was used to determine the design frequency. This results in a return frequency of approximately 400-year for a category 4 storm producing a 12.4-foot stage in Lake Pontchartrain. These results agree favorably with the existing SPH frequency and stage; the SPH has a return frequency of about 300-years with an associated stage of 11.5 feet NGVD in Lake Pontchartrain.

Based on procedures described above, stage-frequency relationships were established for Lake Pontchartrain at East Jefferson Lakefront. The stage-frequency relationship is illustrated on Plate A-1.

d. Design hurricane

A category 4 hurricane was selected as the design hurricane for the reconnaissance study. The design hurricane for the project area has a central pressure of 27.5 inches and a maximum windspeed of 143 mph at a radius of 30 nautical miles. The forward speed of the hurricane is 10 mph, a moderate speed of approach.

The hurricane surge height is the maximum stillwater surface elevation experienced at a

given location during the passage of a hurricane. The design hurricane surge height for the project area is 12.4 feet NGVD. Design stages, wave runup and the height of protective structures to provide Category 4 hurricane protection for East Jefferson are given in Table 2.

TABLE 2
CATEGORY 4 DESIGN HURRICANE
EAST JEFFERSON HURRICANE PROTECTION
DESIGN WAVE RUNUP AND DESIGN ELEVATIONS FOR PROTECTIVE STRUCTURES

Reach	Existing Structure Elevation feet NGVD	Design Water Elevation feet NGVD	Wave Runup feet	Structure Design Elev. feet NGVD
17th Street Canal	16.0 – 16.0	12.5-15	4.5 - 2.0	17.0* – 17.0
Lakefront	16.0	12.5	4.5	17.0
Pump Stations 1&4	22.5	12.5	11.0	23.5
Breakwater at Pump Station 2	14.5	12.5	na	16.5
Breakwater at Pump Station 3	7.5	12.5	na	9.5
Jeff/St. Charles Return Levee	13.0 – 16.0	11.0 - 12.5	3.0 – 4.5	14.0 – 17.0*

*Ties into Lakefront Levee
na – Breakwaters reduce wave heights on their protected side, they do not prevent wave overtopping.

(3) STRUCTURAL DESIGN

The existing hurricane protection levee system consists of several structural features that have been constructed as part of the Lake Pontchartrain and Vicinity, LA Hurricane Protection project. The reconnaissance level analysis assumed that these structures could be upgraded to provide the higher level of protection. In addition, a new structure was envisioned at the mouth of the 17th Street Outfall Canal. This structure would be butterfly gated so that, when stages in the lake permit, flows in the 17th Street Canal could exit into Lake Pontchartrain. This would permit continued use of drainage pumps located at the head of the 17th Street Canal. The new 17th Street Canal structure would be constructed instead of raising the existing protection levees

and floodwalls paralleling the 17th Street Canal. The structure would also eliminate the need to upgrade the Hammond Highway Bridge, the Veterans Memorial Bridge, the I-10 bridge, I-610 bridge and the fronting protection for Pumping Station #6. The structural features reviewed as part of this report are described as follows:

Reach 1: Jefferson Parish-St. Charles Parish Return Levee and Floodwall
Reach 2: Swing Gate, Duncan Canal Pumping Station No. 4 and Williams Blvd. Roller Gate
Reach 3: Elmwood Pumping Station No. 3 and Breakwater
Reach 4: Suburban Canal Pumping Station No. 2 and Breakwater
Reach 5: Causeway Blvd Floodwall and Bonnabel Pumping Station No. 1
Reach 6: 17th St. Canal Butterfly Gate

(4) LEVEES

The existing levee was constructed to the grades and sections outlined in the Lake Pontchartrain, Louisiana and Vicinity, High Level Plan, Design Memorandum No. 17, General Design, Jefferson Parish Lakefront Levee, Volumes I and II. The proposed levee construction shall be accomplished by straddle enlarging the existing levee by utilizing truck hauled embankment material from Bonnet Carre' Spillway. The new levee will be constructed in three lifts with a minimum interval of five years between lifts. The new levee centerline is contiguous with the centerline of the existing levee. The net design grade is generally elevation 17.0 NGVD with a seven foot crown width.

(5) REAL ESTATE

The proposed work described in the Reconnaissance Report will not require the acquisition of new right-of-way. All work that is proposed will occur within the existing levee right-of-way for the Lake Pontchartrain and Vicinity, LA project, except for the new butterfly gated structure at the 17th Street Canal. Since that structure will be constructed on state water bottoms, no additional right-of-way is required.

(6) ENVIRONMENTAL RESOURCES AND IMPACTS

The proposed reconnaissance level alternative will be constructed within the footprint of the existing levee protection project with the exception of the proposed 17th Street Canal Structure. Poor water quality exists in the canal since it is a primary drainage canal for the City of New Orleans and the east bank of Jefferson Parish. There are unlikely to be major environmental impacts at this location. More detail analysis will be needed in the feasibility study.

(7) COST AND ECONOMIC ANALYSIS

First Cost. Table 3 shows the first cost associated with construction of improvements to provide category 4 protection to the east bank of Jefferson Parish.

Table 3

HURRICANE PROTECTION, LOUISIANA RECONNAISSANCE STUDY EAST JEFFERSON PARISH HURRICANE PROTECTION CONSTRUCTION COST ESTIMATE	
CONSTRUCTION	
LEVEES	$8,300,000
STRUCTURES	22,600,000
ENGINEERING & DESIGN	3,700,000
CONSTRUCTION MANAGEMENT	3,100,000
TOTAL PROJECT CONSTRUCTION COST	$37,700,000

Economic Evaluation. This economic evaluation addresses increased hurricane protection for Category 4 hurricanes in the vicinity of Lake Pontchartrain, South Shore, Jefferson Parish, Louisiana. It was prepared in accordance with Engineering Regulation (ER) 1105-2-100, Planning Guidance. The National Economic Development Procedures Manual for Urban Flood Damage, prepared by the Water Resources Support Center, Institute for Water Resources, was used as a reference.

The evaluation consists of a brief description of the methodology used to determine economic damages and benefits, project costs, and benefit-to-cost analysis. The evaluation uses April 2002 price levels. The proposed improvement was evaluated by comparing estimated average annual benefits that would accrue to the study area with estimated average annual project costs.

The basic economic evaluation included the comparison of the urban flood damage setting for "without-project" and "with-project" conditions. Without-project conditions, or existing conditions, reflect conditions expected to prevail in the absence of any alternative plan of improvement. With-project conditions reflect conditions in the project area with a proposed increased level of hurricane protection in place.

Most of the benefits that accrue from a project are usually the result of reducing physical flood damages. Physical inundation reduction damages include structural damages to buildings and losses to contents; damages to roads, bridges, and other public utilities; and damages to privately owned automobiles. Since this is a reconnaissance level report, only inundation reduction benefits on existing development were considered for project justification. Some other

benefits categories that may be considered in the feasibility phase of the project are emergency cost reduction benefits and Flood Insurance Administration (FIA) cost benefits. Projections of increased future economic activity were not made at this stage of the study.

Residential and nonresidential structure values were determined by using an inventory of all structures on the east bank of Jefferson Parish, which was completed December 2000, for the East Bank of Jefferson Feasibility Study. The HEC-FDA Flood Damage Reduction Analysis Program was used to generate an elevation-damage relationship for the existing without- and with-project conditions. Inputs to the program included the floodplain structure inventory, salt-water, long duration (approximately one week) depth-damage relationships developed for the Jefferson-Orleans Feasibility Studies, and stage probabilities obtained from stage-frequency curves for each hydrologic reach.

Project costs were developed to include raising levees to meet requirements for a Category 4 hurricane level of protection. Total project construction first costs and O&M were the only costs considered for this analysis. Mitigation, real estate, and relocation costs were not considered due to the fact that all work described will be done within the current right-of-way. The schedule of yearly expenditures is annualized based on a base year of 2009.

The economic justification of the proposed improvement was determined by comparing the expected annual costs to the expected annual benefits that will accrue over the life of the project (50 years). These values were converted to an equivalent time frame by using the Federal discount rate of 6-1/8 percent. The base year for this conversion is the year in which the project becomes operational (2009). The costs and benefits were then expressed as the present worth of all expenditures and plan outputs. Finally, the net benefits were calculated by subtracting the expected annual costs from the expected annual benefits (see Table 4).

Table 4
Benefit-Cost Summary

Average Annual Benefits	$ 15,200,000
Total First Costs	38,000,000
Average Annual Costs	2,500,000
Benefit-Cost Ratio	6.0
Net Benefits	$ 12,700,000

6. FEDERAL INTEREST

Based on the preliminary analysis in this reconnaissance report, a Federal interest exists to justify proceeding with feasibility phase investigations. Hurricane protection is a high priority project purpose with the Administration. The plan is justified with an average annual cost of $2,500,000 and average annual benefits of $15,200,000. The net benefits are $12,700,000 with a benefit-cost ratio of 6:1.

7. PRELIMINARY FINANCIAL ANALYSIS

The State of Louisiana Department of Transportation and Development would take the lead in sponsoring a comprehensive area wide study. In a letter dated 19 June 2002, the sponsor stated the intent to participate as the non-federal sponsor for the feasibility study.

8. SUMMARY OF FEASIBILITY STUDY ASSUMPTIONS

The feasibility study will analyze alternatives in two distinct areas. The Mississippi River divides the study area and hurricane protection projects on each side of the river perform independently of each other. Therefore it is possible that two separate plans will be recommended on each side of the river. Given that possibility and the very large study area, separate feasibility studies may be prepared. In order to determine the need for separate studies, we propose to conduct a two-phase feasibility analysis.

The first phase analysis would consist of establishing new protection elevations for each alternative, updating economic data in the study area, preliminary analysis of environmental issues, and preliminary cost estimates. Using this data, we would perform a benefit – cost analysis and determine which alternatives are most likely to be implemented. Depending on the results of this analysis, we could recommend that separate feasibility studies be performed.

The second phase analysis would include detailed analysis of the surviving alternatives. An EIS for the selected plan and detailed cost and economic data would be prepared. Because of the complexity of some of the alternatives, major structures would require the preparation of detailed design reports after completion of the feasibility phase. In addition, some of the storm surge elevations will be impacted by coastal restoration actions proposed by the Louisiana Coastal Area (LCA) study. We are assuming that the LCA study will have progressed sufficiently prior to the initiation of the second phase of this feasibility study so that we will be able to incorporate the LCA proposals in our plan formulation efforts.

9. FEASIBILITY PHASE MILESTONES

A schedule of major study milestones is given in Table 5.

Table 5
Feasibility Phase Milestones

Notice of Intent/Notice of Initiation of Feasibility Study	August 2002
Preliminary Draft PMP	October 2002
Supervisory and QC Review of PMP	November 2002
Review of Preliminary draft PMP by Sponsor	January 2003
Local Government/Agency Coordination meeting	February 2003
Preparation of Final PMP	June 2003
Final PMP Review comments by Sponsor	August 2003
Resolution of Comments	September 2003
FCSA signed	October 2003
Phase 1 analysis completed for all alternatives	October 2005
Plan selection for Phase 2 analysis/update PMP	November 2005
Complete Feasibility Report(s) for selected alternatives	October 2007
Review, comment, and revision of Draft Feasibility Report and Draft EIS	January 2008
Transmit Draft Feasibility report and draft EIS to MVD	March 2009
Transmit Final Report to MVD	June 2009
Division Engineer's Notice	August 2009

10. FEASIBILITY PHASE COST ESTIMATE

A breakdown of the estimated cost of the feasibility cost is shown in Table 6. Because the PMP has not been fully developed and coordinated with the local sponsor, a preliminary estimate of costs is shown. Final feasibility costs will be dependent on the plans selected for study in Phase 2.

Table 6
Preliminary Feasibility Cost Estimate

Major Work Items	Estimated Cost ($)
Public Involvement	200,000
Environmental Studies	2,000,000
Economic Studies	2,000,000
Project Management	450,000
Engineering	3,000,000
Real Estate Studies	1,150,000
Model Studies	500,000
Review Cost	200,000
Total Study Cost	9,400,000

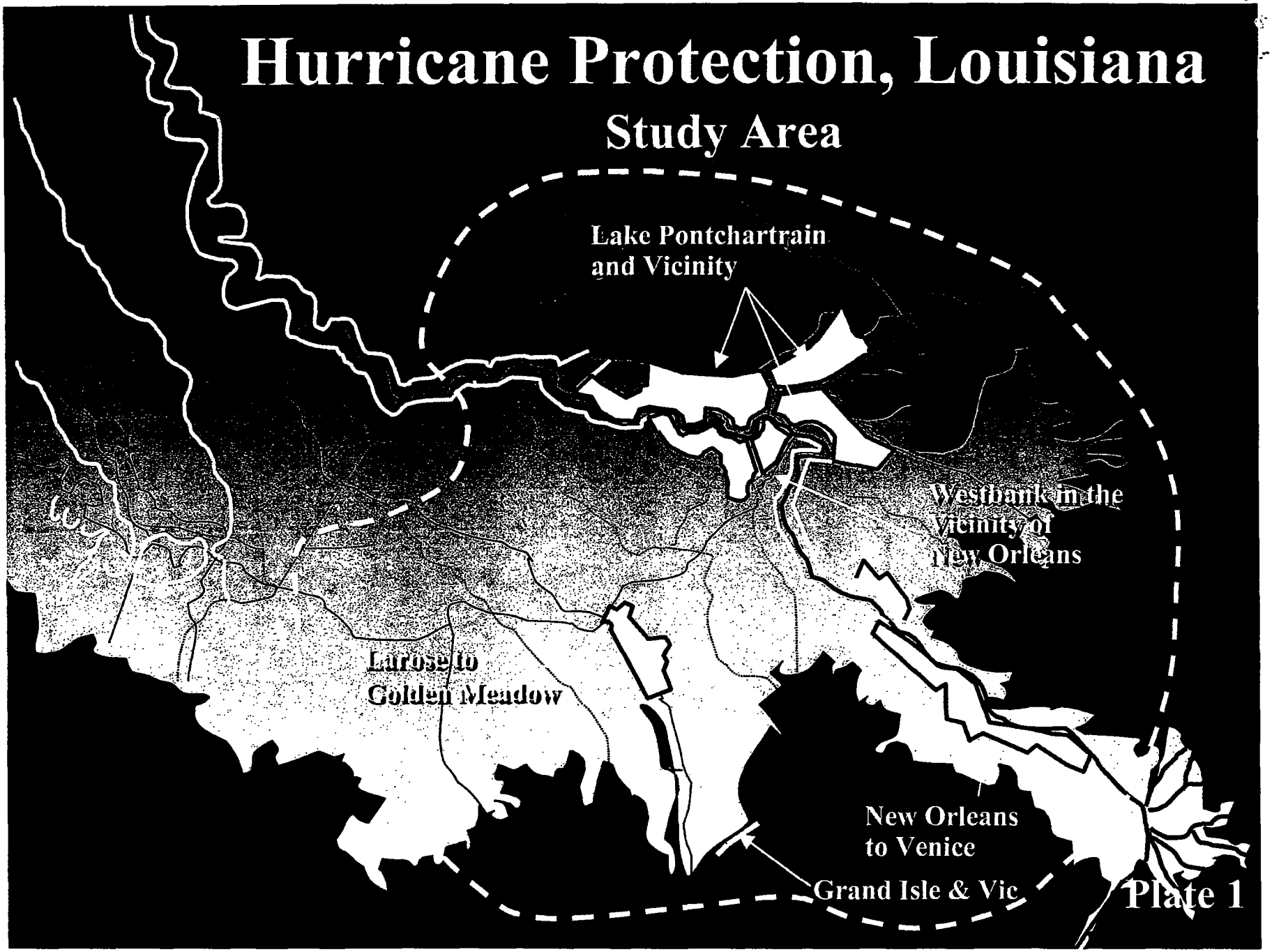
11. RECOMMENDATIONS

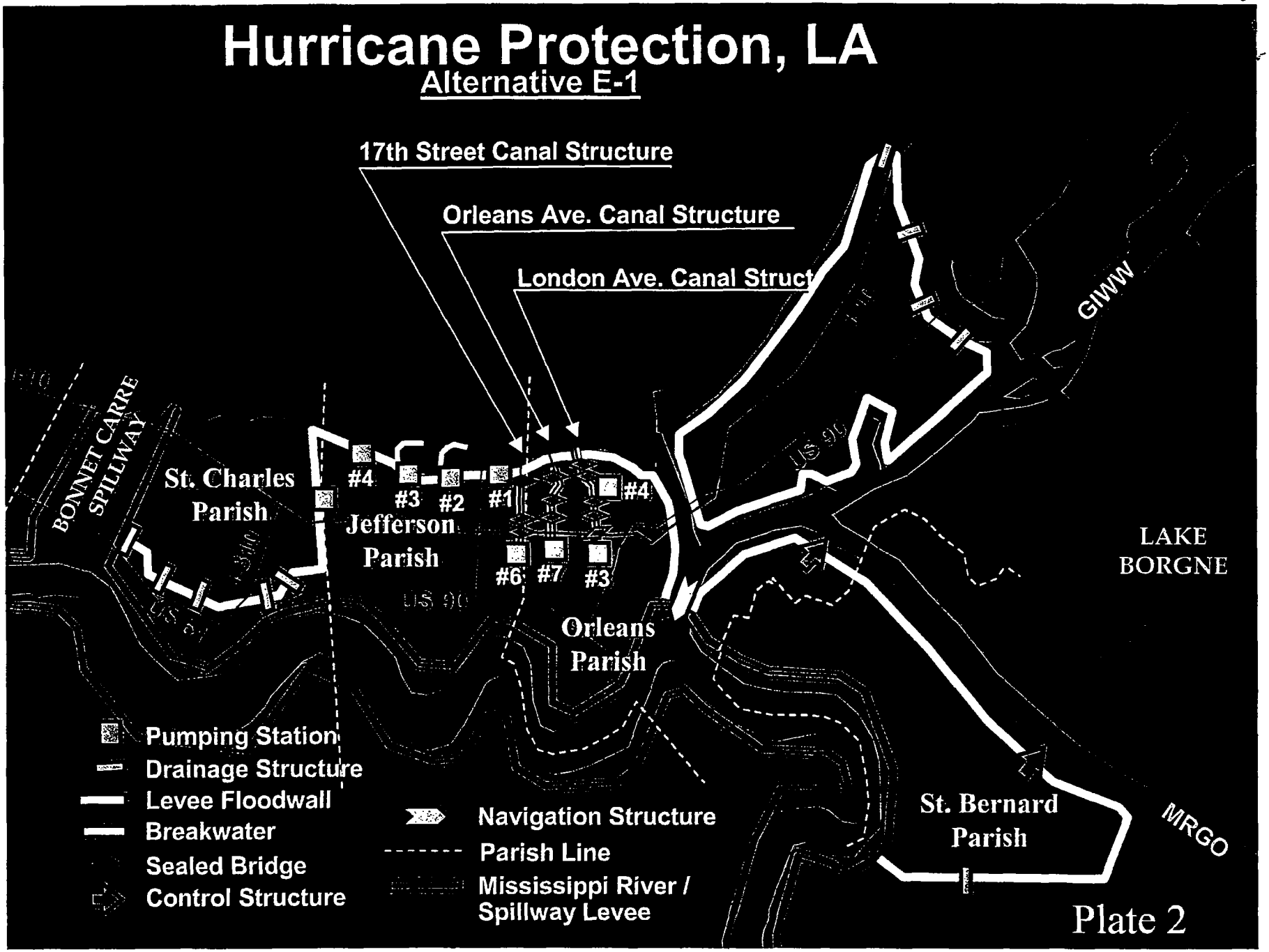
The recommendations contained herein reflect the policies governing formulation of individual projects and the information available at this time. They do not necessarily reflect program and budgeting priorities inherent in the local or state programs or the formulation of a national Civil Works construction program. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, the potential sponsor and other interested agencies will be afforded an opportunity to comment further.

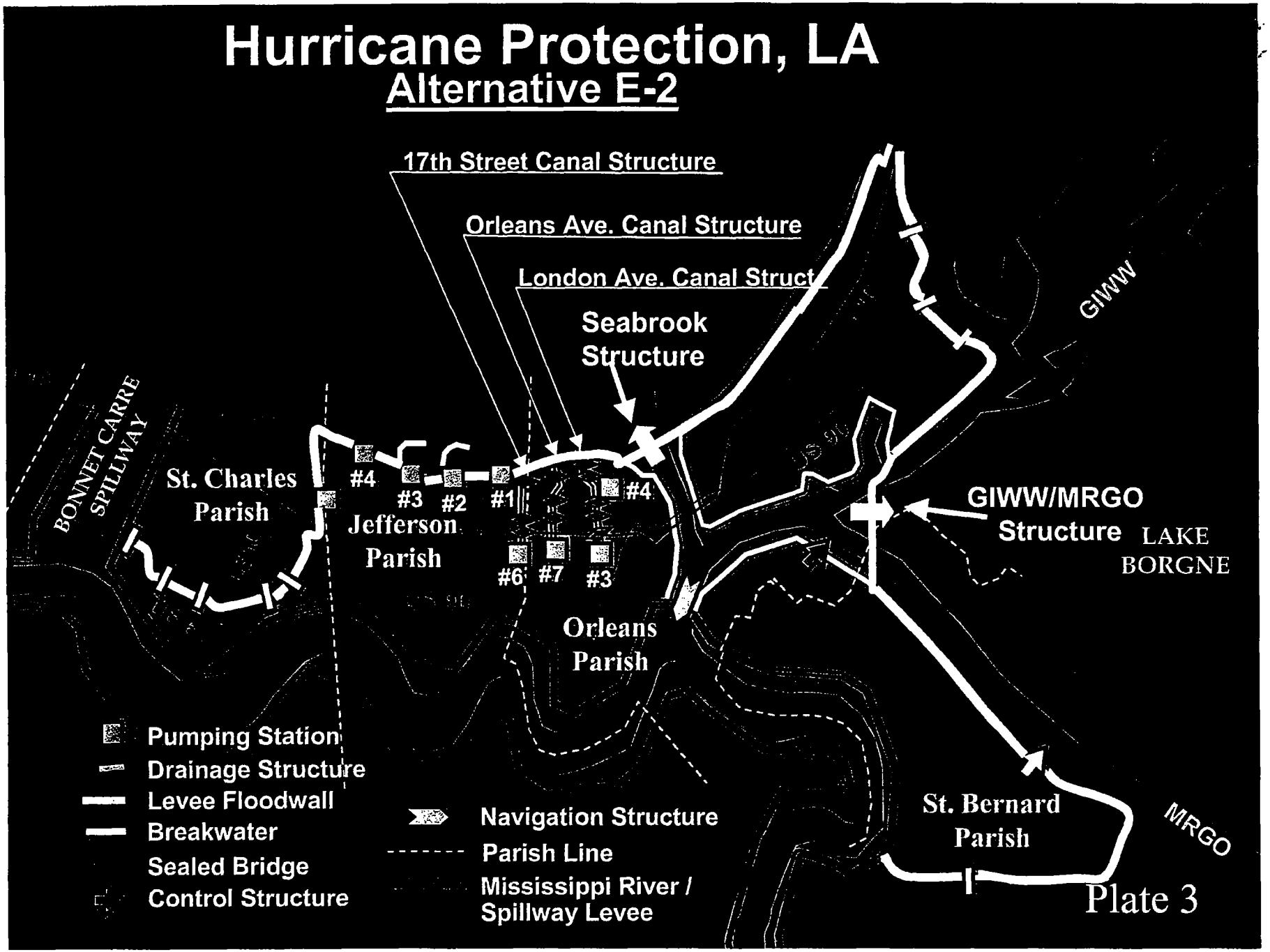
The Hurricane Protection, Louisiana reconnaissance study has provided sufficient analysis to indicate the feasibility of a plan to alleviate hurricane flooding in the study area. This plan has been found to be economically justified and environmentally acceptable. The Hurricane Protection, Louisiana reconnaissance study indicates that further studies are warranted, and that this study should proceed to the feasibility phase.

Based on the findings presented in this reconnaissance report, I recommend that the Hurricane Protection, LA study proceed into the feasibility phase contingent upon the availability of funds and the execution of a feasibility cost sharing agreement with the local sponsor.

Thomas F. Julich
Colonel, U.S. Army
District Engineer


Hurricane Protection, Louisiana
Study Area
Lake Pontchartrain
and Vicinity
Westbank in the
Vicinity of
New Orleans
Larose to
Golden Meadow
New Orleans
to Venice
Grand Isle & Vic
Plate 1


Hurricane Protection, LA
Alternative E-1
17th Street Canal Structure
Orleans Ave. Canal Structure
London Ave. Canal Struct
GIWW
BONNET CARRE SPILLWAY
St. Charles Parish
#4
#3
#2
#1
#4
Jefferson Parish
#6
#7
#3
US 90
Orleans Parish
LAKE BORGNE
St. Bernard Parish
MRGO
Pumping Station
Drainage Structure
Levee Floodwall
Breakwater
Sealed Bridge
Control Structure
Navigation Structure
Parish Line
Mississippi River / Spillway Levee
Plate 2


Hurricane Protection, LA
Alternative E-2
17th Street Canal Structure
Orleans Ave. Canal Structure
London Ave. Canal Struct
Seabrook Structure
GIWW
BONNET CARRE SPILLWAY
St. Charles Parish
#4
#3
#2
#1
Jefferson Parish
#4
#6
#7
#3
Orleans Parish
GIWW/MRGO Structure
LAKE BORGNE
St. Bernard Parish
MRGO
Pumping Station
Drainage Structure
Levee Floodwall
Breakwater
Sealed Bridge
Control Structure
Navigation Structure
Parish Line
Mississippi River / Spillway Levee
Plate 3

Hurricane Protection, LA

Alternative E-3

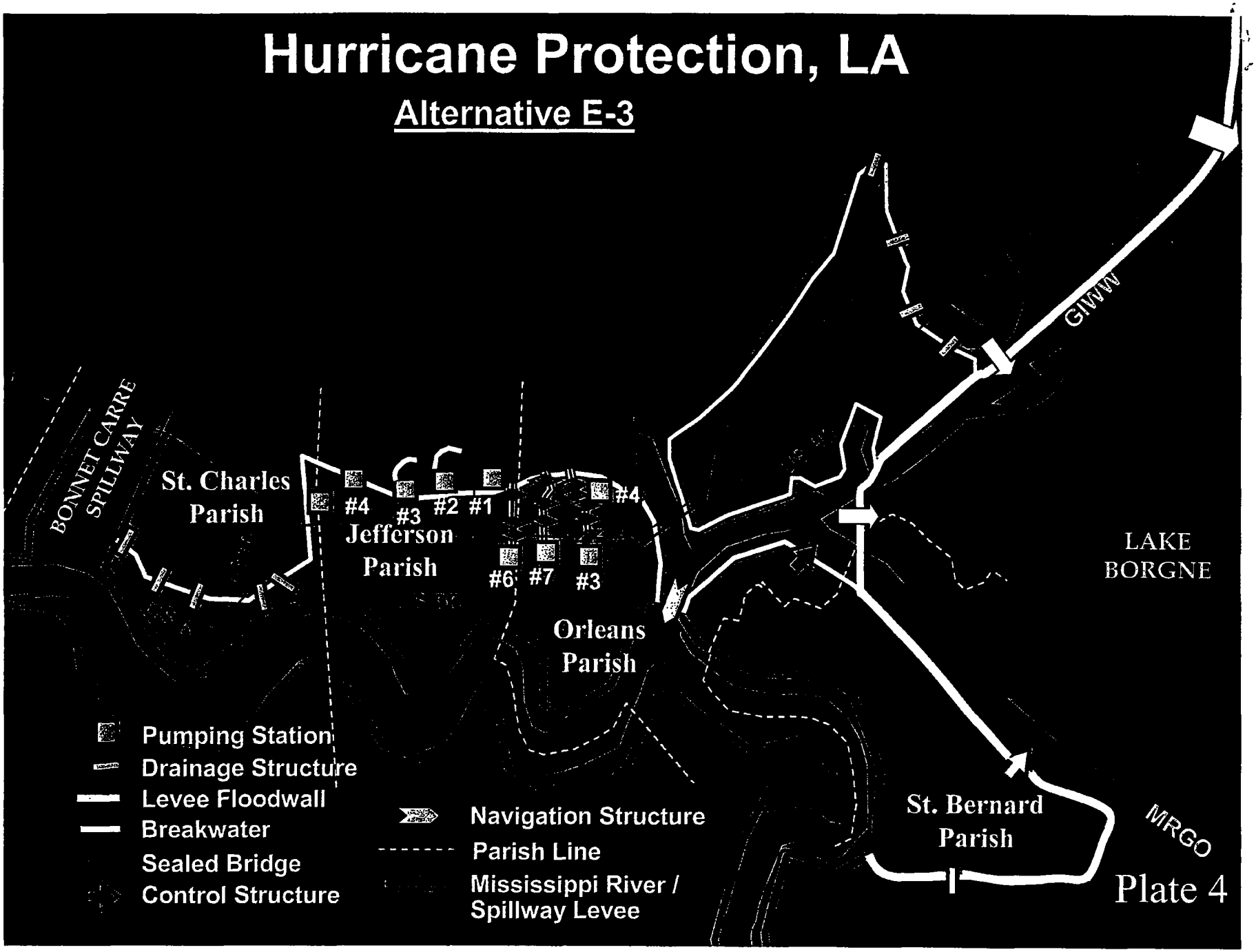
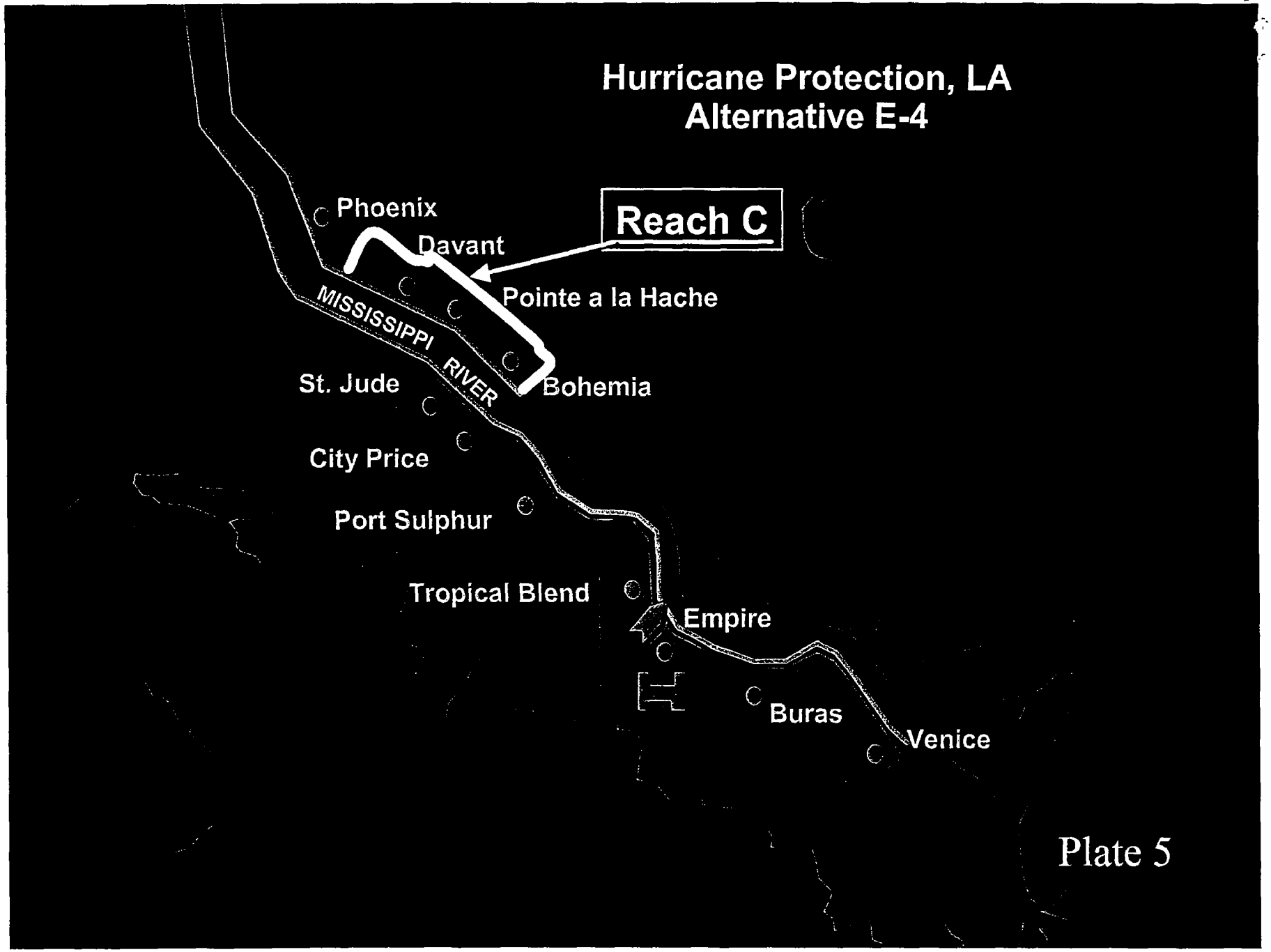
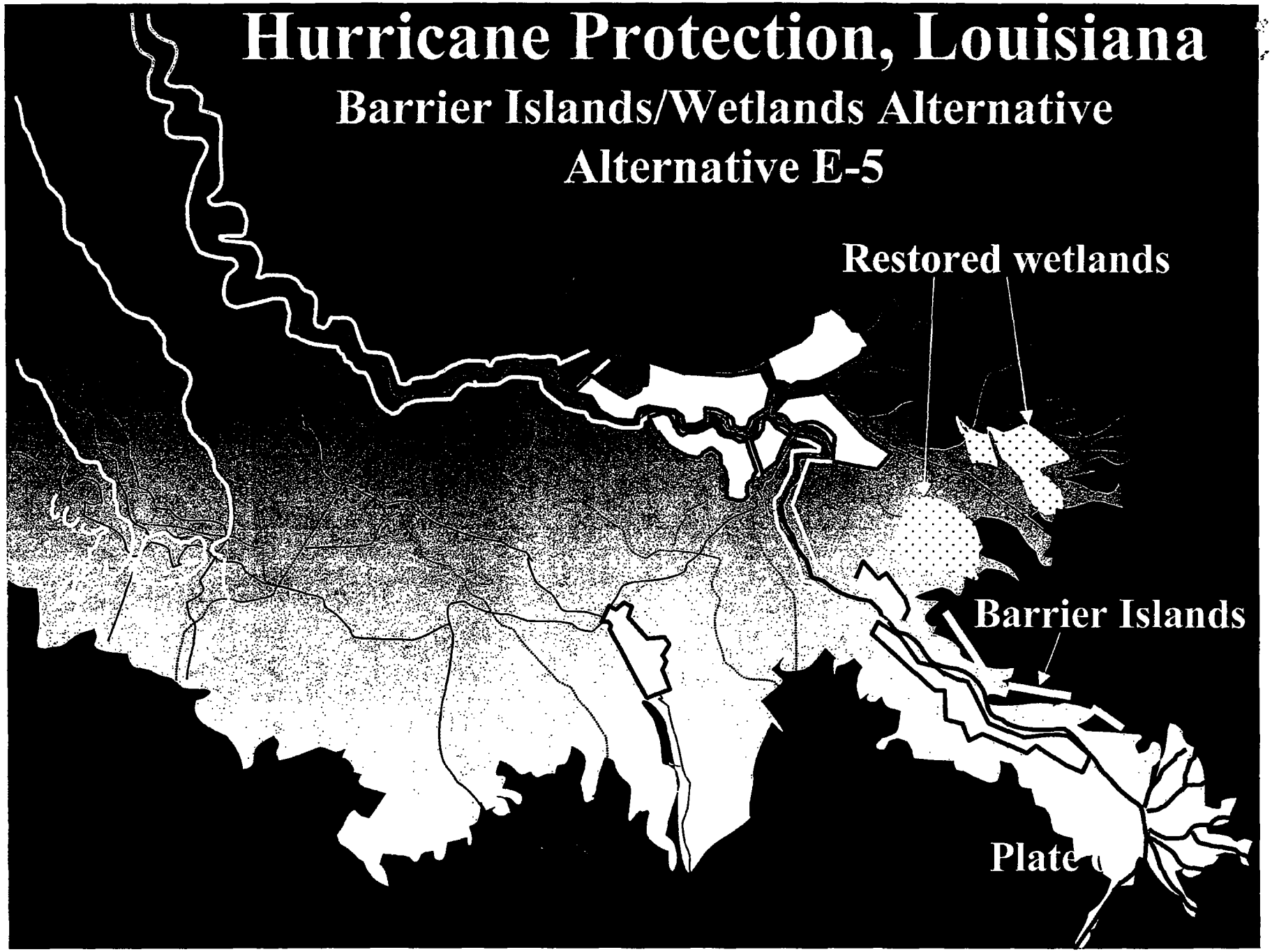
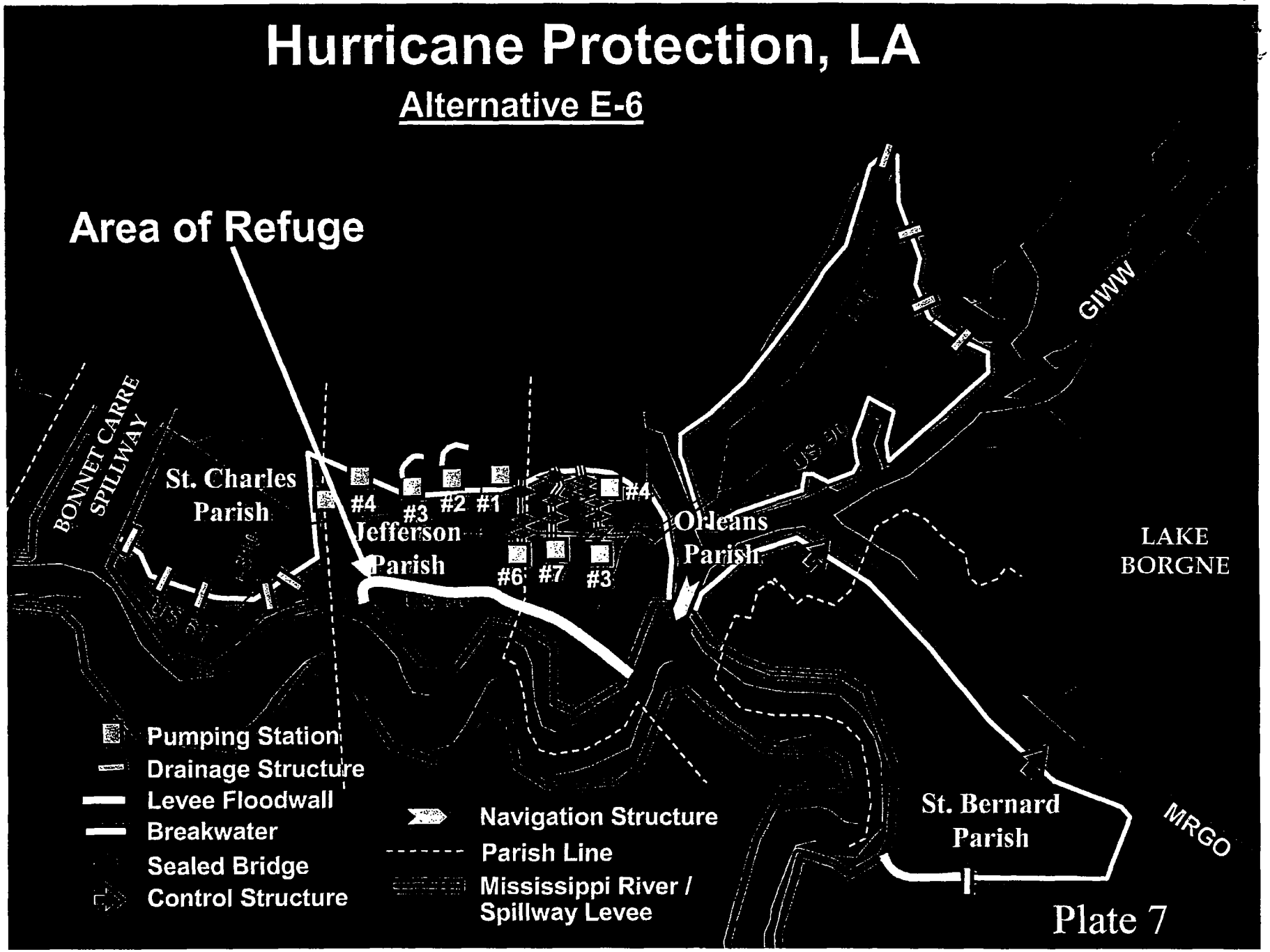


Plate 4


Hurricane Protection, LA
Alternative E-4
Reach C
Phoenix
Davant
Pointe a la Hache
MISSISSIPPI RIVER
St. Jude
Bohemia
City Price
Port Sulphur
Tropical Blend
Empire
Buras
Venice
Plate 5


Hurricane Protection, Louisiana
Barrier Islands/Wetlands Alternative
Alternative E-5
Restored wetlands
Barrier Islands


Hurricane Protection, LA
Alternative E-6
Area of Refuge
BONNET CARRE SPILLWAY
St. Charles Parish
#4
#3
#2
#1
Jefferson Parish
#6
#7
#3
#4
Orleans Parish
GIWW
LAKE BORGNE
St. Bernard Parish
MRGO
Pumping Station
Drainage Structure
Levee Floodwall
Breakwater
Sealed Bridge
Control Structure
Navigation Structure
Parish Line
Mississippi River / Spillway Levee
Plate 7

West Bank & Vicinity, New Orleans, LA, Hurricane Protection Project

Alternative W-1

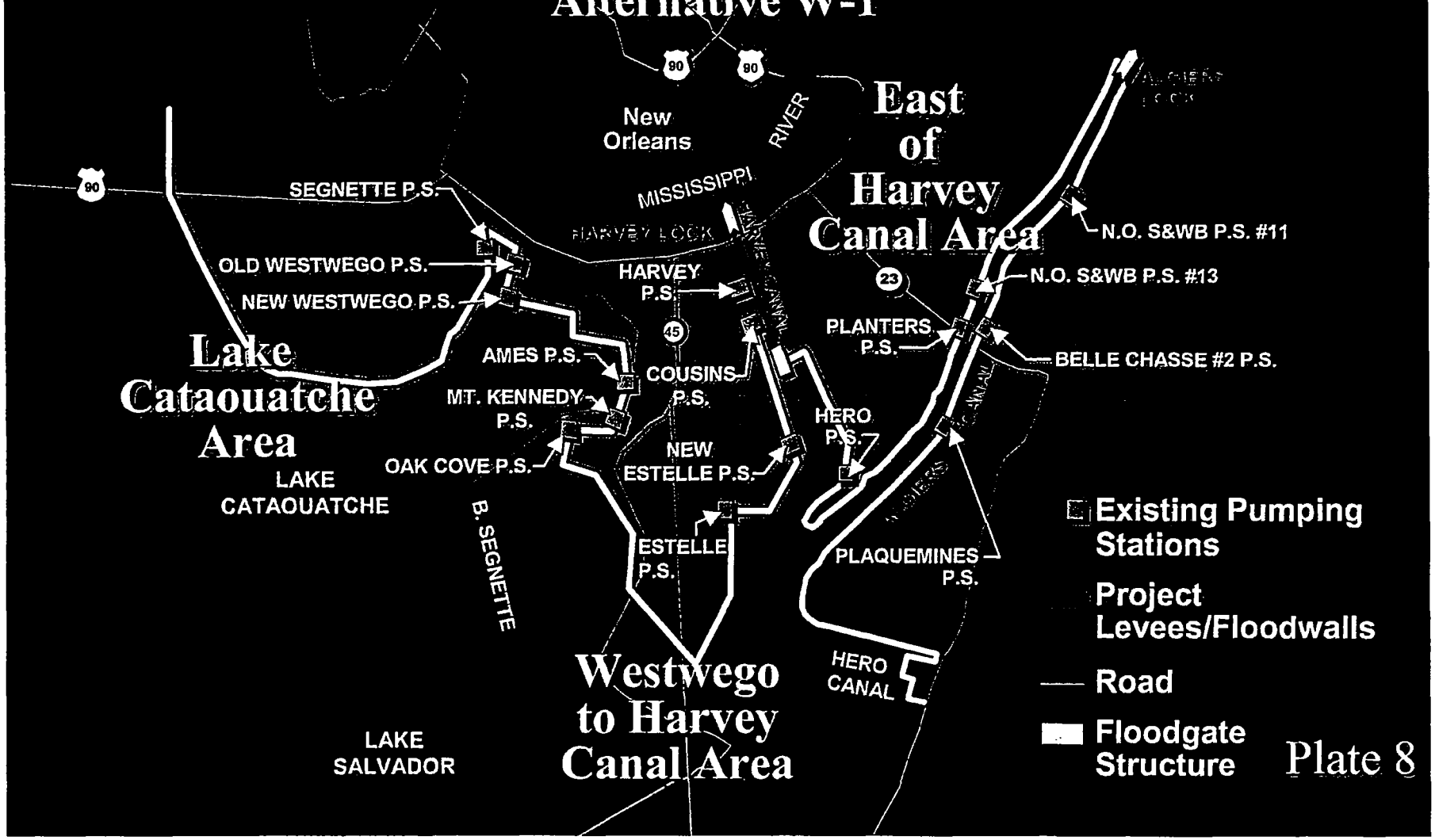


Plate 8

Hurricane Protection, LA
Alternative W-2
GIWW STRUCTURE

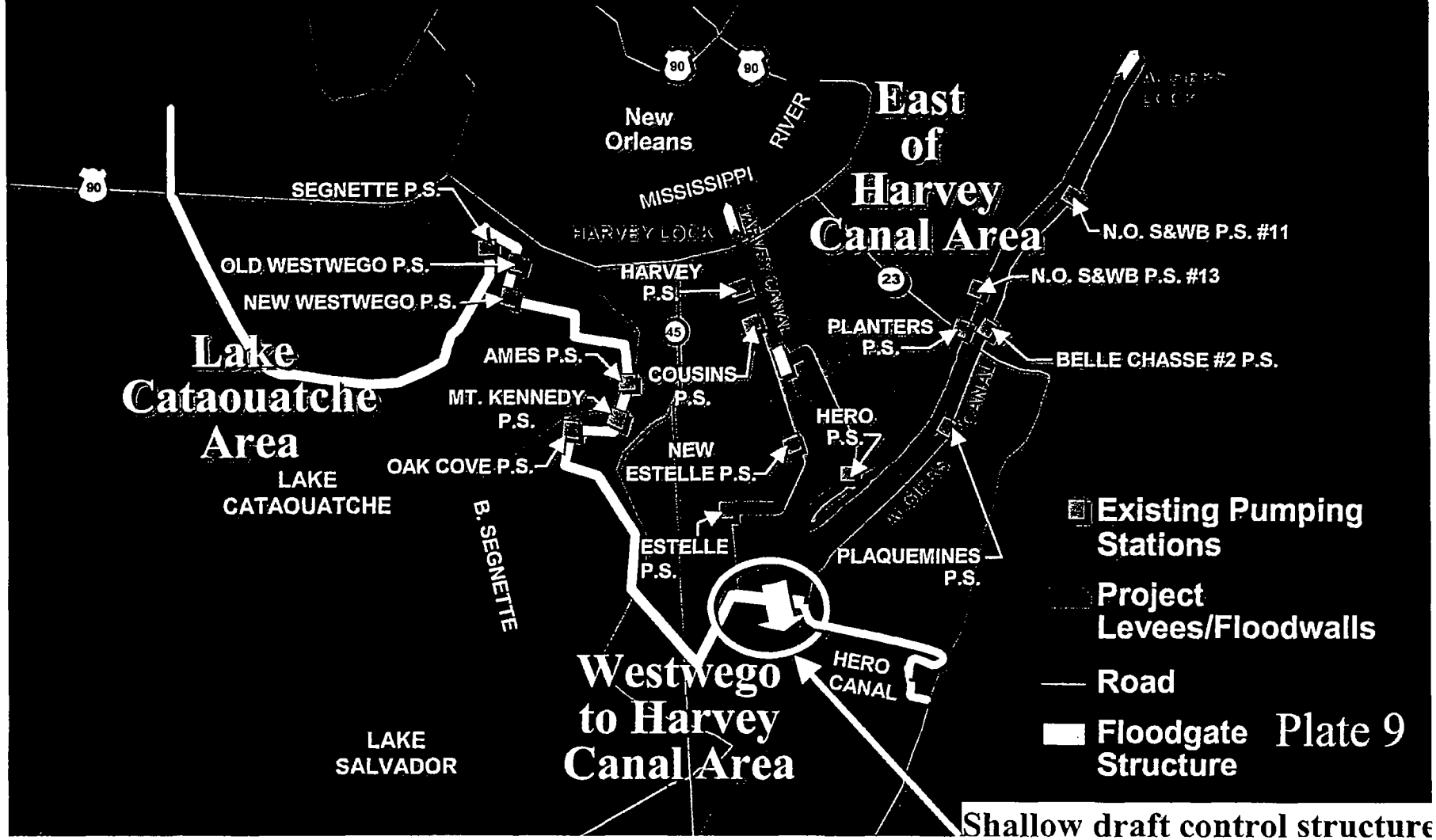
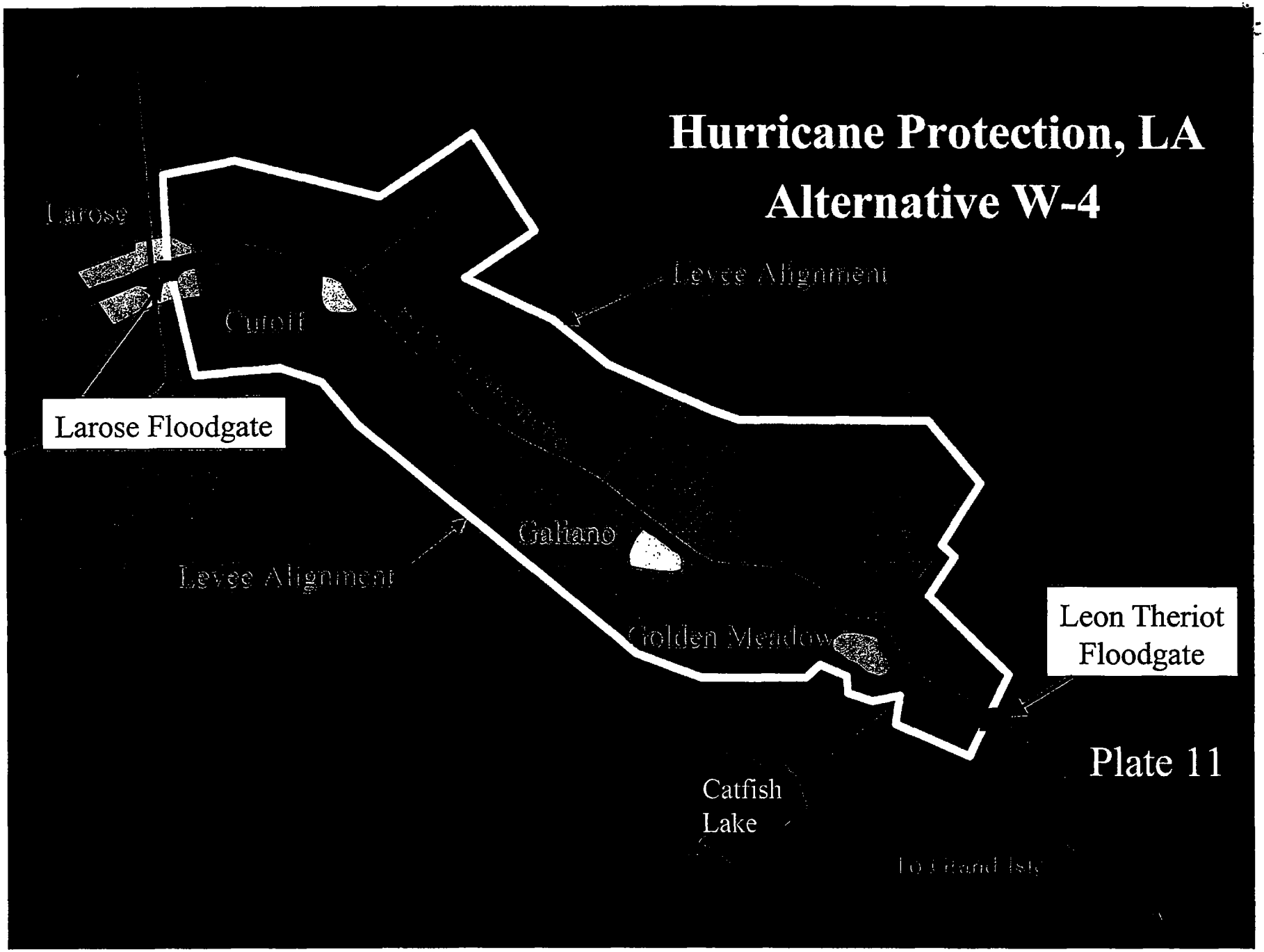
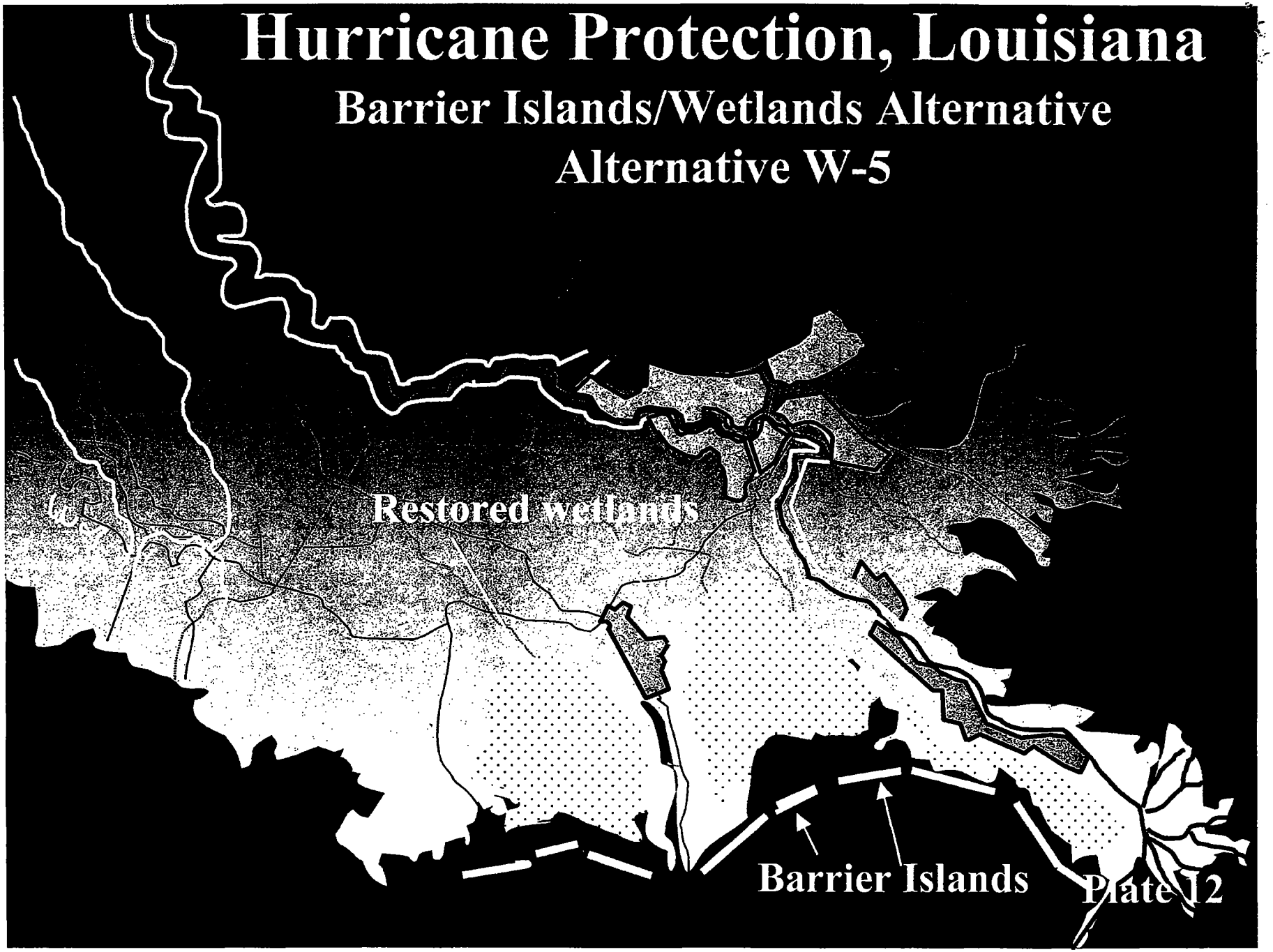


Plate 9

Shallow draft control structure


Hurricane Protection, LA
Alternative W-3
Phoenix
Davant
Reach C
Pointe a la Hache
MISSISSIPPI RIVER
St. Jude
Bohemia
City Price
West Bank
River Levee
Port Sulphur
Reach A
Tropical Blend
Empire
Reach B-1
Buras
Venice
Reach B-2
Plate 10


Hurricane Protection, LA
Alternative W-4
Larose
Cutoff
Levee Alignment
Larose Floodgate
Galiano
Levee Alignment
Golden Meadow
Leon Theriot
Floodgate
Plate 11
Catfish
Lake


Hurricane Protection, Louisiana
Barrier Islands/Wetlands Alternative
Alternative W-5
Restored wetlands
Barrier Islands
Plate 12

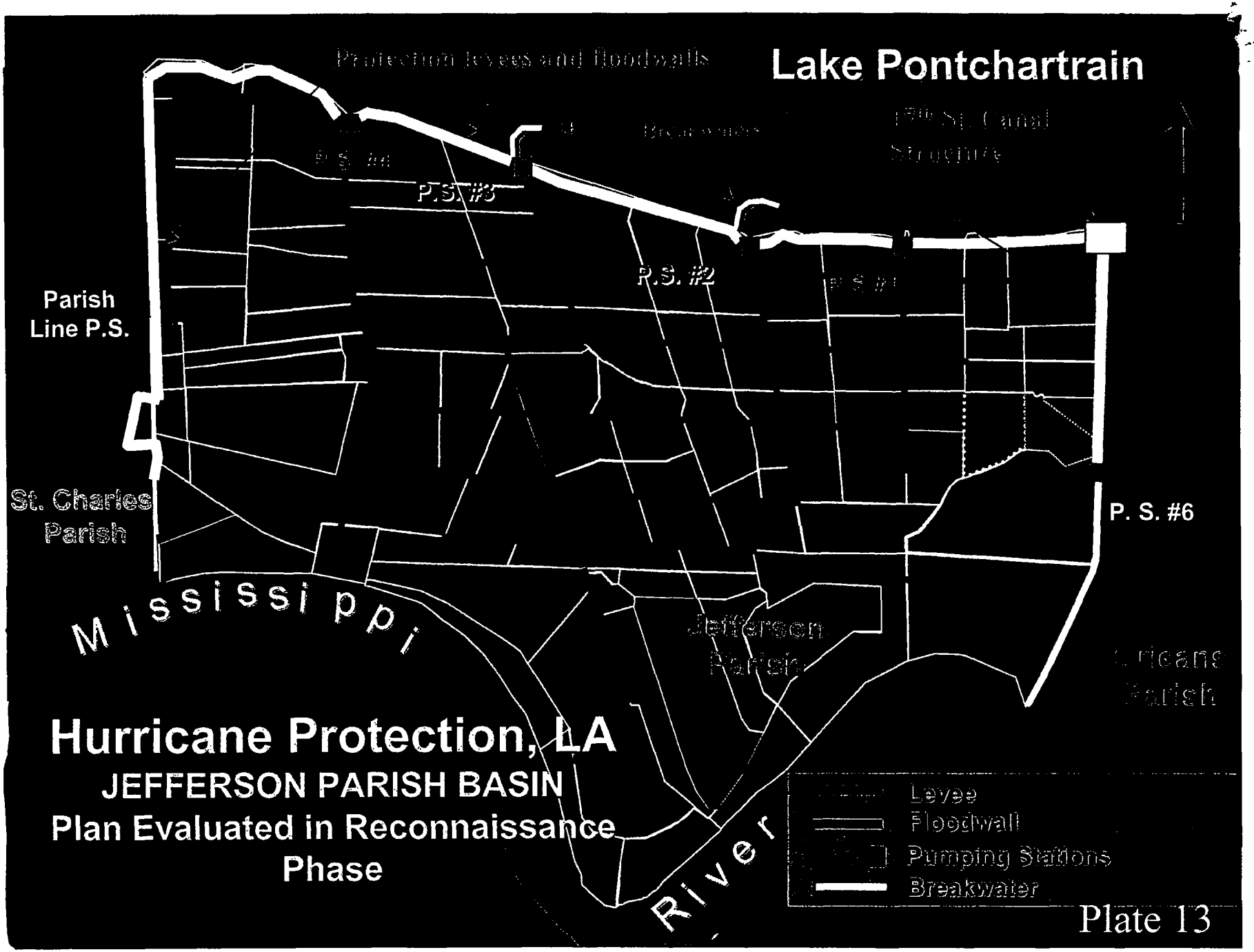

Lake Pontchartrain
Parish Line P.S.
St. Charles Parish
P.S. #3
P.S. #2
P. S. #6
Mississippi River
Jefferson Parish
Levee
Floodwall
Pumping Stations
Breakwater
Hurricane Protection, LA
JEFFERSON PARISH BASIN
Plan Evaluated in Reconnaissance Phase

Plate 13