Mississippi Hurricane Evacuation Study

Technical Data Report

April 2002

For Hancock, Harrison and Jackson Counties

MISSISSIPPI HURRICANE EVACUATION STUDY

April 2002

PREFACE

The three coastal counties in Mississippi have a large growing population, which is mostly located along the coastline within the hurricane hazard area. The coastal region is a desirable tourist attraction and summer vacation spot, which adds a significant number of people and vehicles to any evacuation scenario. These factors along with the unpredictability of hurricanes make it extremely difficult for emergency management officials to know when and if an evacuation order should be given and who should be asked to leave.

Obtaining information critical to good hurricane evacuation planning requires comprehensive and specialized analyses. The fiscal and staffing limitations of state and local emergency management agencies usually preclude the development of this data. In order to provide the needed technical information, the Federal Emergency Management Agency, the U.S. Army Corps of Engineers, and the National Oceanic and Atmospheric Administration have joined the Mississippi State Emergency Management Office and local emergency management agencies to conduct this study.

US Army Corps of Engineers, Mobile

THE MISSISSIPPI HURRICANE EVACUATION STUDY TECHNICAL DATA REPORT

TABLE OF CONTENTS

TOPIC **PAGE NO.**

THE MISSISSIPPI HURRICANE EVACUATION STUDY
TECHNICAL DATA REPORT

TABLE OF CONTENTS (Continued)

TOPIC **PAGE NO.**

THE MISSISSIPPI HURRICANE EVACUATION STUDY
TECHNICAL DATA REPORT

TABLE OF CONTENTS (Continued)

TOPIC **PAGE NO.**

THE MISSISSIPPI HURRICANE EVACUATION STUDY
TECHNICAL DATA REPORT

TABLE OF CONTENTS (Continued)

TOPIC **PAGE NO.**

THE MISSISSIPPI HURRICANE EVACUATION STUDY
TECHNICAL DATA REPORT

TABLE OF CONTENTS (Continued)

LIST OF TABLES

THE MISSISSIPPI HURRICANE EVACUATION STUDY
TECHNICAL DATA REPORT

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

THE MISSISSIPPI HURRICANE EVACUATION STUDY
TECHNICAL DATA REPORT

TABLE OF CONTENTS (Continued)

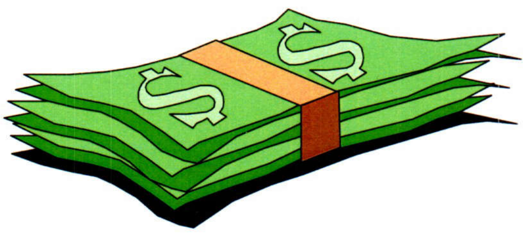
LIST OF PLATES

CHAPTER ONE - INTRODUCTION

STUDY PURPOSE

The purpose of this Hurricane Evacuation Study is to provide emergency management officials information that could assist them in hurricane evacuation decision-making. County and State agencies can use the technical data presented in this report to supplement their hurricane evacuation plans and operational procedures in responding to future hurricane threats.

FUNDING



The Federal Emergency Management Agency (FEMA), the U.S. Army Corps of Engineers (Corps), and the Mississippi State and local emergency management agencies provided funding, data and coordination throughout the study.

AUTHORITY

The authority for the U.S. Army Corps of Engineers' participation in this study is Section 206 of the Flood Control Act of 1960, as amended (Public Law 86-645). The authority for the Federal Emergency Management Agency to participate in this study is the Disaster Relief Act of 1974 (Public Law 93-288). These laws authorize the allocation of resources for planning activities related to hurricane preparedness.

DESCRIPTION OF STUDY AREA

a. Geography

The Mississippi Study area is shown in Figure 1-1. The study area includes the coastal counties of Hancock, Harrison and Jackson. Most of the Gulf coastline of these counties is made up of barrier islands and peninsulas. The shoreline has beautiful white sand beaches with shallow waters. Mean tide range is about 1-2 feet. Excellent roads across the entire coastal area and its natural environment have made it a leading scenic and tourist attraction and a very desirable place to live.

The counties have streams and rivers with significant drainage basins that empty into the bays and sounds of the Gulf of Mexico. Some of the major rivers include the Pascagoula and Escatawpa Rivers in Jackson County, the Biloxi and Wolf Rivers in Harrison County, and the Jourdan River in Hancock County. These rivers empty into the Pascagoula Bay, Biloxi Bay, and St. Louis Bay. The general topography of the study area varies from relatively flat and gradually sloping along the Gulf Coast to steeper areas inland in the northern parts of the counties.

b. Geology and Soils

The coastal plain is generally flat and represents ancient sea bottoms and beaches. The underlying rock in the area began as lime accumulations from marine organisms or sedimentary deposits of silt, sand and clay. The lower tertiary beds of limestone, clay, gravel and sand have thick layers toward the south and taper as they move north. This complex of tertiary limestone forms the principal artesian aquifer in the area. These sediments rest on a base of crystalline rock, which is several thousand feet below the land surface.

The inland areas of the counties have rolling relief and elevations that exceed 100 feet National Geodetic Vertical Datum (NVGD). Most of the soils in the area are sands, clays and loams that have made some of the area highly productive for farming, orchards and pastures. A large part of the inland portion of all three counties is forested. Some areas have dense sandy clay subsoil, and are very susceptible to erosion. Jackson County has a significant wetland marsh along the lower portion of Pascagoula River and Bay.

c. Bathymetry

Shallow water close to shore, tends to increase the magnitude of hurricane storm surge, therefore the depth of water offshore (bathymetry) is extremely important. The 30-foot water depth is about 20 miles offshore. The Gulfport Harbor is used extensively by deep draft navigation vessels and has to be periodically dredged to maintain adequate cannel depths.

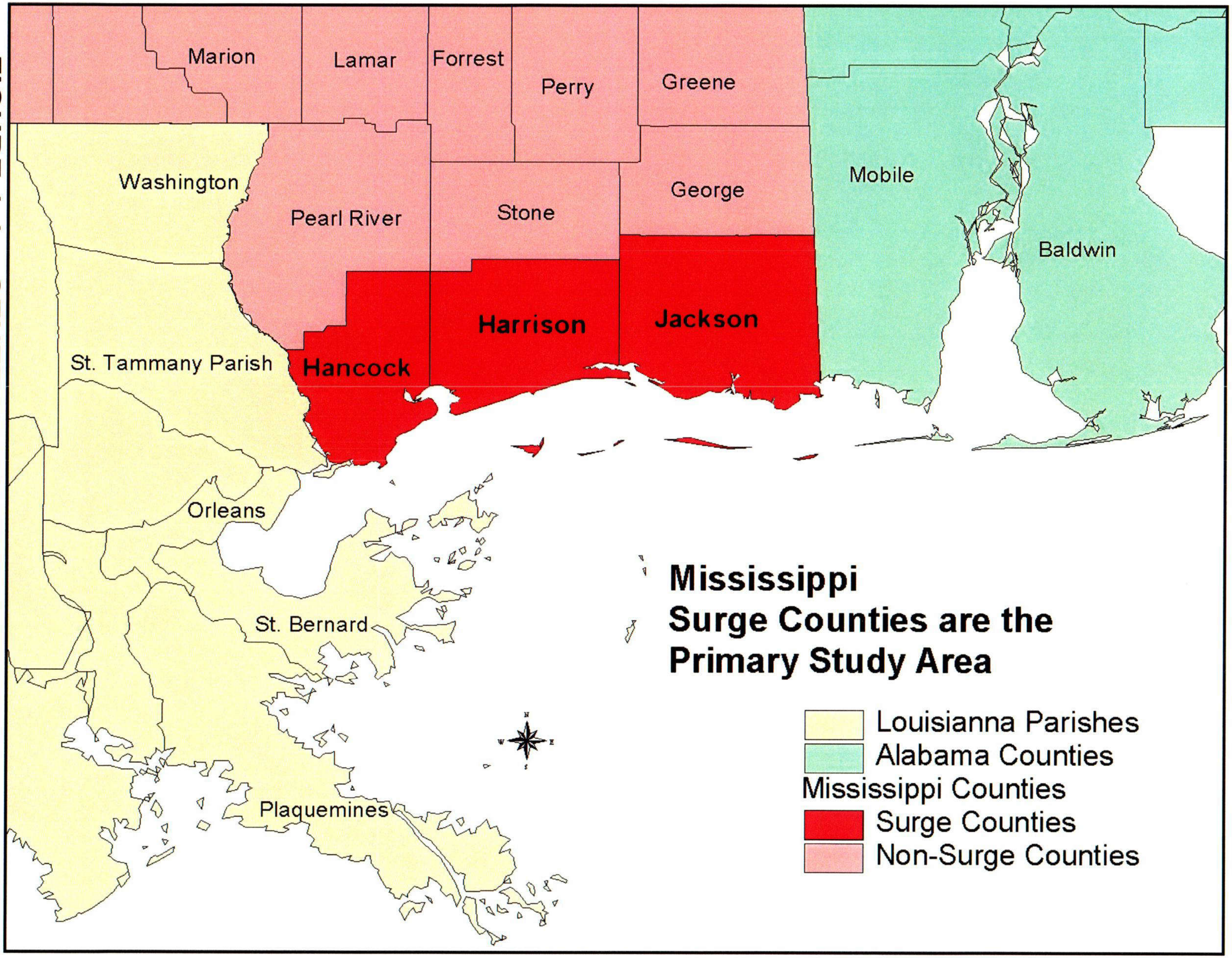


FIGURE 1-1 GENERAL MAP OF THE STUDY AREA

d. Population/Demographics

The study area is generally rural with most of the population concentrating along the coastal areas. Table 1-1 shows the estimated population and total dwelling units for each coastal county in the study area. The population figures were estimated with close coordination with the counties and the Gulf Regional Planning Council.

TABLE 1-1
POPULATION CHARACTERISTICS FOR THE MISSISSIPPI STUDY AREA COUNTIES

COUNTY NAME	Estimated Population Year 2000	Estimated Permanent Dwelling Units
Hancock	40,341	13,447
Harrison	187,097	71,411
Jackson	138,626	49,158

HISTORICAL HURRICANE ACTIVITY

a. General

Hurricanes are a classification of tropical cyclones, which are defined by the National Weather Service (NWS) as non-frontal, low-pressure synoptic scale (large-scale) systems that develop over tropical or subtropical waters and have a definite organized circulation. The classification of tropical cyclones into tropical depressions, tropical storms, or hurricanes depends upon the speed of the sustained (1-minute average) surface winds near the center of the system. Tropical depressions are $\leq$ 33 knots (38 mph), tropical storms are 34 to 63 knots (37-74 mph) inclusive, and hurricanes are $\geq$ 64 knots (75 mph).

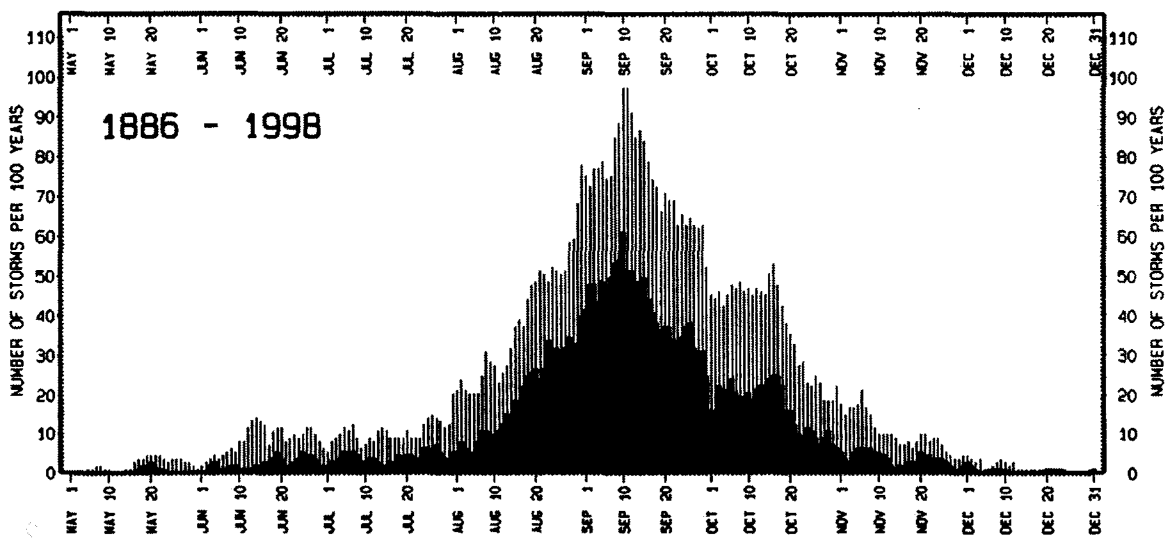
The geographical areas affected by tropical cyclones are referred to as tropical cyclone basins. The Atlantic Tropical Cyclone Basin is one of six in the world and includes much of the North Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico. The official Atlantic hurricane season begins on June 1 and extends through November 30 of each year; however, occasional tropical cyclones can occur outside of this period.

Early season tropical cyclones are almost exclusively confined to the western Caribbean and the Gulf of Mexico. By the end of June or early July, the area of formation gradually shifts eastward. By late July, the frequency begins to slowly increase, and the area of formation shifts still farther eastward. The period from about August 20 through September 15 produces the most severe hurricanes. After mid-September, the frequency begins to decline and the formative area retreats westward. By early October, the area of maximum occurrence returns to the western Caribbean. In November, the tropical cyclone threat in the Gulf is minimal.

b. Atlantic Tropical Cyclone Basin

Through the research efforts of the National Climate Center (NCC) in cooperation with the National Hurricane Center (NHC), records of tropical cyclone occurrences within the Atlantic Tropical Cyclone Basin have been compiled dating back to 1871. Although other researchers have compiled fragmentary data concerning tropical cyclones within this basin back to the late fifteenth century, the years from 1871 to the present represent the complete period of the development of meteorology and organized weather services in the United States. From 1871 through 2000, over 1000 tropical cyclones have occurred within the Atlantic Tropical Cyclone Basin. Data for the years 1871 through 1885 do not allow accurate determinations of the intensities of the storms occurring during those years. The NHC maintains detailed computer files of the Atlantic tropical cyclone tracks back to 1886. Of the known Atlantic tropical cyclones of at least tropical storm intensity occurring during the period 1886 through 2000, over 500 have reached hurricane intensity. Figure 1-2 below illustrates the total number of tropical storms and hurricanes observed on each day, May 1 through December 31. The Figure shows that mid September is the peak of the hurricane season.

Figure 1-2 Tropical Storms and Hurricanes, 1886 – 1998



Tropical Storms are shown in Black and Hurricanes are in Gray.

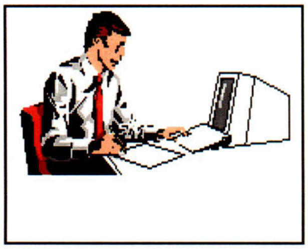
c. Mississippi Sound SLOSH Basin

Between 1886 and 1998, 29 tropical cyclones of hurricane intensity passed within 125 statute miles of Gulfport, Mississippi for an average of one hurricane within the 125-mile circle every 3.9 years. The tracks of these 29 storms with hurricane force winds are displayed on Plates 1-1 through 1-4 at the end of this Chapter. Storms heading west-northwest and northwest are shown on Plate 1-1. Plate 1-2 shows storms heading north-northwest and north. Plate 1-3 shows storms moving north-northeast. Plate 1-4 shows storms moving northeast and east-northeast. On each plate the tracks are labeled at six-hour intervals, with month/day/hour

MAJOR ANALYSES

The Mississippi Hurricane Evacuation Study consists of several related analyses that develop technical data concerning hurricane hazards, vulnerability of the population, public response to evacuation advisories, timing of evacuations, and sheltering needs for various hurricane threat situations. The major analyses are briefly summarized in the following paragraphs. Detailed descriptions of the analyses and the methodologies of each are contained in subsequent chapters of this report.

a. Hazards Analysis

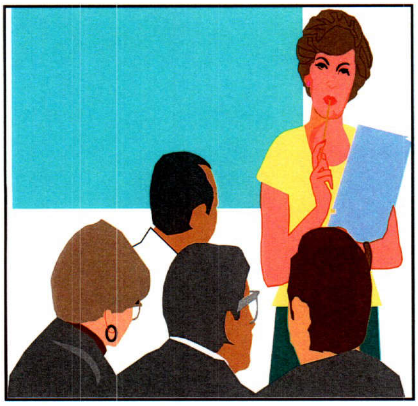


The hazards analysis determines the timing and magnitude of wind and storm surge hazards that can be expected from hurricanes of various categories, tracks, and forward speeds. The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) numerical model was used by the NHC to compute surge heights. Hazards from freshwater flooding are based on the Flood Insurance Rate Maps (FIRM). The Hazards Analysis is presented in more detail in Chapter Two.

b. Vulnerability Analysis

Utilizing the results of the hazards analysis, the vulnerability analysis identifies those areas, populations, and facilities that are vulnerable to specific hazards under a variety of hurricane threats. Inundation maps were produced and evacuation scenarios were developed. Hurricane evacuation zones were delineated for all three coastal counties in the study area. Population data were used to determine the vulnerable population within each evacuation zone. In areas of potential inundation, critical facilities were identified; such as family care homes, nursing homes, and hospitals. Wind damage vulnerability has also been considered in this study. Further discussion on all aspects of the Vulnerability Analysis is provided in Chapter Three.

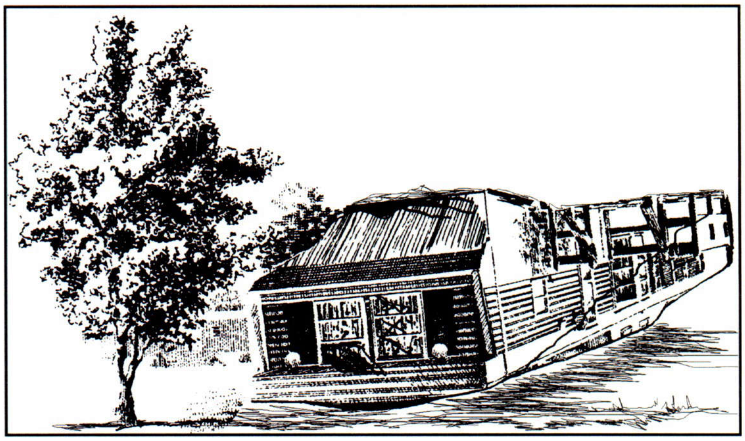
c. Behavioral Analysis



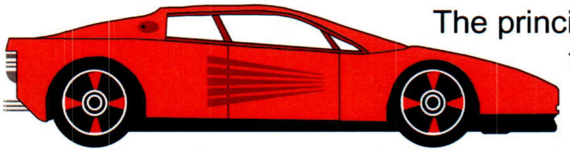
This analysis determines the expected response of the population threatened by various hurricane events in terms of the percentage expected to evacuate, probable destinations of evacuees, public shelter use, and utilization of available vehicles. The methodology employed to develop the behavioral data relied on telephone sample surveys and personal interviews within the study area, information from other hurricane evacuation studies, and post-hurricane behavioral studies. A presentation of the Behavioral Studies can be found in Chapter Four.

d. Shelter Analysis

The shelter analysis presents an inventory of public shelter facilities, capacities of the shelters, vulnerability of shelters to storm surge flooding, and shelter demand for each county. Emergency management offices in each county furnished shelter inventories. Shelter demands were estimated from behavioral analysis data. Chapter Five contains additional information on the Shelter Analysis.



e. Transportation Analysis



The principal purpose of the transportation analysis is to determine the time required to evacuate the threatened population (clearance times) under a variety of hurricane situations and to evaluate traffic control measures that could improve the flow of evacuating traffic. Transportation computer modeling techniques developed to simulate hurricane evacuation traffic patterns were used to conduct this analysis. Behavioral studies were made to estimate what portion of the evacuees will go to other inland counties or other States. Complete details on the Transportation Analysis are presented in Chapter Six.

COORDINATION

A coordination program was established for the Mississippi Hurricane Evacuation Study that included State and Local emergency management officials and representatives from other organizations having direct responsibilities in hurricane emergencies. The State Emergency Management Office maintains close coordination with County Directors of Emergency Management. The U.S. Army Corps of Engineers and Federal Emergency Management Agency relied on this established system to coordinate the study effort. All meetings with the counties were coordinated with the State Emergency Management Office. The U.S. Army Corps of Engineers, Mobile District, provided quarterly status reports to the Federal Emergency Management Agency, the Mississippi State Emergency Management Office, the Gulf Regional Planning Council and Hancock, Harrison and Jackson Counties.

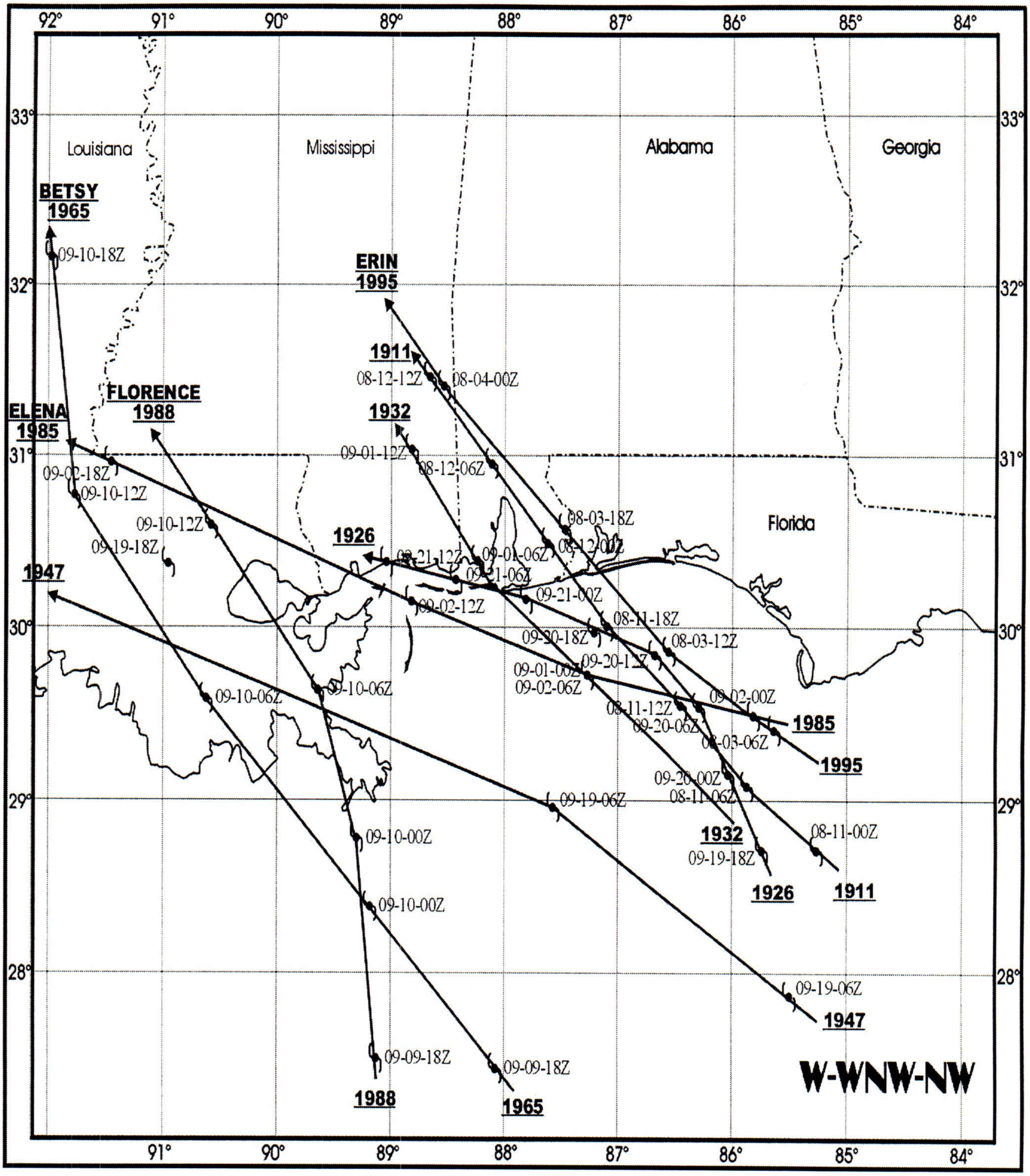


PLATE 1-1 **W-WNW AND NW HISTORIC STORM TRACKS FOR THE MISSISSIPPI COAST**

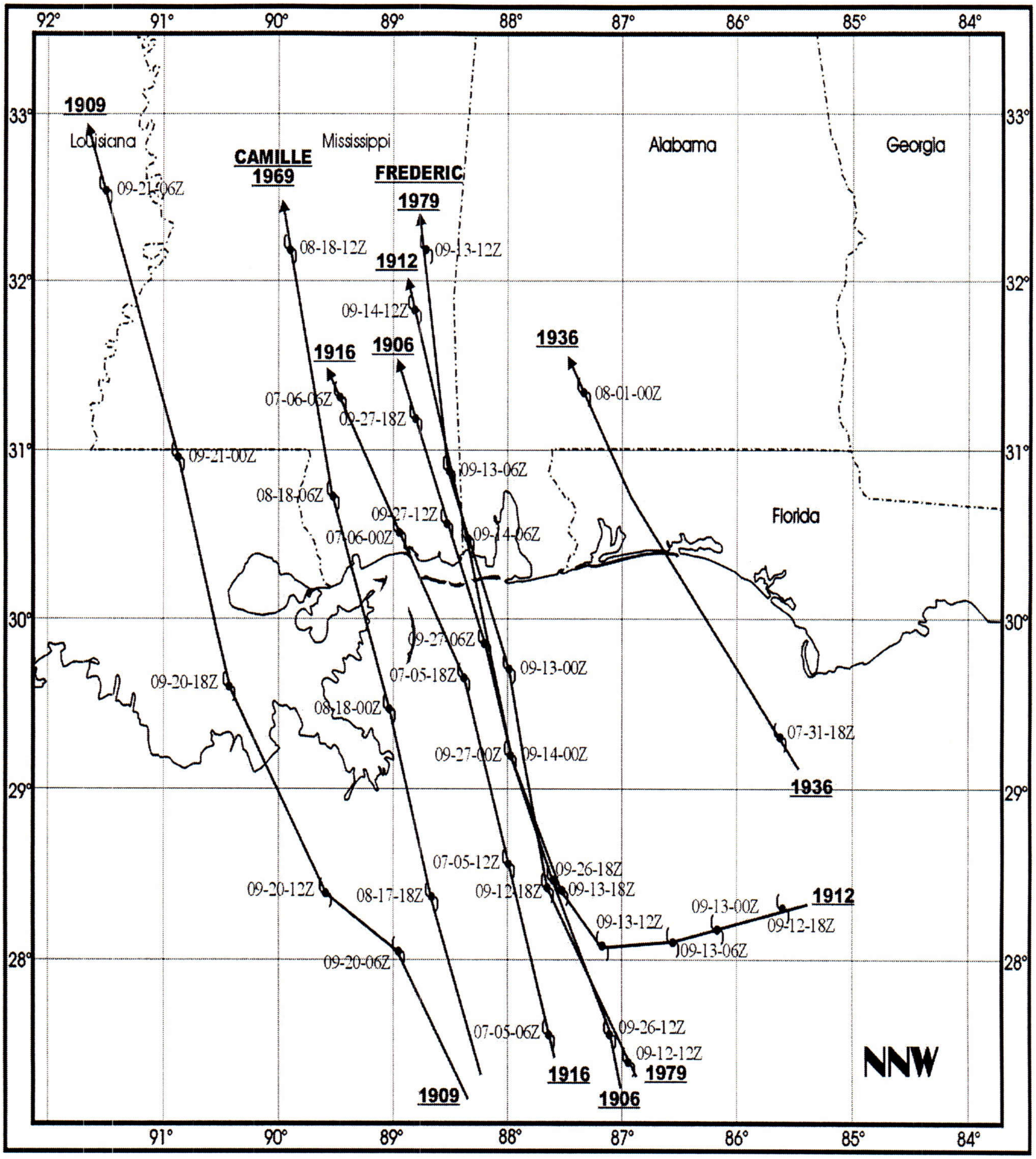


PLATE 1-2 **NNW HISTORIC STORM TRACKS FOR THE MISSISSIPPI COAST**

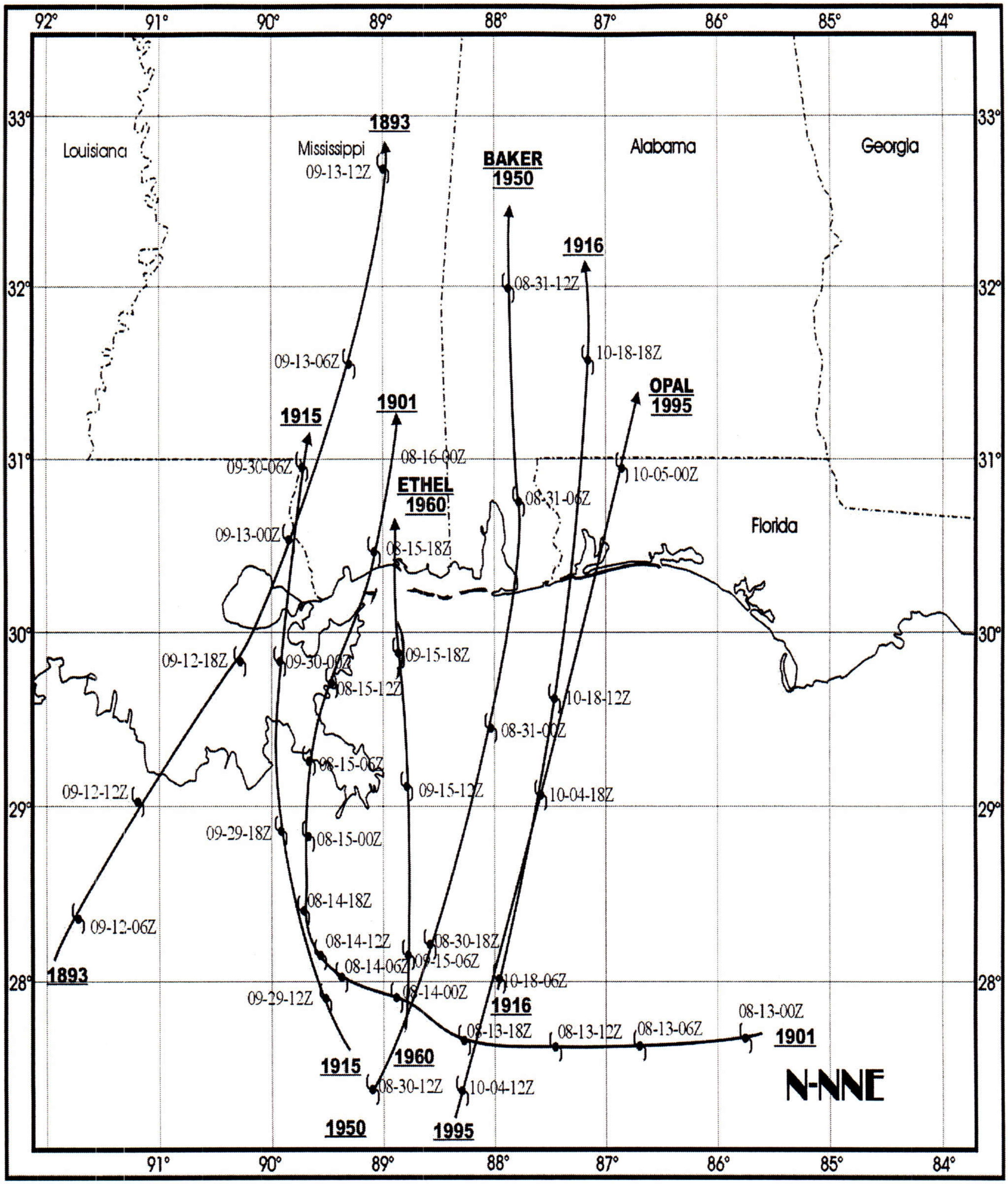


PLATE 1-3 **N–NNE HISTORIC STORM TRACKS FOR THE MISSISSIPPI COAST**

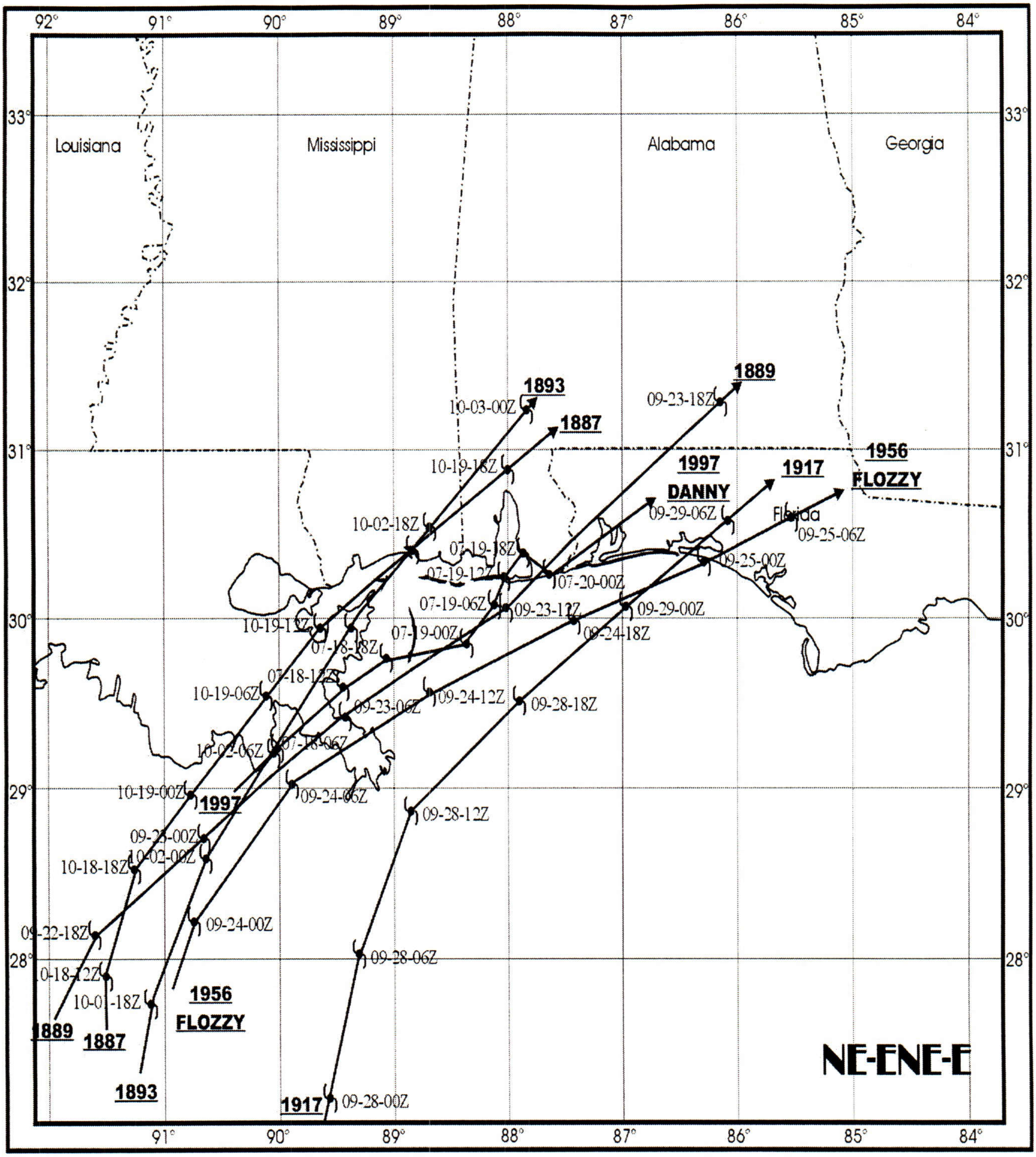


PLATE 1-4 NE-ENE AND E HISTORIC STORM TRACKS FOR THE MISSISSIPPI COAST

HAZARDS
ANALYSIS

CHAPTER TWO - HAZARDS ANALYSIS

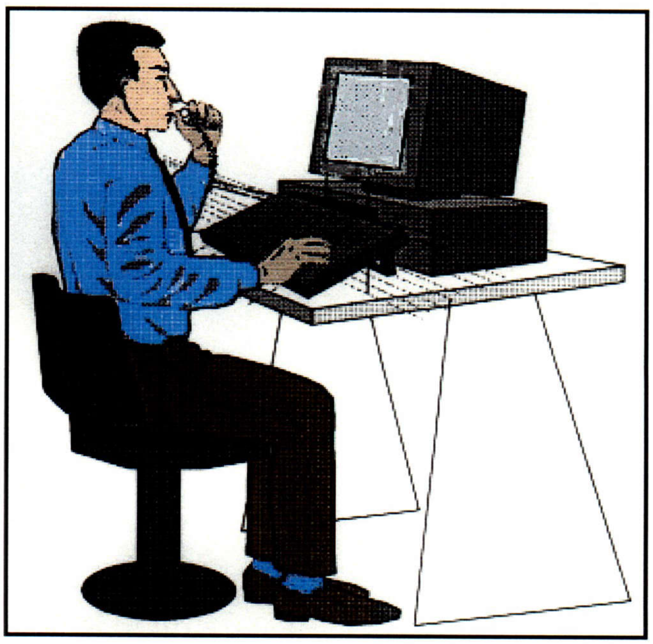
PURPOSE

The purpose of the hazards analysis is to quantify the wind speeds and still-water surge heights for hurricanes that have a reasonable meteorological probability of occurring in the study area. Freshwater flooding from heavy rainfall accompanying hurricanes is an additional hazard, which must be considered.

The primary objective of the hazards analysis is to determine the probable worst-case effects from hurricanes of various intensities that could strike the region. For the purposes of this study, the term worst-case is used to describe the peak surges and wind speeds that can be expected at all locations within the study area without regard to hurricane track.

FORECASTING INACCURACIES

The worst-case approach is used in the hazards analysis because of inaccuracies in forecasting the precise tracks and other parameters of approaching hurricanes. The National Hurricane Center has made an analysis of hurricane forecasts to determine the normal magnitude of error. The average error in the official 24-hour hurricane track forecast is about 100 statute miles left or right of the forecast track.



The average error in the official 24-hour wind speed forecast is 15 miles per hour (mph), and the average error in the 12-hour official forecast is about 10 mph. Hurricane evacuation decision-makers should note that an increase of 10 to 15 mph could easily raise the intensity value of the approaching hurricane one category on the Saffir/Simpson Hurricane Scale, which is discussed in the following paragraph. Other factors may work to increase apparent hurricane surge heights above the potential heights calculated by the SLOSH model. Because of these forecast and modeling inaccuracies, public officials who are faced with an imminent evacuation should consider preparing for a hurricane at landfall that may be one category above the forecast strength.

SAFFIR/SIMPSON HURRICANE SCALE

One of the earlier guides developed to describe the potential storm surge generated by hurricanes is the Saffir/Simpson Hurricane Scale. Herbert Saffir, Dade County, Florida, Consulting Engineer, and Dr. Robert H. Simpson, former Director of the National Hurricane Center developed the Saffir/Simpson scale. The National Hurricane Center has added a range of central barometric pressures associated with each category of hurricane described by the Saffir/Simpson Hurricane Scale. A condensed version of the Saffir/Simpson Hurricane Scale with the barometric pressure ranges by category is shown in Table 2-1. The related damage potential of each hurricane category is described in Table 2-2.

TABLE 2-1
SAFFIR/SIMPSON HURRICANE SCALE

	Central Pressure		**Winds**		**Damage**
Category	Millibars	Inches	(Mph)	(Kts)	
1	>980	>28.9	74-95	64-83	Minimal
2	965-979	28.5-28.9	96-110	84-96	Moderate
3	945-964	27.9 - 28.5	111-130	97-113	Extensive
4	920-944	27.2 - 27.9	131-155	114-135	Extreme
5	< 920	<27.2	>155	>135	Catastrophic

TABLE 2-2
SAFFIR/SIMPSON HURRICANE CATEGORY DAMAGE SCALE

Category 1. Winds of 74 to 95 miles per hour. Damage occurs primarily to shrubbery, trees, foliage, and mobile homes. No real wind damage occurs to other structures. There is some damage to poorly constructed signs. Low-lying coastal roads are inundated, minor pier damage; some small craft in exposed anchorage areas are torn from moorings.

Category 2. Winds of 96 to 110 miles per hour. Considerable damage occurs to shrubbery and tree foliage; some trees blown down. Major damage occurs to exposed mobile homes. Extensive damage too poorly constructed signs. Some damage to roofing materials of buildings; some window and door damage. No major wind damage to buildings. Considerable damage could occur to piers. Marinas are usually flooded. Small craft may be torn from moorings.

Category 3. Winds of 111 to 130 miles per hour. Foliage is likely to be torn from trees; large trees blown down. Practically all poorly constructed signs blown down. Some damage to roofing materials of buildings; some window and door damage. Some structural damage is likely to small buildings. Mobile homes are frequently destroyed. Serious flooding occurs at the coast and many smaller structures near the coast are destroyed. Battering waves and floating debris often damage larger structures near the coast.

Category 4. Winds of 131 to 155 miles per hour. Many shrubs and trees are blown down and most street signs are damaged. Extensive damage to roofing materials, windows, and doors is expected. Complete failure of roofs on many small residences is likely. Complete destruction of mobile homes is almost certain. Major damage to lower floors of structures near the shore can be expected from flooding and battering by waves and floating debris. Major erosion of beaches is likely.

Category 5. Winds greater than 155 miles per hour. Shrubs and trees are blown down; considerable damage to roofs of buildings and all signs are damaged or destroyed. There would be very severe and extensive damage to windows and doors. Complete failure of roofs on many residences and industrial buildings can be expected. Extensive shattering of glass in windows and doors would occur. Some complete building structure failures may occur. Small buildings may be overturned or blown away. Complete destruction of mobile homes is probable.

STORM SURGE

a. Introduction

Storm surge is the abnormal rise in water level caused by wind and pressure forces of a hurricane. Storm surge produces most of the flood damage and drowning associated with tropical storms. A numerical storm surge model has been created for the Mississippi coastal area. The model calculates sea, lake and overland surges from hurricanes and has the acronym "SLOSH."

The output of the SLOSH-model provides heights of storm surge for various combinations of hurricane strength, forward speed of storm, and direction of storm. Storm strength is modeled by use of the central pressure and storm eye size using the five categories of storm intensity. Nine storm-track headings and three speeds were selected as being representative of storm behavior in this region.

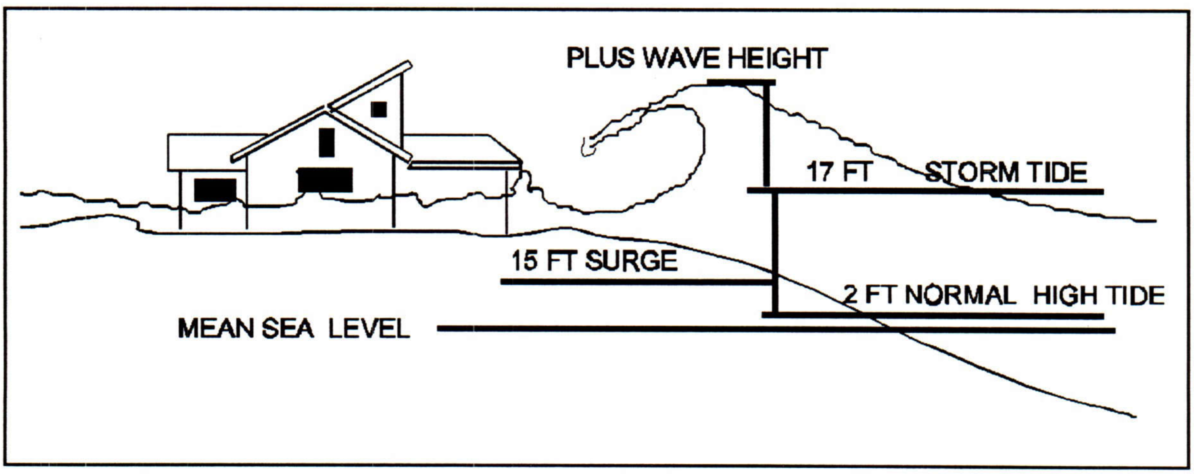
Various storm events can cause abnormally high water levels along ocean coasts and interior shorelines. These higher than expected water levels, known as storm surges, are generally the result of a synoptic scale meteorological disturbance. Storm surges can affect a shoreline over distances of more than 100 miles; however, there may be significant spatial variations in the magnitude of the surge due to local bathymetric and topographic features. Wind is the primary cause of storm surge. Wind blowing over the surface of the water exerts a horizontal force that induces a surface current in the general direction of the wind. The surface current, in turn, forms currents in subsurface water. In the case of a hurricane, the depth affected by this process of current creation depends upon the intensity and forward motion of the storm. For example, a fast-moving hurricane of moderate intensity may only induce currents to a depth of a hundred feet, whereas a slow moving hurricane of the same intensity might induce currents to several hundred feet. As the hurricane approaches the coastline, these horizontal currents are impeded by a sloping continental shelf, thereby causing the water level to rise. The amount of rise increases shoreward to a maximum level that is often inland from the usual coastline.

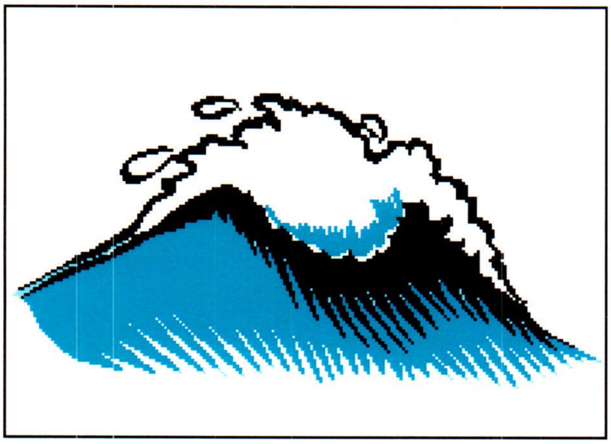
b. Factors Affecting Surge Height

The elevation reached by the storm surge within a coastal basin depends upon the meteorological parameters of the hurricane and the physical characteristics existing within the basin. The meteorological parameters affecting the height of the storm surge include the intensity of the hurricane; measured by the storm-center sea-level pressure, track (path) of the storm, forward speed, and radius of maximum winds. Due to the complementary effects of forward motion and the counterclockwise rotation of the wind field, highest surges from a hurricane usually occur on the northeast quadrant of the storm's track. This radius of maximum winds, which is measured from the center of the hurricane eye to the location of the highest wind speeds within the storm, can vary from as little as four miles to as much as 50 miles or greater. Peak storm surge may vary drastically within a relatively short distance along the coastline depending on the radius of maximum winds and the point of hurricane eye landfall. The physical characteristics of a basin that influence the surge heights include the basin bathymetry (water depths), roughness of the continental shelf, configuration of the coastline, and natural or man-made barriers. A wide, gentle sloping continental shelf or a large bay may produce particularly large storm surges.

c. Total Flood Elevation

Other factors that contribute to the total water height are the initial water level within the basin at the time the hurricane strikes and wave effects. Storm surge is defined as the difference between the observed water level and the normal astronomical tide. Any astronomical tide level above the mean is additive to the storm surge. The timing of the arrival of storm surge is important in that the difference in total flood elevation can be as much as 1 to 2 feet in the study area.

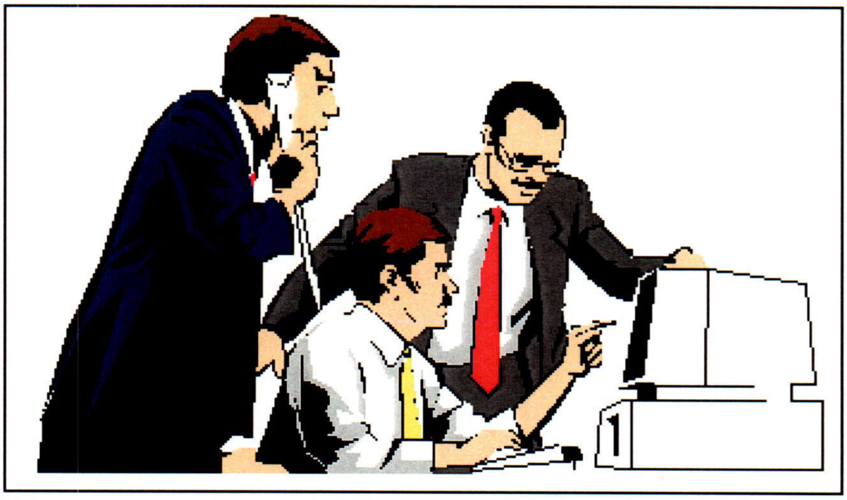




Waves breaking near the shore cause a transport of water shoreward. When there is an increase in wave height water cannot flow back to the sea as rapidly as it came in. This phenomenon, known as "wave setup", increases the water level along the beachfront. Waves will break and dissipate their energy in shallow water. Therefore, a relatively steep offshore beach slope allows large ocean waves to get closer to the shore before breaking and usually promotes larger waves. Wave setup is primarily a concern near the beachfront because waves are generally not transmitted inland of the coastline even if the beach has been overtopped.

THE SLOSH COMPUTER MODEL

a. General



The Sea, Lake, and Overland Surge from Hurricanes (SLOSH) model was developed by the National Weather Service to calculate potential surge heights from hurricanes. Jelesnianski and Taylor developed the hurricane model, which drives the storm surge model. The SLOSH model is used for real-time forecasting of surges from approaching hurricanes within selected Gulf and Atlantic Coastal Basins. In addition to computing surge heights for the open coast, the SLOSH model has the added capability to simulate the routing of storm surge into sounds, bays, estuaries, and coastal river basins, as well as calculating surge heights for overland locations. Significant natural and man-made barriers are represented in the model and their effects simulated in the calculations of surge heights within a basin.

The SLOSH model uses time-dependent meteorological data to determine the driving forces of a simulated storm. These data are as follows:

(1) Central barometric pressure at 6-hour intervals.

(2) Latitude and longitude of storm positions at 6-hour intervals.

(3) The storm size measured from the center (eye) to the region of maximum winds. Wind speed is not an input parameter, since the model calculates a wind-field for the modeled storm based on meteorological input parameters.

The height of the water surface well before the storm directly affects the area of interest is also required. This initial height is the observed water surface height occurring about two days before storm arrival. Astronomical high tide was not set in the model.

The values or functions for the coefficients within the SLOSH model are generalized to serve for modeling all storms within all basins and are set empirically through comparisons of computed and observed meteorological and surge height data from numerous historical hurricanes. The coefficients are a function of differing storm parameters and basin characteristics. Calibration of the model based on a single storm event within a basin is avoided since there is no guarantee that the same coefficient values will serve as well for other storms.

b. Mississippi Sound SLOSH Grid

Figure 2-1 illustrates the area covered by the grid for the Mississippi Sound SLOSH model. The area covered by the grid is called a "basin"--the "Mississippi Sound Basin." The grid is a telescoping hyperbolic coordinate system with 120 arc lengths and 120 radials. This type grid is used to put more grid cells over land for better surge delineation but still have a large water body covered for adequate calculations.

The telescoping grid provides a large geographical area with detailed land topography. The smallest grid represents an area of about 0.01 square miles. This permits inclusion of topographic details such as highway and railroad embankments, causeways, levees, etc. The largest grid cell is about 14 square miles. The grid is tangent to the earth at 30 degrees 28'55"N and 89 degrees 04'52"W. The basin center is located at 30 degrees 28'16"N and 89 degrees 09'11"W.

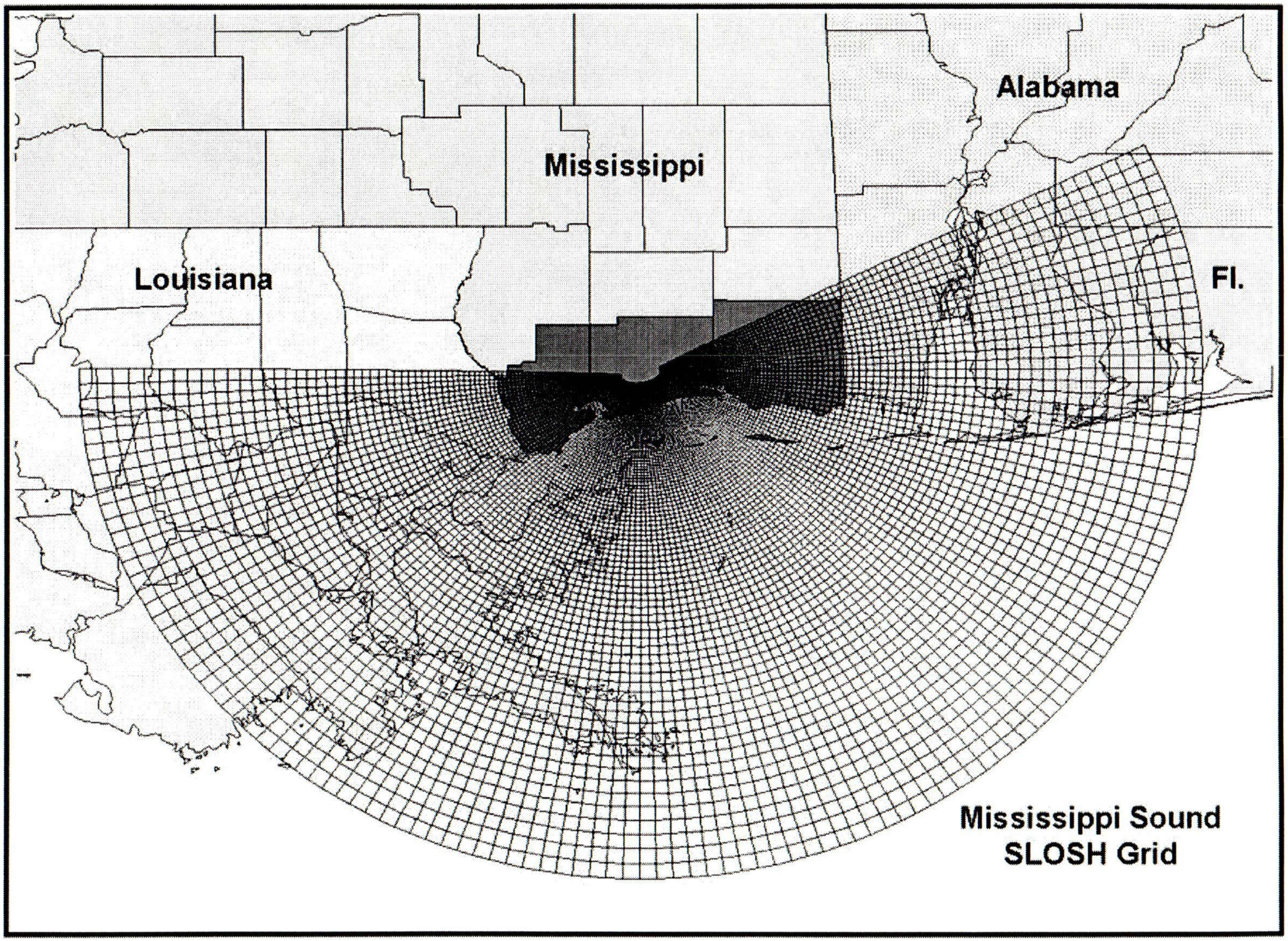
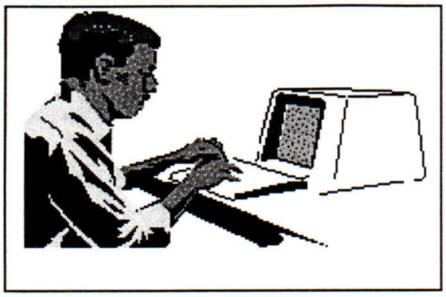


FIGURE 2-1 MISSISSIPPI SOUND SLOSH GRID

c. Verification of the Model



After a SLOSH model has been constructed for a coastal basin, verification is conducted with real-time runs of historical storms. The computed surge heights are compared with those measured from historical storms and, if necessary, adjustments are made to the input or basin data. In instances where the model has given realistic results in one area of a basin, but not in another, closer examination has often revealed inaccuracies in the representation of barrier heights or missing values in bathymetric or topographic data. The actual high water marks from Hurricane Georges were used to calibrate the Mississippi Sound SLOSH Model.

THE MISSISSIPPI SOUND MODELING PROCESS

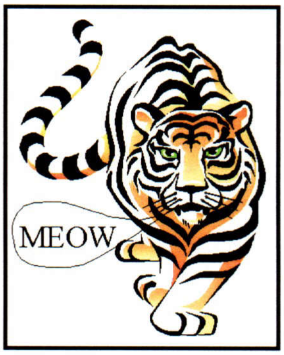
A total of 2445 hypothetical hurricanes were run through the Mississippi Sound SLOSH Model. The characteristics of the simulated hurricanes were determined from an analysis of historical hurricanes. The selected storms varied in intensities, forward speeds and approach directions. The 2445 storms are summarized in Table 2-3. The tracks are graphically presented on Plates 2-1 through 2-9 at the end of this chapter. The simulated hurricanes included Category 1 through Category 5 hurricane intensities and nine approach directions. Forward speeds of 5, 15 and 25 miles per hour were used. The radius of maximum winds specified for all the simulated hurricanes at landfall was 25 miles.

TABLE 2-3
MISSISSIPPI SOUND HYPOTHETICAL STORM SCENARIOS

Direction	Speed (mph)	Intensities	Tracks	Runs	MEOWS
W	5, 15, 25	Cat. 1-5	15	225	15
WNW	5, 15, 25	Cat. 1-5	16	240	15
NW	5, 15, 25	Cat. 1-5	21	315	15
NNW	5, 15, 25	Cat. 1-5	22	330	15
N	5, 15, 25	Cat. 1-5	22	330	15
NNE	5, 15, 25	Cat. 1-5	21	315	15
NE	5, 15, 25	Cat. 1-5	18	270	15
ENE	5, 15, 25	Cat. 1-5	13	195	15
E	5, 15, 25	Cat. 1-5	16	225	15
			TOTAL	2445	135

After making landfall, most hurricanes weaken because the central pressure and radius of maximum winds increase. This was taken into account in modeling each of the storm tracks. The initial sea surface height set in the Mississippi Sound SLOSH model was 1.25 foot. This initial height, known as tide anomaly, represents the height of the water surface above M.S.L. existing several days in advance of approaching hurricanes. Furthermore, to simulate conditions at high tide, an additional .75-foot was included. Thus all SLOSH runs of hypothetical hurricanes were supplied with initial datum of 2.0 feet M.S.L., and the resulting calculations of storm surge represent conditions at time of high tide.

MAXIMUM ENVELOPS OF WATER (MEOWS)



The maximum surge in the affected area is called the peak surge. The location of the peak surge depends on where the eye of a hurricane crosses the coastline, storm intensity, the shape of the coastline, the approach direction, and the radius of maximum winds. The peak surge from a hurricane usually occurs to the right of the storm path and within a few miles of the radius of maximum winds.

Due to the inability to precisely forecast the landfall location for a hurricane, the National Hurricane Center developed MEOWs (Maximum Envelopes of Water). A MEOW stores the maximum water surface elevation in each grid cell for all the hurricane tracks in one direction for a particular forward speed, and storm intensity. There are 135 MEOWs for the Mississippi Sound SLOSH Basin.

The results of the 135 original MEOWs were analyzed to determine which changes in storm parameters (i.e., intensity, approach speed, and approach direction) resulted in the greatest differences in the values of the peak surges for all locations and those that could reasonably be combined to facilitate evacuation decision-making. Changes in storm category accounted for the greatest change in peak surge heights. Therefore, the National Hurricane Center was asked to compile groups of MEOWs by category.

The National Hurricane Center subsequently created MOMs (MEOWs of MEOWs), which eliminate consideration of hurricane approach speed and direction but maintaining the separation of categories 1, through 5 storms. The MOMs basically represent the maximum water surface elevation for each grid cell regardless of approach direction, forward speed or track. The MOMs were used to develop the hurricane surge maps, shown on Plates 2-10 through 2-12. These hurricane surge inundation maps depict maximum storm surge heights that could be generated by the five hurricane categories, without regard to approach speed, direction, or track.

TIME-HISTORY POINT DATA

The time-history information produced by the SLOSH model includes still-water surge heights, wind speeds, and wind direction at 30-minute intervals for 72 hours. Emergency Management Directors selected time history points for key locations in their county. They are located at low-lying roads and bridges that would be critical to an evacuation, at potentially vulnerable population centers, or at significant natural or manmade barriers. Figures 2-2 though 2-4 shows the location of time history points for each coastal county. Tables 2-4 through 2-6 show the maximum surge heights for each time history point for the category 1 through 5 hurricane.

The purpose of the time-history data is to determine the pre-landfall hazard distances for each of the counties within the study area. Pre-landfall hazard distance is the distance from the eye of an approaching hurricane to each jurisdiction at the time an evacuation would be curtailed by hazardous weather conditions. This distance must be accounted for in timing evacuation decision-making. For this hurricane evacuation study, two specific conditions were evaluated: the arrival of sustained gale-force winds (34-knot sustained wind speed, 1-minute average) and the onset of storm surge inundation of low-lying roads, bridges, or other critical areas. The first of these two conditions to occur determines the pre-landfall hazard distance.

The time of arrival of sustained tropical storm winds is one selected goal for completing an evacuation because high-profile vehicles and vehicles pulling campers or boats could easily be overturned, especially on high-rise bridges. Such an accident would most certainly cripple or halt traffic flow on that evacuation route. The arrival of sustained tropical force winds is also the time, under the majority of hurricane threats, when heavy rainfall begins. Generally, one-half of the total amounts of rainfall received from a hurricane occur from the arrival of sustained tropical storm winds until the eye reaches the coastline.

Storm surge inundation is the other condition limiting evacuation, but should not be a significant factor in most of the study area prior to the arrival of sustained tropical storm winds. The lowest roadway elevations in the study area should be considered when determining the pre-landfall hazard distance. As discussed previously, evacuation decision-making officials should be aware that the coincidental occurrence of astronomical high tide and rising storm surge could cause moderate flooding in low-lying areas, particularly on causeways, prior to the arrival of sustained tropical storm winds.

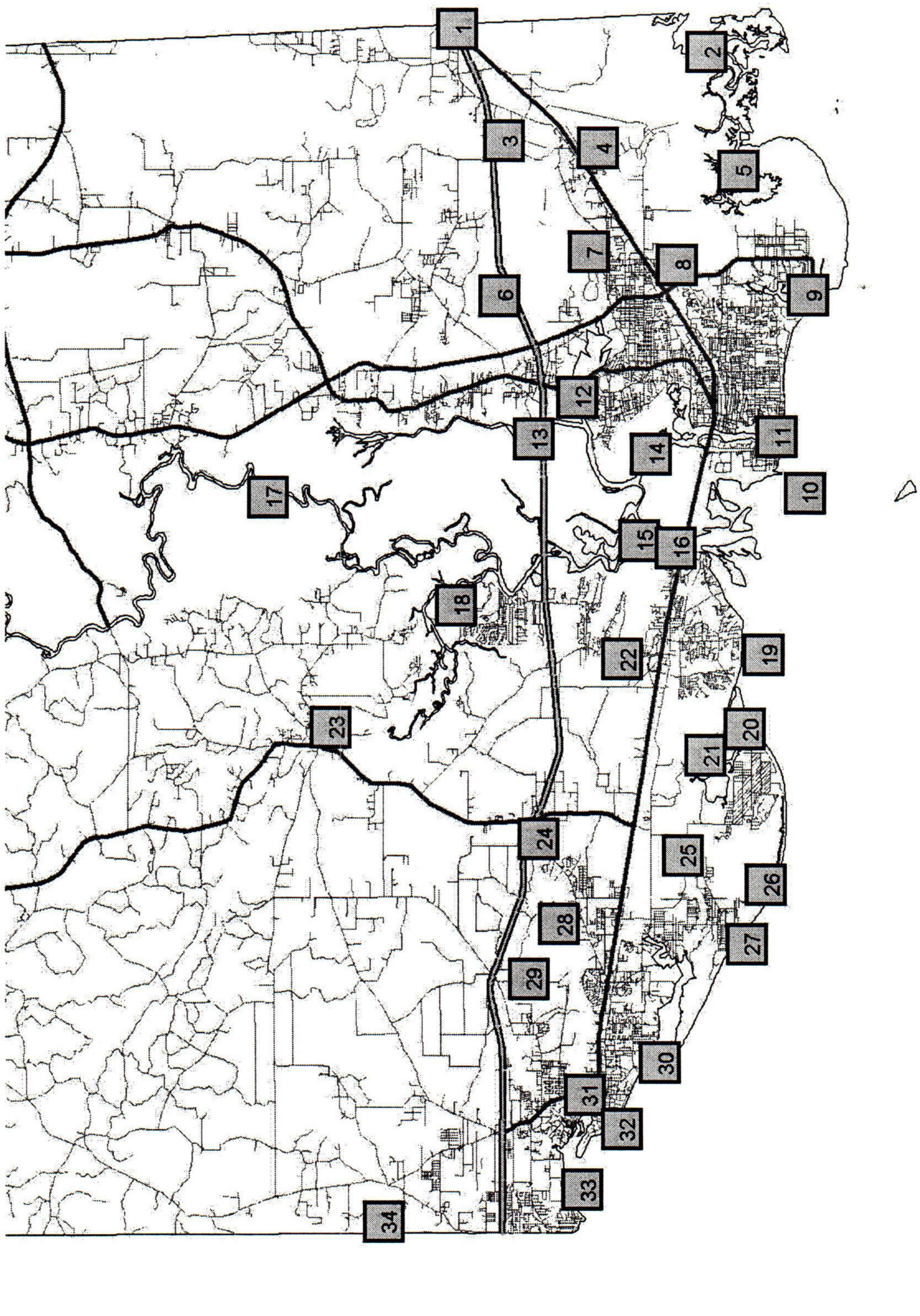


FIGURE 2-2 JACKSON COUNTY TIME HISTORY POINTS

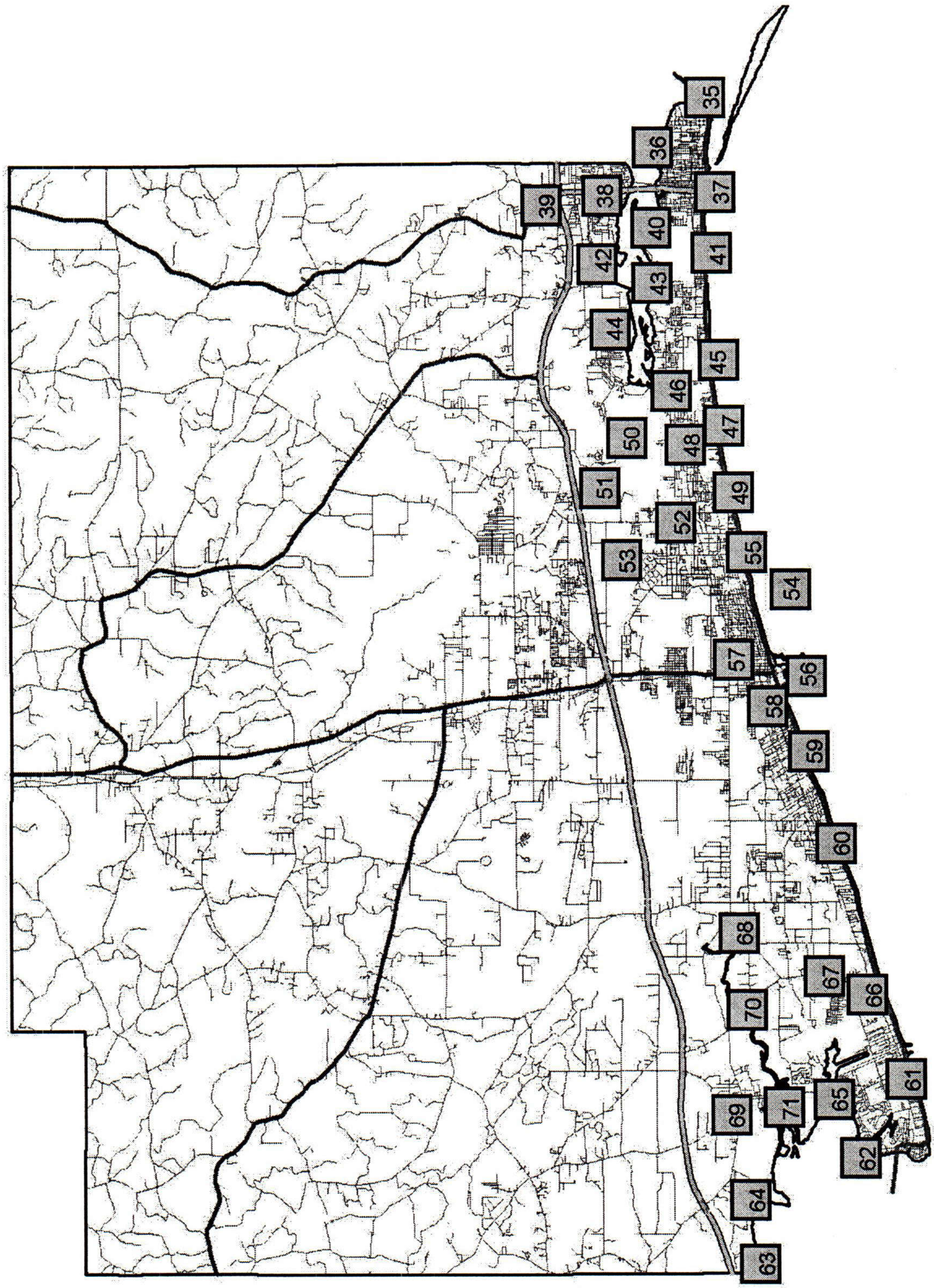


FIGURE 2-3 HARRISON COUNTY TIME HISTORY POINTS

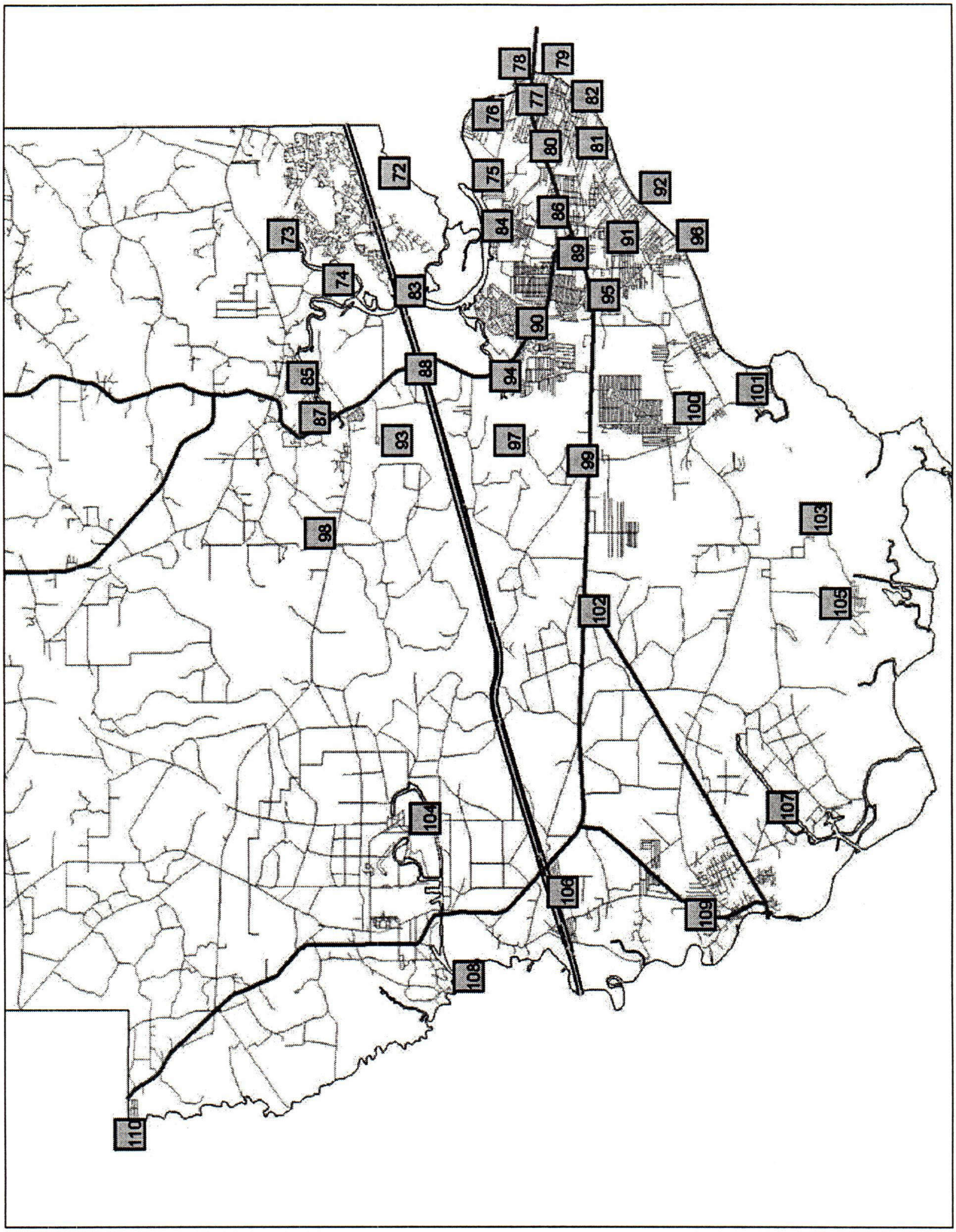


FIGURE 2-4 HANCOCK COUNTY TIME HISTORY POINTS

TABLE 2-4
JACKSON COUNTY TIME HISTORY POINTS

		Surge Elevation in Feet NGVD				
Point#	Time History Point Name	CAT 1	CAT 2	CAT 3	CAT 4	CAT 5
1	Franklin Crk Interchange: Us 90 & I-10	7.1	12.2	17.3	22.2	26.7
2	Middle Bay	7.2	12.4	15.8	19.2	23.0
3	Escatawpa River @ Interstate 10	7.1	12.3	17.5	22.4	26.8
4	Orange Grove	7.5	12.8	16.6	21.0	25.2
5	Bayou Cumbest	7.3	12.3	16.0	19.0	22.8
6	Black Creek @ Interstate 10	3.1	8.7	17.7	22.3	26.8
7	International Paper	3.3	11.8	16.6	21.2	25.3
8	Old Mobile Hwy @ Hwy 611	7.4	12.6	16.3	19.9	23.9
9	Chevron USA Refinery	7.2	11.9	15.6	18.8	22.2
10	Naval Station Pascagoula	7.3	12.3	15.5	19.5	23.2
11	Pascagoula Beach	7.4	12.3	15.5	19.5	23.3
12	Downtown Moss Point	4.2	11.0	17.1	21.5	25.7
13	Escatawpa	4.8	10.1	17.5	21.9	26.2
14	Krebs Lake	4.9	9.6	16.2	20.7	24.7
15	Mary Walker Bayou	5.2	9.8	16.3	20.9	25.1
16	West Singing River	6.2	10.0	16.1	20.6	24.8
17	Three River	5.3	10.2	15.9	22.6	27.9
18	Hickory Hills	5.2	10.2	18.8	23.0	27.5
19	Gautier Beach Front	7.6	13.3	16.8	20.9	25.0
20	Ocean Beach Estates	7.6	13.5	17.8	21.8	25.7
21	Graveline Bay	7.1	13.6	18.4	22.3	26.2
22	Singing River Mall	7.0	10.0	16.6	21.5	26.0
23	Vancleave High School	4.2	10.4	19.2	24.0	29.0
24	Interstate 10 & Highway 57	10.4	12.1	15.7	21.8	27.3
25	Gulfpark	7.1	13.8	19.4	23.4	27.2
26	Belle Fontaine Point	8.1	13.7	18.7	22.8	26.8
27	West Pointe-Aux-Chennes	8.4	14.2	19.3	23.5	27.5
28	Old Fort Bayou, East	10.4	12.1	18.0	24.5	28.6
29	St. Martins High School	10.4	12.1	21.4	25.2	30.5
30	Marsh Point	9.1	15.5	20.7	25.2	29.6
31	Old Fort Bayou	9.7	16.5	21.2	26.7	30.8
32	Biloxi - Ocean Springs Bridge	9.2	15.8	21.1	26.2	30.4
33	Saint Martin	9.6	16.2	21.5	26.5	30.8
34	Latimer	5.2	11.5	14.6	23.1	28.4

TABLE 2-5
HARRISON COUNTY TIME HISTORY POINTS

Point#	Time History Point Name	Surge Elevation in Feet NGVD CAT 1	CAT 2	CAT 3	CAT 4	CAT 5
35	Point Caddie	9.1	15.6	20.9	25.7	29.9
36	Back Bay	9.7	16.0	21.5	26.3	30.5
37	Interstate 110 & Us 90	9.2	15.6	21.0	25.7	30.1
38	D'iberville High School	8.5	15.7	22.0	26.4	30.2
39	Interstate 10 & Hwy 15 & 67	5.1	11.1	16.7	22.8	27.5
40	Keesler Med Cntr; Dept Marine Resrs	9.0	15.5	21.8	25.9	29.6
41	Biloxi High School	9.3	15.7	21.3	25.9	30.2
42	D'iberville Elementary School	7.9	15.3	22.0	25.7	29.0
43	V.A. Hospital, Biloxi	7.5	15.0	21.8	25.1	28.2
44	Watersview	7.5	14.7	21.7	24.8	27.7
45	Coliseum	9.3	15.7	21.4	26.4	31.2
46	Popps Ferry Elementary School	9.4	15.8	21.4	26.4	26.6
47	Gulf Coast Medical Center	9.4	15.8	21.6	26.7	30.7
48	Fernwood Elementary School	9.4	15.8	21.6	26.7	28.3
49	Lorraine & Us 90	9.5	15.9	22.0	27.1	31.2
50	Big Lake	5.9	11.0	15.9	22.3	27.4
51	Biloxi River	5.9	11.0	16.1	22.4	27.7
52	Bayou Bernard	6.0	11.1	15.7	22.2	27.6
53	Seaway And Lorraine	5.9	11.2	15.4	21.8	27.5
54	V.A. Hospital, Gulfport	9.5	15.9	22.0	27.2	31.5
55	Courthouse & Us 90	9.5	15.9	22.0	27.1	31.6
56	Us 90 & Hwy 49	9.4	15.7	21.8	27.0	30.9
57	Emergency Operations Center	9.4	15.8	21.8	27.1	31.0
58	Memorial (Columbia Garden) Hospital	9.4	15.7	21.8	27.1	30.6
59	Us 90 & Broad; Navy Battalion Base	9.2	15.6	21.6	26.6	30.6
60	Jeff Davis & US 90	9.0	15.4	21.2	25.8	29.9
61	Henderson Avenue & US 90	8.4	14.0	20.5	25.7	30.2
62	Mallini Point	8.0	13.8	20.3	25.4	30.1
63	Harrison Line	8.3	14.2	20.4	26.3	31.0
64	Dupont Chemical Plant	8.3	14.0	20.7	26.2	30.9
65	Henderson Avenue @ Bayou Portage	8.1	14.0	20.6	25.8	30.9
66	Menges Avenue & US 90	8.7	14.1	21.2	25.8	30.5
67	Dixie White House Nursing Home	8.0	14.1	21.3	26.3	31.2
68	Johnson Bayou & Pass Christian Isles	7.3	14.5	99.9	27.5	32.0
69	De Lisle Bayou	8.2	14.1	20.8	26.4	31.4
70	Kiln Road @ Wolfe River	7.9	14.1	21.8	27.7	32.2
71	Bayou Acadian	8.2	14.1	20.7	26.3	31.3

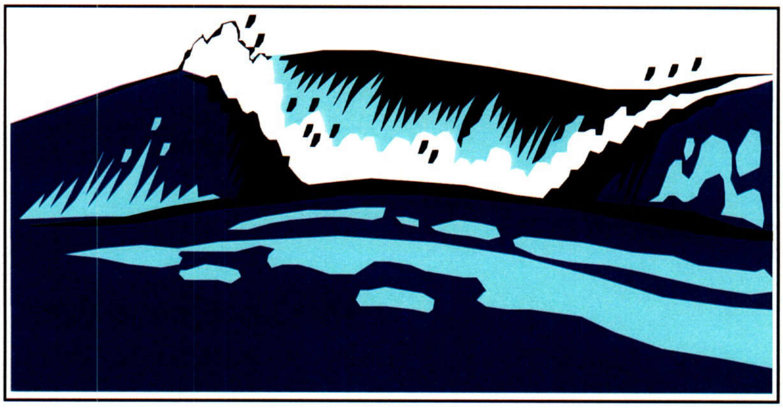
TABLE 2-6
HANCOCK COUNTY TIME HISTORY POINTS

Point#	Time History Point Name	Surge Elevation in Feet NGVD				
		CAT 1	CAT 2	CAT 3	CAT 4	CAT 5
72	Diamond Head Yacht Club	8.3	14.3	20.5	26.3	31.3
73	Fenton	8.5	14.7	21.3	28.9	33.8
74	Rotten Bayou	8.1	14.6	21.1	28.1	33.3
75	Casino Magic	7.7	13.8	19.8	25.4	30.3
76	North Bay Elem. - Dunbar Village N.H.	8.1	13.6	19.7	25.2	29.9
77	Notre Dame De La Mer Retirement Apts	8.1	13.5	19.8	25.2	29.8
78	Us 90 Bridge, West End	8.1	13.6	19.9	25.1	29.8
79	Hotel Reed Nursing Home	8.3	14.0	19.9	25.1	29.7
80	Hancock Medical Center	8.3	14.0	19.7	25.1	29.8
81	Fire & Police Dept; Senior Citizen's Ctr	8.3	14.0	19.7	25.2	29.7
82	St. Stanislaus/ Ola	8.3	14.0	19.9	25.0	29.4
83	Jourdan River Bridge, Interstate 10	8.0	14.4	20.7	27.1	32.2
84	Blue Meadow	7.8	13.8	19.8	25.6	30.6
85	Jourdan River Shores	7.9	14.2	21.4	28.1	33.6
86	Civic Center	7.8	13.8	19.7	25.0	30.0
87	Highway 603 At Jourdan River	7.8	13.9	21.4	28.1	33.5
88	Interstate 10 & Hwy 603	8.1	14.5	20.8	27.2	32.6
89	US 90 & Hwy 603; Walmart	7.8	13.7	19.6	25.0	29.9
90	Kiln Cutoff & Hwy 603	7.7	13.8	19.8	25.4	30.5
91	Waveland Elementary School	8.3	14.0	19.4	24.8	29.3
92	Downtown Waveland	8.3	14.2	19.6	24.5	29.0
93	Hancock H. S. - Stennis Int'l Airport	8.1	14.5	20.9	27.4	32.9
94	Hwy 43 & 603@ Bayou La Croix	7.8	14.1	20.2	25.9	31.2
95	Waveland Avenue & US 90	8.2	13.8	19.4	24.8	29.6
96	Buccaneer Park; Gulfside Assembly	8.2	14.1	19.4	24.3	28.6
97	Harbor Drive	8.0	14.1	20.1	26.1	31.2
98	Mccloud	7.8	13.5	21.6	27.7	33.0
99	Lakeshore & US 90	8.0	13.9	19.6	25.3	30.3
100	Gulf View Elementary	7.2	14.3	19.2	24.2	28.7
101	Bayou Caddy	8.2	14.1	19.0	23.8	28.1
102	US 90 & Hwy 607	8.0	13.9	19.3	24.5	29.9
103	Ansley	7.9	13.9	18.7	23.2	28.0
104	Nasa Stennis Space Center	7.9	14.1	20.2	26.0	31.1
105	Heron Bay	7.3	13.5	18.2	22.8	27.6
106	Interstate 10 & Hwy 607	4.7	10.9	19.4	22.6	28.8
107	Port Bienville	7.3	11.4	17.0	21.8	26.3
108	Gainesville & Napoleon	4.2	10.9	16.4	22.2	27.7
109	Pearlington School	7.0	11.3	16.4	21.5	26.2
110	Interstate 59 & Hwy 607	4.2	10.9	16.4	23.6	29.5

TROPICAL CYCLONE ADVISORY

Tropical cyclone advisories, produced by the National Hurricane Center every six hours, give the measured distance in nautical miles of the 34-knot (approximately 40 miles per hour), 1-minute sustained wind speed (tropical storm) from the eye of an approaching hurricane. These distances are given for the four quadrants of the storm (i.e., northwest, northeast, southeast, southwest). Forecasts of these distances for 12, 24, 36, 48, and 72 hours into the future are also given. The largest radius listed should be used for the pre-landfall hazard distance in evacuation decision-making. Further discussion of the application of the radius of gale force winds to hurricane evacuation decision-making is contained in Chapter 7, Decision Tools.

WAVE EFFECT



The SLOSH model does **not** provide data concerning the additional heights of waves generated on top of the still-water storm surge. Generally, waves do not add significantly to the area flooded and have little effect on the number of people that will be required to evacuate. Wave phenomena under hurricane conditions are not well understood, but it is believed that maximum wave heights occur near the time of landfall. Immediately along the coastline of very large sounds and estuaries, waves can increase the expected still-water depth by one-third or more. Due to the presence of barriers such as structures, dunes, or vegetation, the waves break and dissipate a tremendous amount of energy within a few hundred yards of the coastline. Buildings within that zone that are not specifically designed to withstand the forces of wave action are often heavily damaged or destroyed.

For evacuation planning purposes, it is perhaps more important to consider potential wave effects for less than sustained tropical storm winds. If wave heights above theoretical still-water levels exceed the elevations of roads, bridges, or other critical areas near the coastline, evacuation could be curtailed sooner than expected, increasing the pre-landfall hazards distance. Evacuation planners should be aware that low-lying sections of highway could be subject to some wave action and over-wash prior to the arrival of sustained tropical storm winds, especially with the coincidental occurrence of astronomical high tide.

HURRICANE WINDS

After hurricane Hugo in North Carolina and Andrew in south Florida it became apparent that storm surge was not the only life-threatening feature of hurricanes. Destructive hurricane force winds and tornadoes effected many inland counties as far as 100 miles from the coast. Studies by the National Hurricane Center (NHC) have resulted in modifying the Tropical Cyclone Advisory to include additional information to help inland counties prepare for threatening high wind conditions. An inland wind analysis option is included in the HURREVAC software program to assist inland communities in estimating when damaging winds might hit their county. The inland wind analysis should be used ONLY A FEW HOURS before the hurricane makes landfall. This is when the NHC track and wind-field forecast errors are relatively low.

FRESHWATER FLOODING

Amounts and arrival times of rainfall associated with hurricanes are highly unpredictable. For most hurricanes, rainfall begins near the time of arrival of sustained tropical storm winds and generally reaches maximum rainfall rates as the center passes by. Unrelated weather systems in advance of the hurricane can also contribute significant rainfall amounts within a basin. The 100-year floodplain boundaries for each county are shown on the National Flood Insurance Rate Maps (FIRM), which are published by the Federal Emergency Management Agency (FEMA).

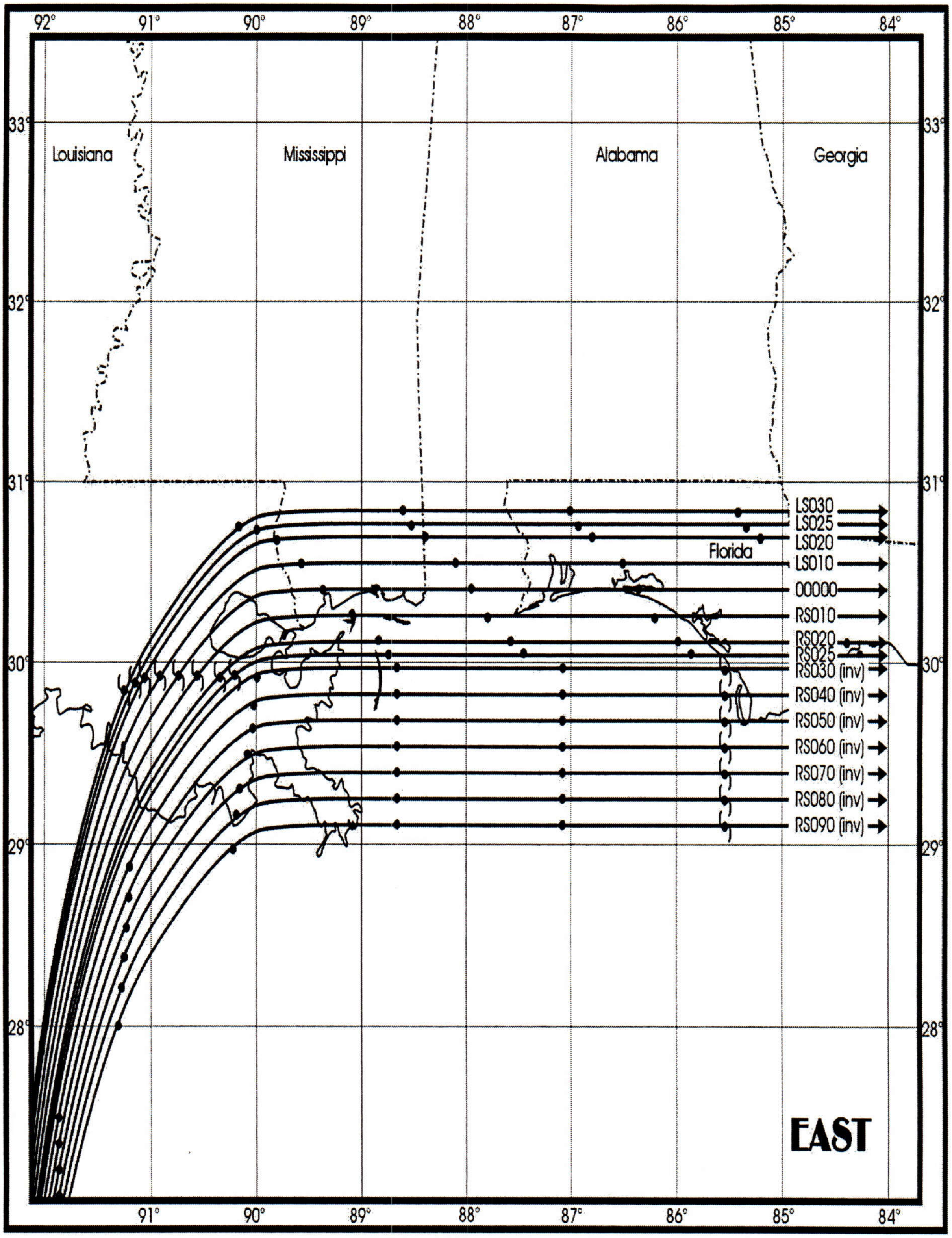


PLATE 2-1 HYPOTHETICAL STORMS MOVING EAST

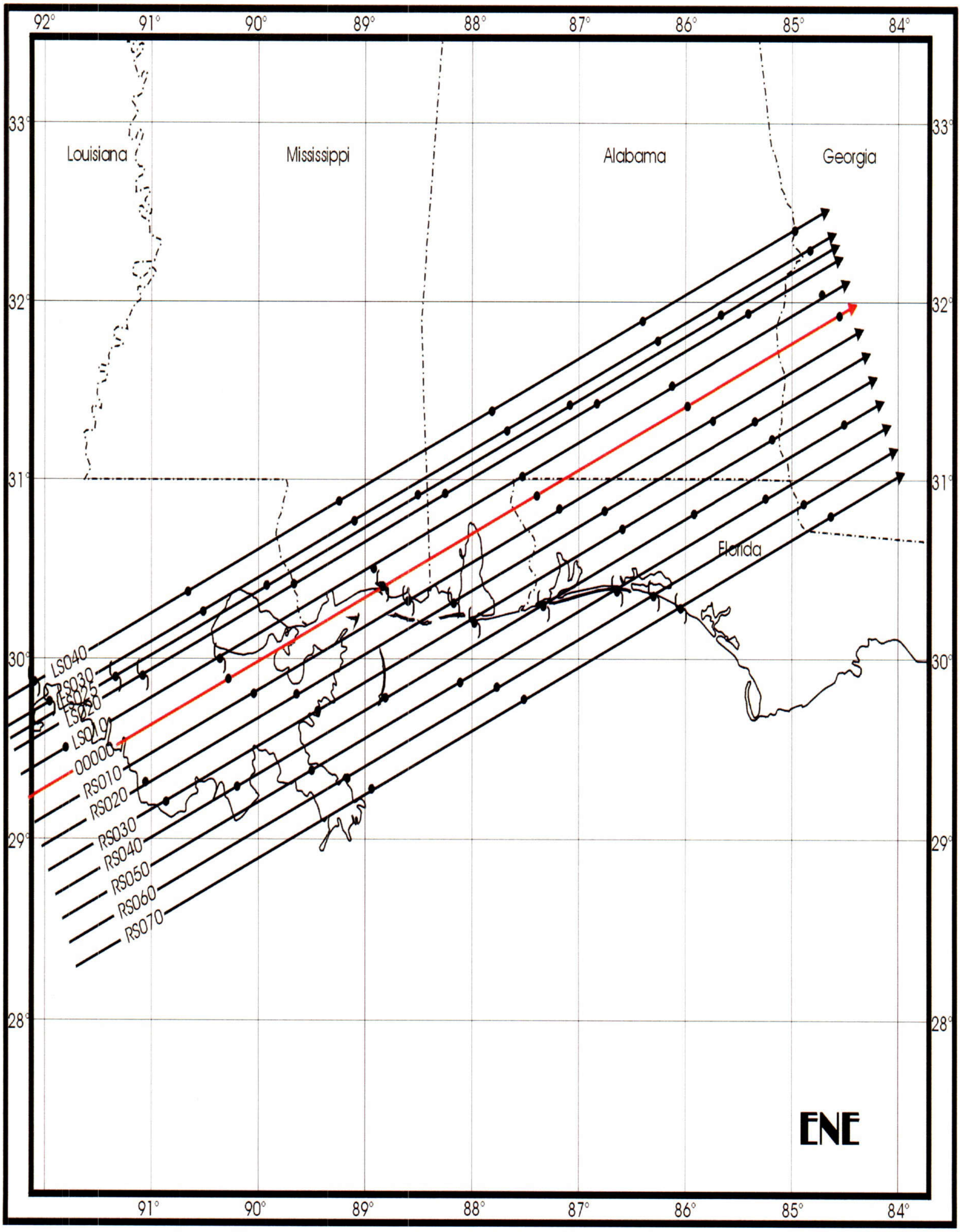


PLATE 2-2 HYPOTHETICAL STORMS MOVING EAST-NORTH-EAST

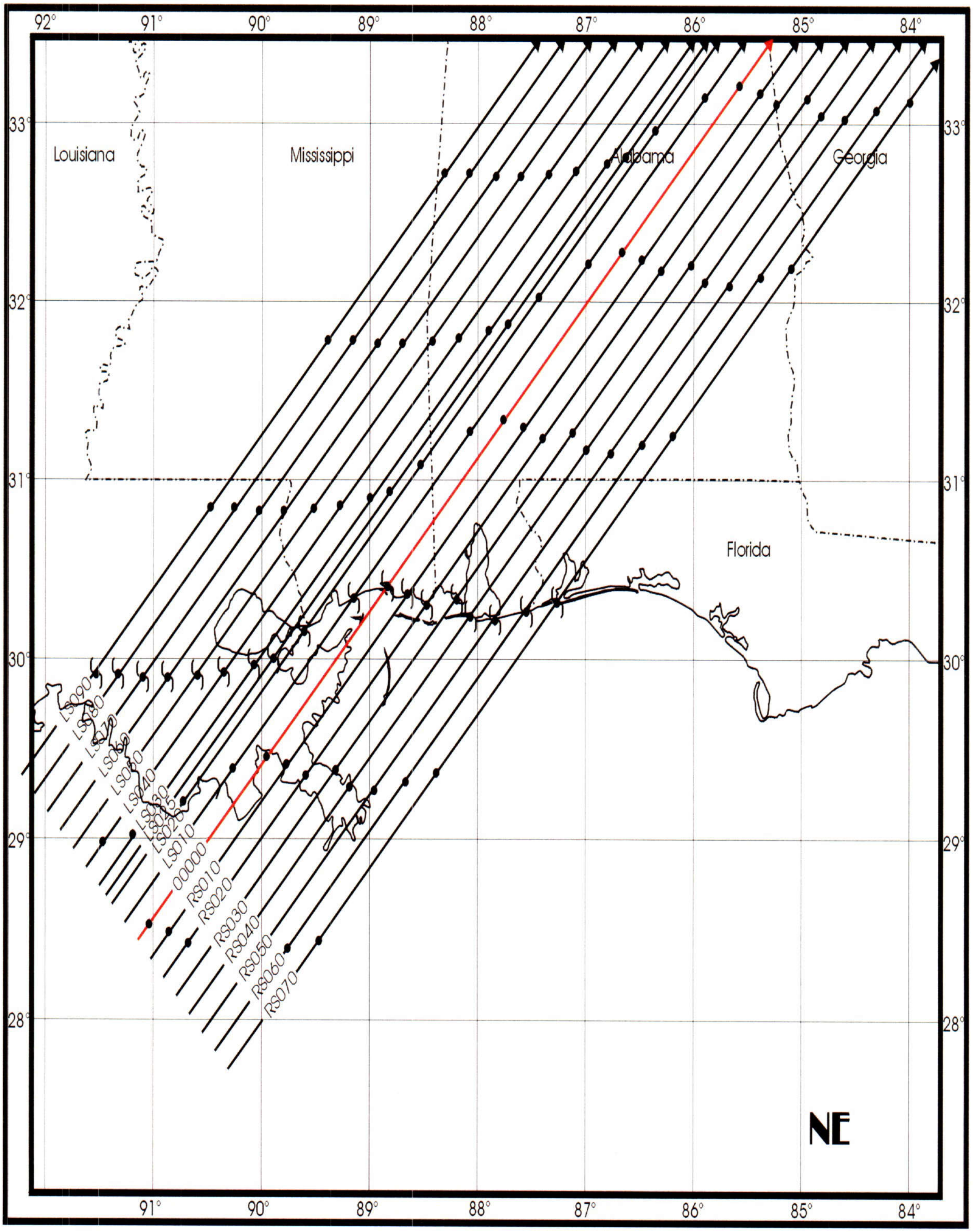


PLATE 2-3 HYPOTHETICAL STORMS MOVING NORTH-EAST

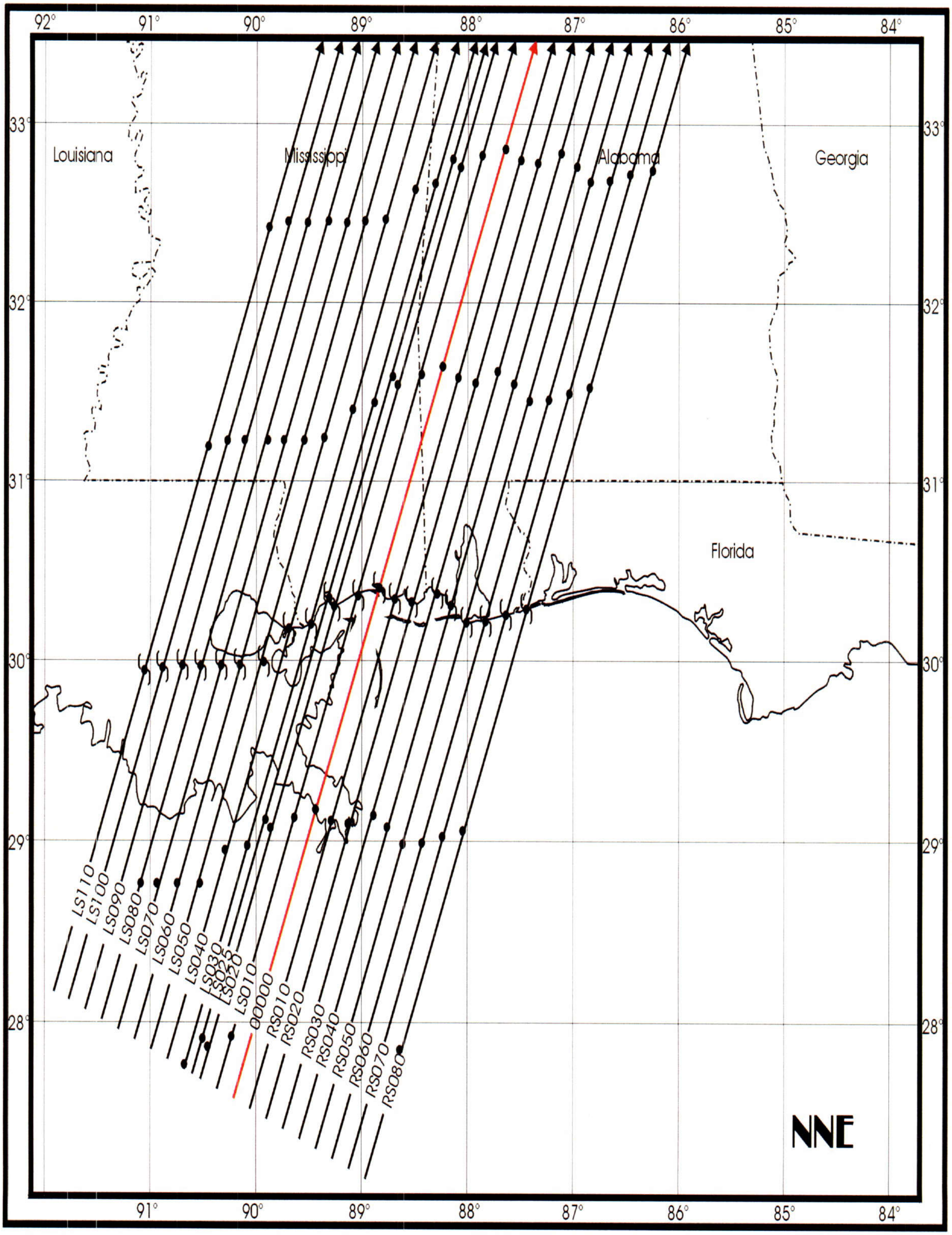


PLATE 2-4 **HYPOTHETICAL STORMS MOVING NORTH-NORTH-EAST**

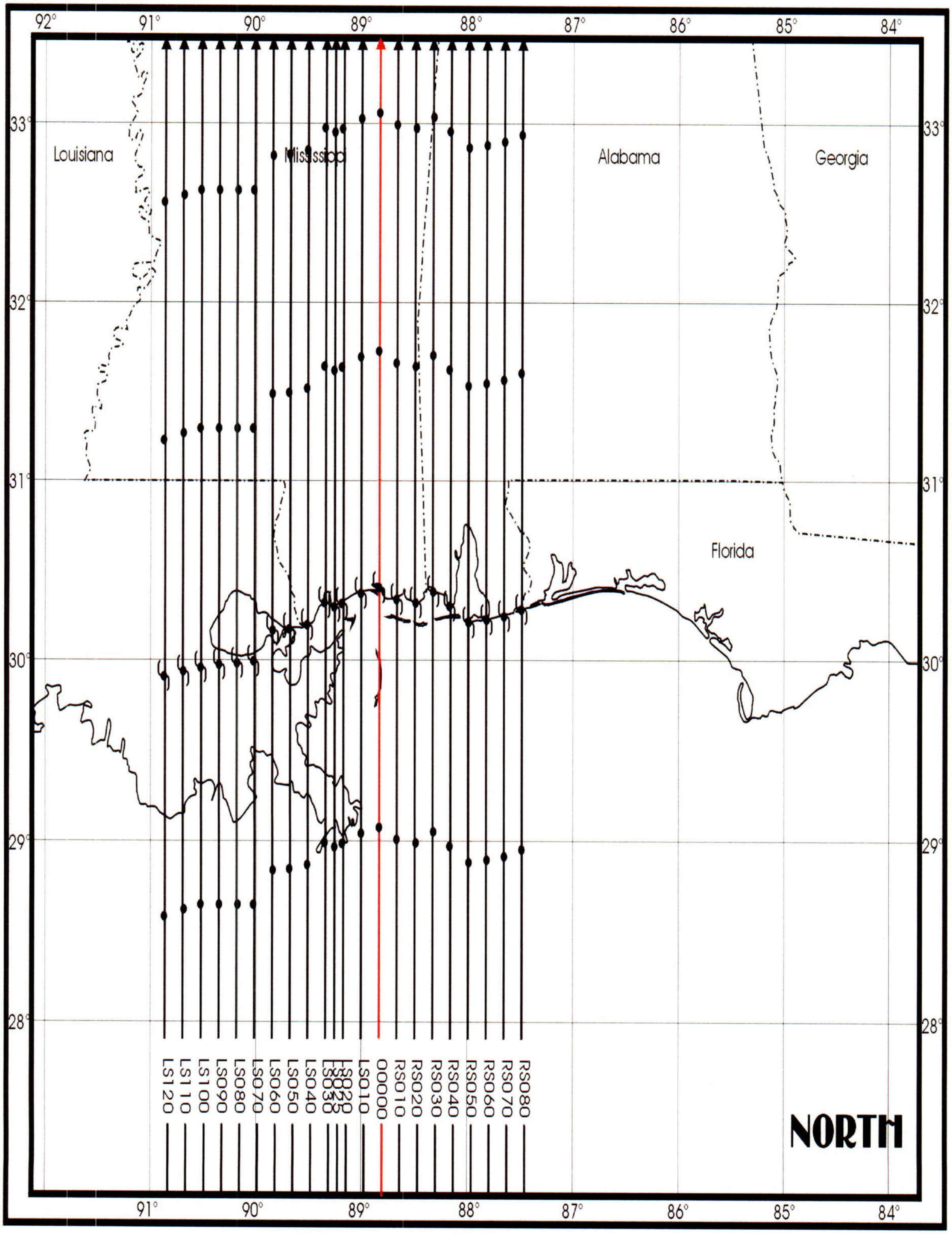


PLATE 2-5 HYPOTHETICAL STORMS MOVING NORTH

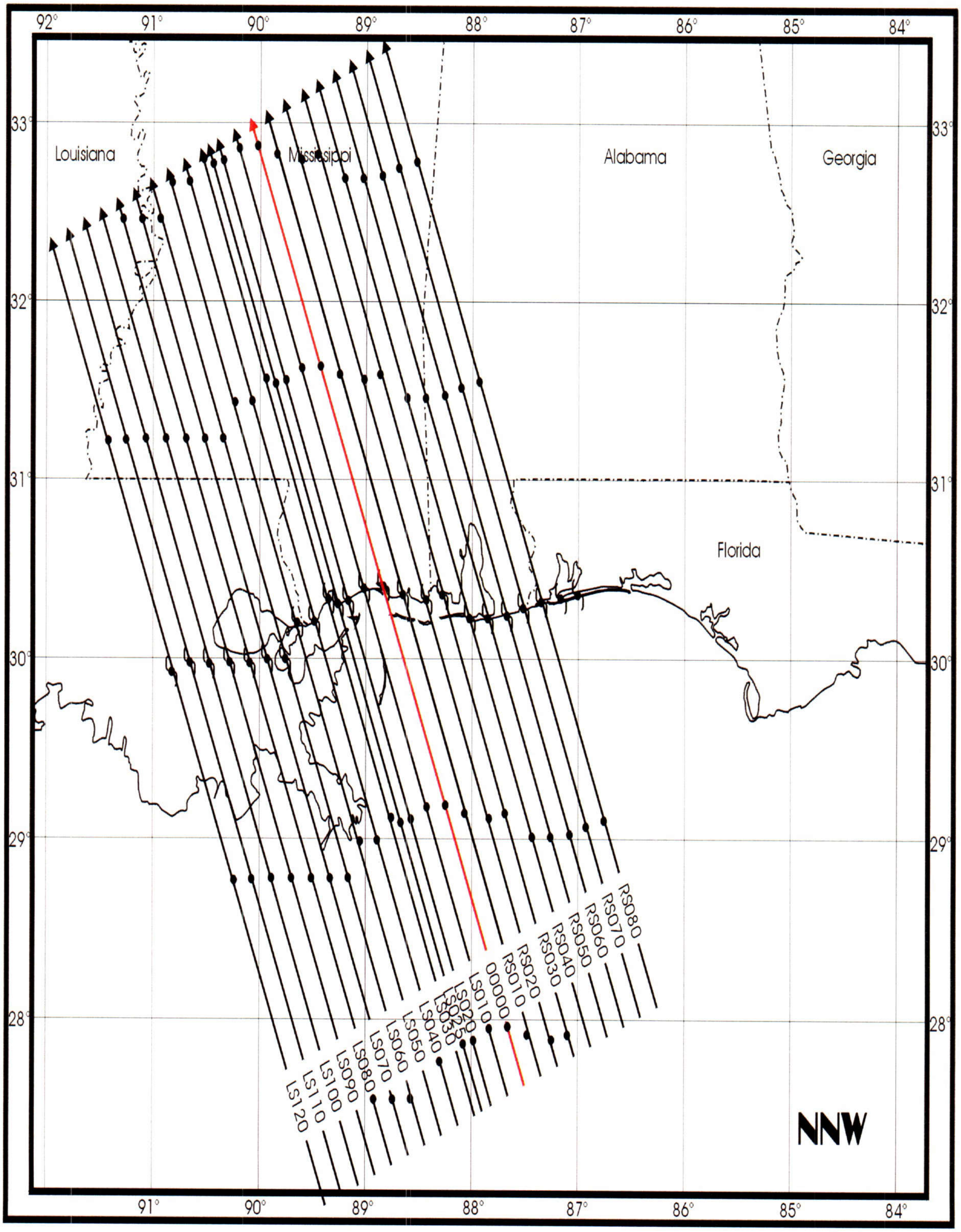


PLATE 2-6 **HYPOTHETICAL STORMS MOVING NORTH-NORTH-WEST**

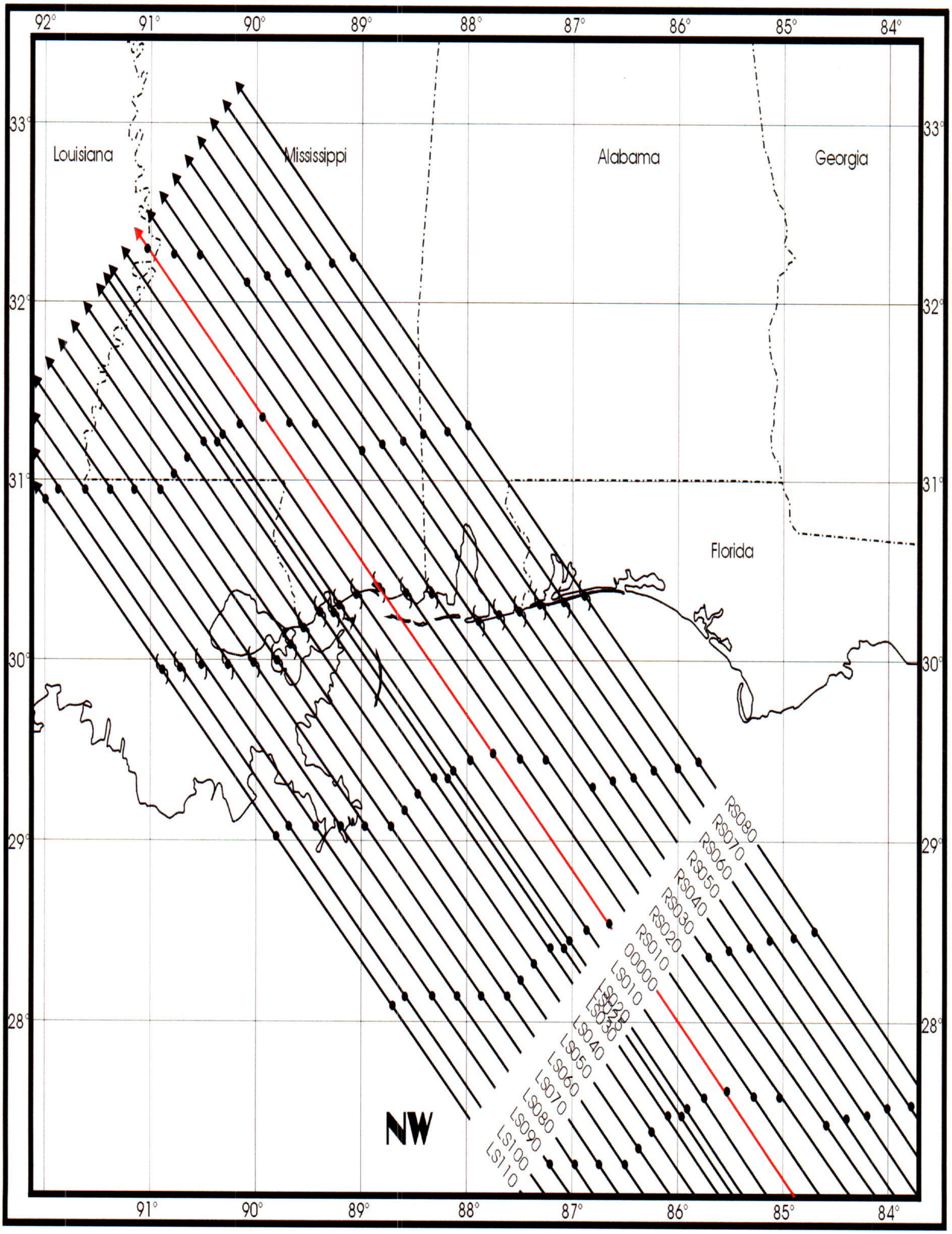


PLATE 2-7 HYPOTHETICAL STORMS MOVING NORTH-WEST

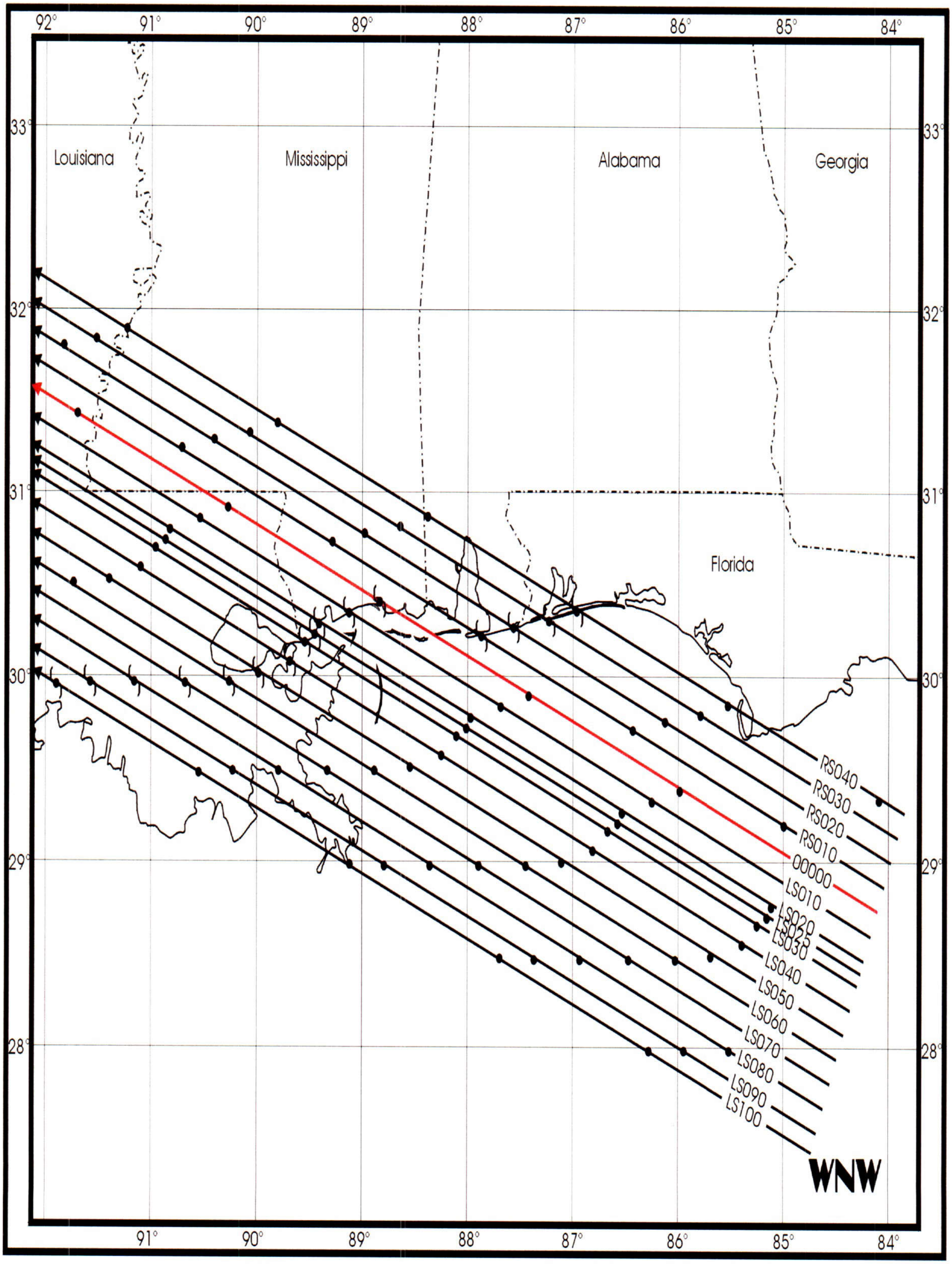


PLATE 2-8 HYPOTHETICAL STORMS MOVING WEST-NORTH-WEST

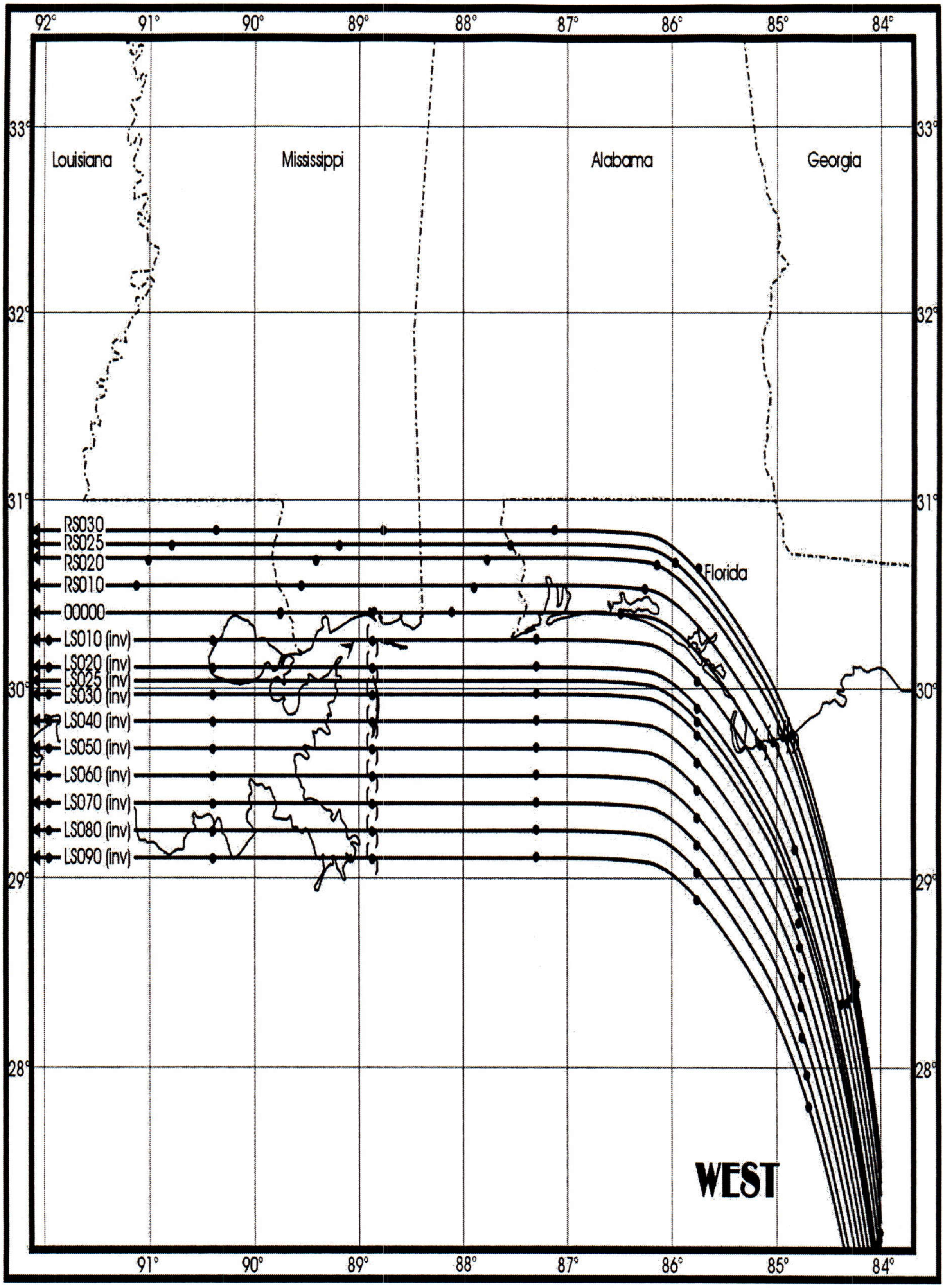
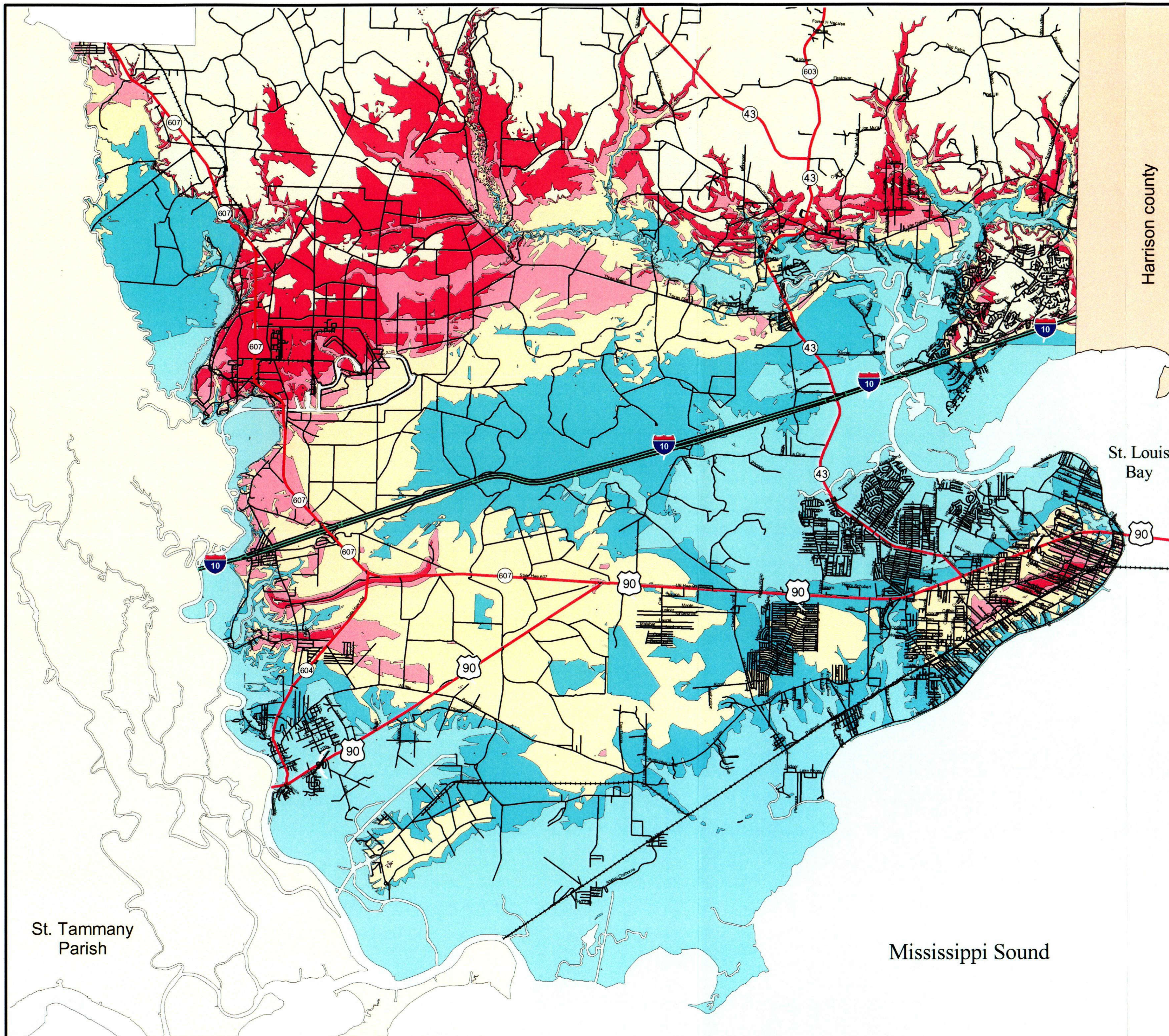


PLATE 2-9 HYPOTHETICAL STORMS MOVING WEST



LEGEND

- Streams
- Railroads
- Streets/Roads
  - Highways
  - Interstates
  - Roads
- Cat. 1 Surge
- Cat. 2 Surge
- Cat. 3 Surge
- Cat. 4 Surge
- Cat. 5 Surge

NOTES:

1. Surge limits are based on still water storm tide elevations above National Geodetic Vertical Datum (NGVD) estimated from a 1999 SLOSH model at mean high tide. No wave setup is included.

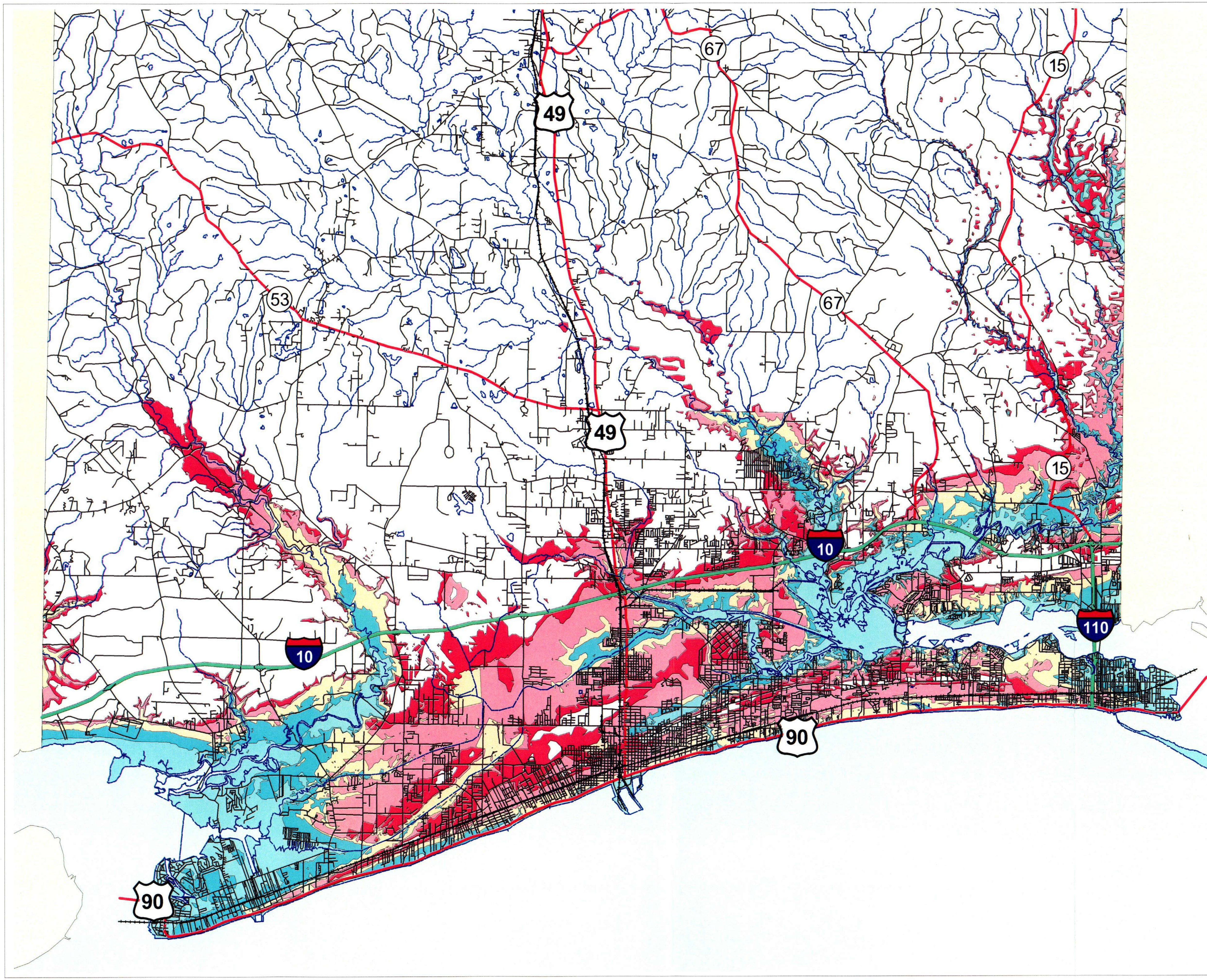
2. Source of base mapping is U.S.G.S. 1:100,000 scale maps and Tiger data.

3. Hurricane surge limits were determined by overlaying SLOSH model water surface elevations on U.S.G.S. 7.5 minute digital elevation models.

N
W E
S

HANCOCK COUNTY
Mississippi
Hurricane Surge Map

Plate 2-10



LEGEND

Streams		Cat.1 Surge	
Railroads		Cat.2 Surge	
Streets		Cat.3 Surge	
Highways		Cat.4 Surge	
Interstates		Cat.5 Surge	
Roads			

NOTE:

1. Surge limits are based on still water storm tide elevations above National Geodetic Vertical Datum (NGVD) estimated from a 1999 SLOSH model at mean high tide. No wave setup is included.

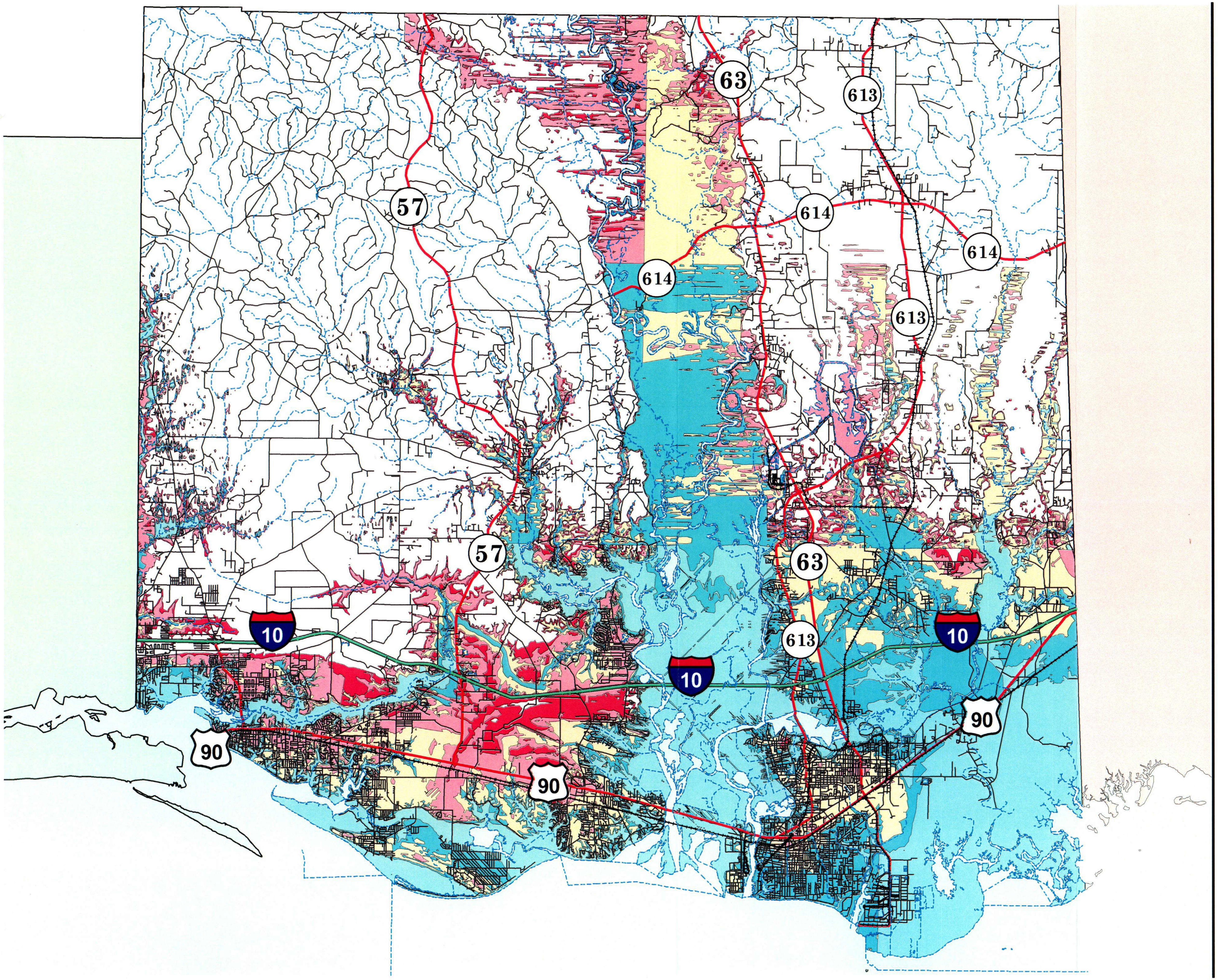
2. Source of base mapping is USGS 1:100,000 scale maps and Tiger data.

3. Hurricane surge limits were determined by overlaying SLOSH water surface elevations on USGS 7.5 minute digital elevation models.

N
W E
S

Harrison County Mississippi Hurricane Surge MAP

Plate 2-11



LEGEND

Streams		Cat. 1 Surge	
Railroads		Cat. 2 Surge	
Streets		Cat. 3 Surge	
Highways		Cat. 4 Surge	
Interstates		Cat. 5 Surge	
Roads			

NOTE:

1. Surge limits are based on still water storm tide elevations above National Geodetic Vertical Datum (NGVD) estimated from a 1999 SLOSH model at mean high tide. No wave setup is included

2. Source of base mapping is USGS 1:100,000 scale maps and Tiger data.

3. Hurricane surge limits were determined by overlaying SLOSH water surface elevations on USGS 7.5 minute digital elevation models.

N
W E
S

Jackson County Mississippi Hurricane Surge MAP

Plate 2-12

VULNERABILITY
ANALYSIS

CHAPTER THREE - VULNERABILITY ANALYSIS

PURPOSE

The primary purpose of the vulnerability analysis is to identify the areas, facilities and populations that are vulnerable to storm surge and to wind damage. Storm surge data from the hazard analysis were used to map inundation areas and develop evacuation scenarios and evacuation zones. The surge maps were also used to quantify the vulnerable population; and to identify major medical, institutional, and other facilities that are potentially vulnerable to storm surge.

Since mobile homes have proven to be particularly susceptible to wind damage, they should be considered vulnerable under any storm category. No attempt has been made to identify other types of construction that may have a high risk of wind damage.

HURRICANE SURGE INUNDATION

Because of unavoidable inaccuracies in hurricane forecasting we cannot predict the exact track a hurricane will take. Within a few hours a hurricane can change its forward speed, intensity and direction, which create quite different flooding scenarios at landfall. In response to this uncertainty, hurricane surge mapping depicts the maximum extent of storm surge flooding at high tide. Hurricane Surge Atlases showing peak surge flooding for the MOMs discussed in Chapter 2 have been produced as a separate document for all three coastal counties. The maps are based on still water surge heights that include an upward adjustment for observed tidal anomalies before the arrival of the hurricane, and the coincidence of the surge arriving at the mean high astronomical tide. Since the actual hurricane surge flooding will depend a great deal on the hurricane track, the entire flooded area shown on the inundation maps for each hurricane category could not be flooded by one single storm.

The Hurricane Surge Atlases were produced with the use of Arcview Spatial Analyst, which is a grid-based analysis. U.S. Geological Survey 7.5-minute Digital Elevation Model (DEM) maps were used for all three counties. The grid size was 30 meters. The SLOSH water surface elevations were converted to grids that matched the county data to determine which grids were flooded and which were dry. The surge limits were then plotted over USGS 1:100,000 scale digital base maps. The final atlases were printed in color at a scale of 1-inch equal's 4,000 feet. There is a separate atlas for each coastal county.

The estimated depth of flooding at a selected location can be calculated by subtracting the known ground elevation from the surge elevation at that point. The ground elevation must be referenced to the NGVD. The surge elevation can be determined from the SLOSH grid cell data or estimated by selecting the surge elevation from the nearest time history point.

HURRICANE EVACUATION ZONES

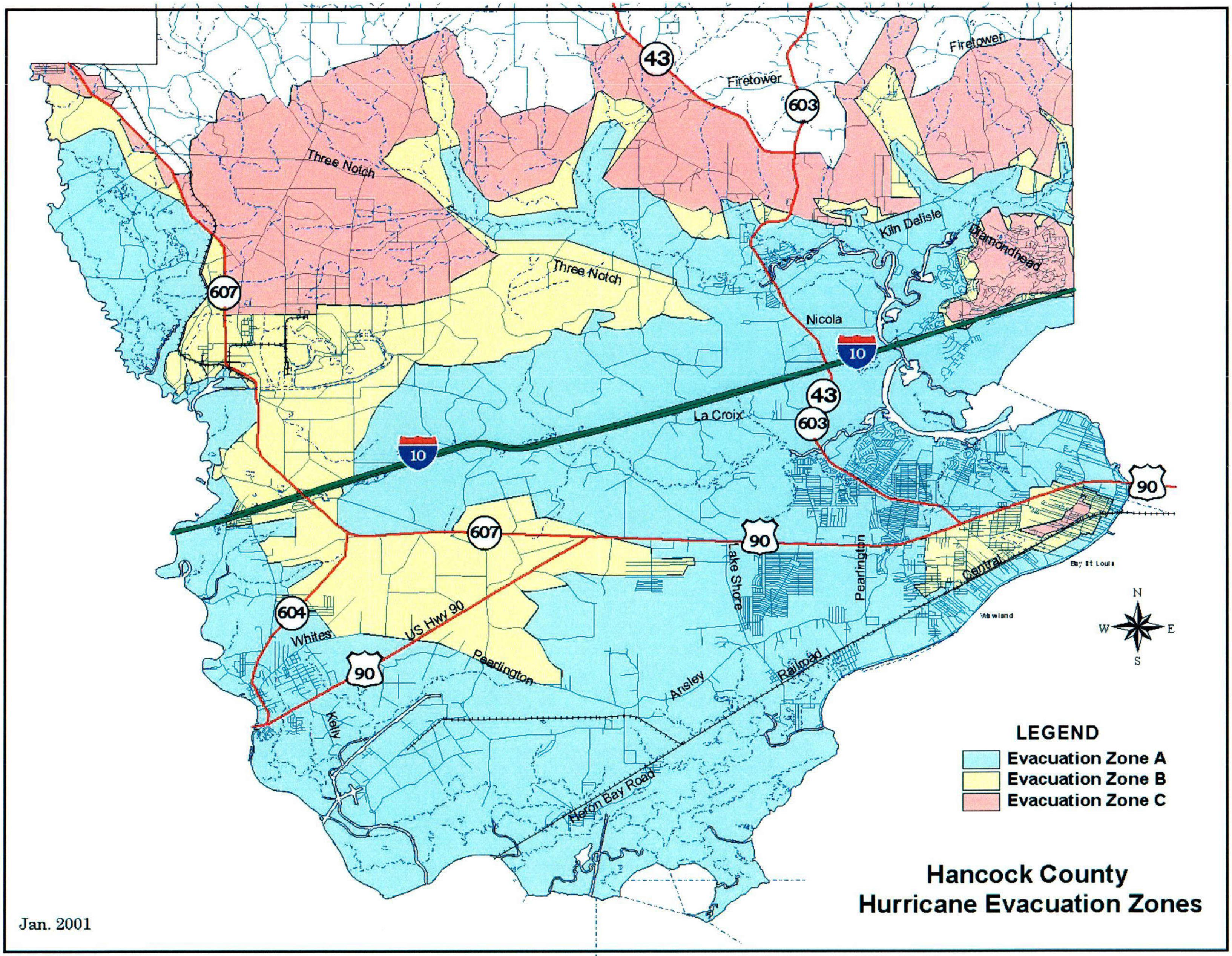
Hurricane evacuation zones are the areas that need to be evacuated for a particular hurricane scenario to protect residents at risk from flooding or high winds. Evacuation zones include all areas having a serious risk of flooding. Evacuation zones sometimes include non-flood areas if they are cut off or completely surrounded by flooded areas. The counties developed three evacuation zones, A, B and C, that closely fit the category 1,3 and 5 MOM's. This approach minimizes the number of people being told to leave for the surge flooding risk.

Evacuation Zone A includes all areas potentially flooded by a category 1 or 2 hurricane, Zones A and B includes all areas potentially flooded by the category 3 hurricane and Zones A, B, and C includes all areas potentially flooded by a category 4 or 5 hurricane. These evacuation zones have been used to estimate the evacuating population and number of evacuating vehicles. This information is a key element to the transportation analysis. Table 3-1 shows the evacuation zones and the hurricane categories they include for each county. Figures 3-1 through 3-3 are maps of the evacuation zones in each county.

TABLE 3-1
HURRICANE EVACUATION ZONES

Evacuation Zones	Saffir-Simpson Category	All Residents in Evacuation Zones:	All Mobile Home Residents:
A	Category 1-2 hurricane	A	In the County
B	Category 3 hurricane	A & B	In the County
C	Category 4-5 hurricane	A,B & C	In the County

FIGURE 3-1 HANCOCK COUNTY HURRICANE EVACUATION ZONES



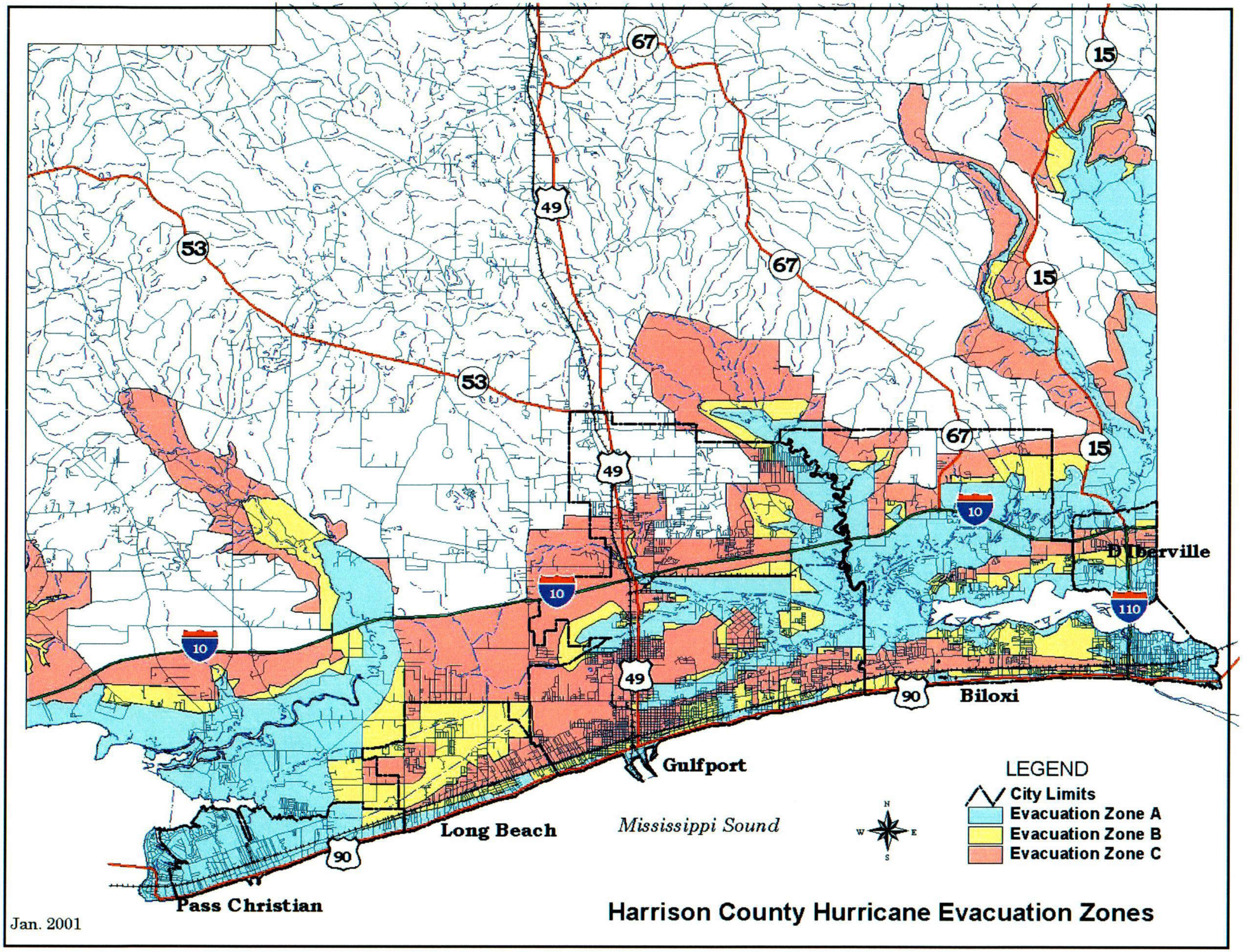
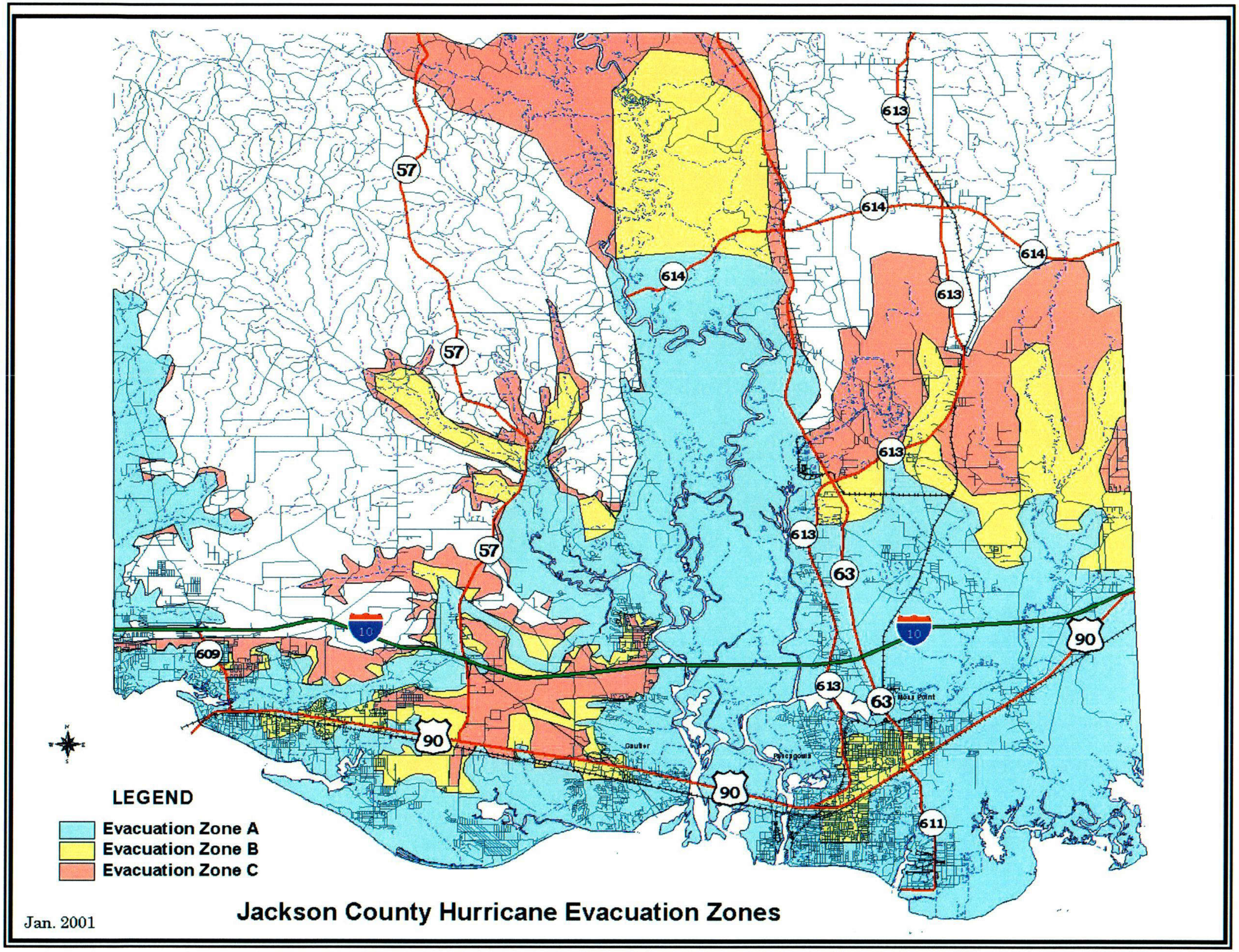
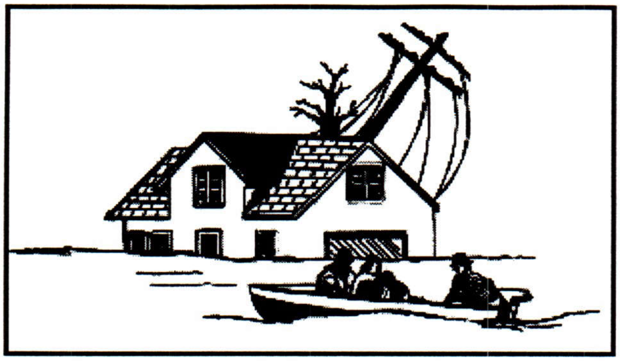


FIGURE 3-2 HARRISON COUNTY HURRICANE EVACUATION ZONES

FIGURE 3-3 JACKSON COUNTY HURRICANE EVACUATION ZONES



VULNERABLE POPULATION



The vulnerable population is persons residing within the evacuation zones subject to storm surge and the residents of mobile homes, which may be threatened by hurricane force winds. Mobile home residents are usually advised to evacuate when they may be subjected to hurricane winds. The tourist population varies with the tourist season. A low (35 percent) and high (95 percent) tourist occupancy rate has been used for all three coastal counties and all evacuation scenarios. Table 3-2 gives estimates of the Year 2000 vulnerable population for all three Counties for different evacuation scenarios.

TABLE 3-2
VULNERABLE POPULATION BY EVACUATION ZONE
(BASED ON THE YEAR 2000 POPULATION ESTIMATES)

County Evacuation Zones	Mobile Home Population	Permanent Population	Non-Mobile Home Population Columns 3-2	Total Mobile Home Population	100 Percent Tourist Population	Vulnerable Population Columns 4+5+6 Total
Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
HANCOCK COUNTY						
Total Population	6,132	43,719	37,587	6,132	19,626	63,345
Zone A - Cat. 1-2	3,093	21,129	18,036	6,132	13,284	37,452
Zone B - Cat. 3	4,305	29,721	25,416	6,132	15,777	47,325
Zone C - Cat. 4-5	4,956	36,450	31,494	6,132	18,624	56,250
HARRISON COUNTY						
Total Population	18,596	187,098	168,502	18,596	46,980	234,078
Zone A - Cat. 1-2	5,695	58,349	52,654	18,596	20,202	91,452
Zone B - Cat. 3	8,363	91,624	83,261	18,596	32,727	134,584
Zone C - Cat. 4-5	13,877	154,800	140,923	18,596	43,905	203,424
JACKSON COUNTY						
Total Population	13,664	139,686	126,022	13,664	25,338	165,024
Zone A - Cat. 1-2	6,421	87,084	80,663	13,664	14,808	109,135
Zone B - Cat. 3	8,906	116,881	107,975	13,664	21,267	142,906
Zone C - Cat. 4-5	11,364	129,410	118,046	13,664	23,391	155,101

CRITICAL FACILITIES

Critical facilities include facilities that may need assistance or special consideration prior to evacuation or immediately after the storm has past. Medical facilities, nursing homes or correctional institutions are examples of critical facilities needing special consideration and planning if they are to be evacuated. Other critical facilities might include police and fire departments or facilities that supply critical services and supplies such as food, water, power, fuel, medical services and building and repair supplies. Tables 3-3 through 3-5 under the next heading list the critical facilities in each coastal county.

Administrative officials should be aware of the potential for wind damage to multi-story buildings. Post-hurricane surveys in other areas show that extreme winds can inflict major damage to substantial structures, exposing occupants to life-threatening danger. Agencies responsible for hurricane preparedness of special needs facilities (hospitals, nursing homes, adult homes, and correctional facilities) should ensure that proper attention is given to the complex task of planning and coordinating emergency response.

CRITICAL FACILITIES TABLES

Tables 3-3 through 3-5 list the critical facilities designated by each county. The tables show the facility name address and what hurricane category and floodplain zone it is in. If the hurricane category (Surge Cat. column), is zero then the facility is not located in a hurricane surge area. The table also has a column for the National Flood Insurance Program (NFIP Flood Zone) showing the flood zone that the facility is in. Note the "Surge CAT." and "NFIP Flood Zone" columns were populated using Latitude and Longitude provided by the counties and a geographic query using ArcView software. If any of the zone designations are questionable the coordinates should be checked and field verification should be made.

TABLE 3-3 HANCOCK COUNTY CRITICAL FACILITIES

Facility Name	Address	Surge Cat.	NFIP Flood Zone
Woodland Village Nursing Center	5427 Gex Road	0	X
Diamondhead Fire Department	4440 Kalani Drive	0	X
Casino Magic	711 Casino Magic Boulevard	1	AE
Dunbar Village	725 Dunbar Avenue	2	AE
Notre Dame De La Mer Retirement Apts.	292 Hwy 90	3	X
Bay Waveland Hancock Co. Civil Defense	508 Ulman Avenue	3	X
Hotel Reed Nursing Center	400 N. Beach Boulevard	4	X
Hancock County Sheriff Department	122 Court Street	4	X
Hancock Medical Center	149 Drink Water		
Hancock County Courthouse	150 Main Street		
Stennis International Airport	7248 Stennis Airport Drive		
Public Safety Complex (VCJ)	310 Old Spanish Trail		
Bay St. Louis City Hall	300 S. Second Street		
Police Department (Waveland)	628 Hwy 90		
Fire Department 1 (Waveland)	Bourgeois		
Fire Department 2 (Waveland)	322 Gulfside		
Faith Street Well	Waveland		
Davis Street Well	Waveland		
Water Street Well	Waveland		
Gulf Street Well	Waveland		
Waveland City Hall	301 Coleman		
Waveland Waste Water Plant	323 Gulfside		

Note: If the CAT or NFIP column is blank, coordinates were unavailable.

TABLE 3-4 HARRISON COUNTY CRITICAL FACILITIES

Facility Name	Address	Surge Cat.	NFIP Flood Zone
Saucier-Success Volunteer Fire Dept.	12342 School Road	0	X
Saucier Volunteer Fire Department	23560 Old Still Rd.	0	X
West Wortham Volunteer Fire Dept.	W. Wortham Road	0	X
Lizana Volunteer Fire Department	16445 Lizana School Road	0	X
Harrison County Code Office	15309 Community Rd.	4	AE
Harrison Co. Adult Detention Center	13050 Seaway Road	4	X
Orange Grove Volunteer Fire Station #1		4	X
Woolmarket Volunteer Fire Department	8479 Woolmarket Road	0	X
Sheriff Sub-Station	10456 D'Iberville Blvd.	4	X
Volunteer Fire Station	Big Ridge Rd.	4	X
Biloxi Courthouse	730 Washington Loop	3	X
Justice Court Annex	524 Lameuse St.	3	X
Juvenile Detention Center	Maples Street	0	X

TABLE 3-4 (Continued)
HARRISON COUNTY CRITICAL FACILITIES

Facility Name	Address	Surge Cat.	NFIP Flood Zone
Gulf Coast Mental Health	1600 Broad Ave	4	X
North Gulfport Volunteer Fire Station	8272 Texas Ave	4	X
Cuevas Volunteer Fire Dept.	22338 Fire Station Rd.	4	X
Delisle Volunteer Fire Department	25242 Cuevas-Delisle Road	2	A
Henderson Point Volunteer Fire Department	300 Livingston Street	1	AE
West Harrison Volunteer Fire Department	10071 Vidalia Rd.	0	X
Harrison County Courthouse	1801 23rd Avenue	4	X
Fire Dept.		5	X
AMR	12020 Intraplex Pkwy.	4	X
Gulfport Police Department	15th Street	4	X
Biloxi Police Department	1045 W. Howard Ave.	3	X
City Hall	140 Lameuse Street	2	X
Long Beach PD	645 Klondyke Rd.	5	X
Keesler Medical Center	KAFB, Biloxi	3	X
Biloxi Regional Medical Center	150 Reynoir Street	3	X
Gulf Coast Medical Center	1802 Debuys Rd.	4	X
Memorial Hospital at Gulfport	4500 13th Street	5	X
Biloxi VA Medical Center	400 Veterans Avenue	3	X
Gulfport VA Medical Center	200 E. Beach Boulevard	2	X500
Garden Park Medical Center	15200 Community Rd.	4	X
Pass Christian Health Department	257 Davis Avenue	2	X500
Health Department	15199 Community Rd., GPT	0	X
Biloxi Health Dept.	761 Esters Blvd.	3	X
Alpha Personal Care	2521 21st Ave	5	X
Boyington Personal Care Home	1530 Broad Ave	4	X
Driftwood Nursing Center	1500 Broad Ave	4	X
Jackson Personal Care	620 Moose Ave.	5	X
Lakeview Nursing Center	16411 Robinson Road	0	X
Chapman Oaks Personal Care	210 Roberts Ave.	5	X
Dixie White house	538 Menge Ave.	2	X500
Miramar Lodge	216 W Beach Blvd.	2	X500
Seashore Personal Care	1450 Beach Blvd	2	X
Biloxi Community Living Center	2279 Atkinson Rd.	5	X
LB Public Safety Complex	645 Klondyke Rd.	4	X
Long Beach FD	645 Klondyke Rd.	5	X
Pass FD	707 W North St	2	AE
Pass FD	808 E Second St	3	X
MSPCO Work Center	28th St.	4	X
MSPCO Plant Jack Watson	Lorraine Rd.	2	AE

TABLE 3-4 (Continued)
HARRISON COUNTY CRITICAL FACILITIES

Facility Name	Address	Surge Cat.	NFIP Flood Zone
GPT Fire STA. #8	13440 Old Hwy 49	0	X
Memorial Behavioral Health	11150 Hwy 49 GPT.	5	X
Dupont	7685 Kiln Delisle Rd. PC	1	VE
Gulf Oaks Hospital	180-A DeBuys Rd., Biloxi	4	X
Coast Electric	14082 Hwy 49 GPT	0	X
Biloxi Vehicle Storage	780 Esters Blvd.	3	X500
Gulfport Vehicle Storage	Hewes Ave.	4	X
Harrison County Workcenter Dist. 4	10076 Lorraine Rd.	4	X
Harrison County Workcenter Dist. 1	10085 1st Ave	2	X500
Harrison County Workcenter Dist. 5	16395 Old Woolmarket Rd	3	X
Harrison County Workcenter Dist. 2	15001 County Farm Rd	0	X
Harrison County Workcenter Dist. 3	605 N Seal Ave	5	X
Munro Petro	540 Bayview Ave	1	AE
A and M Petro	2123 23rd Ave	5	X
Eagle Energy	568 1/2 Courthouse Rd	5	X
Waring Oil	11207 Lorraine Rd	4	X
Pass Christian Police Department	110 West Second St. P.C.	2	AH
North Gulfport Police Substation	8335 Tennessee Ave	4	X

TABLE 3-5
JACKSON COUNTY CRITICAL FACILITIES

Facility Name	Address	Surge Cat.	NFIP Flood Zone
Navy Home Port/Singing River Island	Singing River Island	0	VE
Pascagoula Police Department	611 Live Oak Avenue	2	X
Pascagoula City Hall	603 Watts Avenue	2	X
Pascagoula Central Fire Station	1707 Jackson Avenue	3	X
Singing River Hospital	2809 Denny Avenue	3	A
Jackson County Courthouse	3104 Magnolia Street	2	X
Jackson County Civil Defense/EOC	600 Convent Avenue	2	X500
Moss Point City Hall	4412 Denny Street	3	X
Moss Point Central Fire Station	4323 McInnis Avenue	3	X
Trent Lott International Airport	8301 Saracennia Rd.,	2	AE
Gautier City Hall	3330 Hwy 90	4	X
Gautier Police Department	3330 Hwy 90	4	X
Gautier Central Fire	3330 Hwy 90	4	X
Ocean Springs City Hall	1018 Porter Street	4	X
Ocean Springs Police Department	503 Dewey Avenue	4	X
Ocean Springs Central Fire Department	Bienville Boulevard	4	X
Ocean Springs Hospital	3109 Bienville Boulevard	4	X

EVACUATION ROUTE FLOODING

Evacuation route flooding can be caused by rainfall runoff and storm tide. Hurricane evacuations are normally timed so that evacuees can reach safe shelter prior to the arrival of sustained tropical storm winds. Because of the wide variation in amounts and times of occurrence from one storm to another, rainfall can only be addressed in general terms. For most hurricanes, the heaviest rainfall begins near the time of arrival of sustained tropical storm winds. In some cases, however, over 20 inches of rain has preceded an approaching hurricane by as much as 24 hours. The county emergency management office should increase clearance times if it appears that the capacity of any evacuation routes would be reduced as a result of flooding prior to or during the evacuation.

Shown below is a listing of potential roads that are subject to flooding during heavy rains.

HANCOCK COUNTY POTENTIAL ROAD FLOODING

Major roadways subject to fresh water flooding in Hancock County are:

Country Routes:
Highway 43/603 North of I-10 at Jordan River
Highway 43/603 South of I-10 at Bayou La Croix
Heron Bay Road, Ansley
Whites Road, between 2nd Avenue and Melody Lane, Pearlington
Corner of Lagan and Central, Shoreline

City of Bay St. Louis:
East end of the 500 Block on Esplanade and Highland Drive
700 Block of Dunbar

City of Waveland:
Nicholoson Avenue – Exxon & 90 – 100 Block on Beach
Waveland Avenue – 100 Beach – Highway 90
South Central Avenue – 100 Colman Avenue – Waveland Avenue & Central
North Central Avenue – City line past Lakewood Drive – Colman Avenue
Old Spanish Trail Highway 90 – Nicholson Avenue

HARRISON COUNTY POTENTIAL ROAD FLOODING

Major roadways subject to fresh water flooding in Harrison County are:

<u>City Of D'Iberville</u>--Bay Shore Drive (Boney To Santa Cruz)-- East Gay Road 3rd Avenue (Seymour Avenue To D'iberville Blvd.)-- Cypress Drive-- Moye Road Lamey Bridge Road (Toncrey To Bachman)-- Shannon Drive-- Arceneaux Road Mallett Road (Lamey Bridge Road To Sangani Blvd.)-- Springdale Circle Rodriguez (Between Central Ave. & Gorenflo)-- Brodie Road (By Sadler Lane) Barkwood Circle--Neal Drive--Meadow Drive

<u>City Of Long Beach</u>--Sedgewick Drive--Paula Drive--Shalimar Drive--Allen Road Leigh Street--Harris Ave. & Old Pass Rd.--Maxine Drive-- Joyce Avenue-- Rita Lane Beatline Road (South Of 28th Street)-- 28th Street (West Of Klondyke Road) Ferguson Avenue---8th Street---9th Street---Pittman Drive---Sea Pine Lane Mason Avenue---5th Street (East Of Mason)---Simmons (South End) Seal Avenue (South End)---Cleveland Avenue & Highway 90

<u>City Of Biloxi</u> --Portions of Highway 90---Sections of Bayview Avenue Intersection of Crawford at Division Street--- Some Portions Of Eagle Point Lorraine Road Near The Bridge (Jiggs Fishing Camp) Cedar Lake Road Just North Of Cedar Lake Bridge---John Lee Road near E. Fritz Creek Bridge---Riverland Road---Snug Harbor Road---Woolmarket Lake Road

<u>City Of Gulfport</u> --*Subdivisions that have experienced flooding of streets*---Biloxi River EstatesRetreat Village --- Fisherman's Trail---Bayou View West---Belaire – East Of Klein Road --- Joseoh/Gournier Avenues – North Of Railroad Street *The City received calls on the following roads about having drainage problems due to intense rainfall*: --- 4719 Illinois Avenue ---14044 Gladys Street---113 Danube 15324 St. Charles Street -- 5112 29th Street -- Rippy Rd and Three Rivers Rd 14210 Sweetgum Court (Off Trailwood In Countryhills Subdivision) 3101 & 3108 Catz Avenue -- 232 Myrtle Street -- 13028 Three Rivers Road Creosote Road And Three Rivers Road -- 5015 Courthouse Road Lorriane Road And Hillcrest Road -- 15369 Pinewood Court -- 1216 22nd Street 8147 Georgia Avenue -- 2300 Collins Blvd -- 2013 Collins Blvd --O'neal Road #30 47th Street -- 3925 Monterrey Drive -- Duckworth Rd And Three Rivers Rd 11249 Helen Drive -- 3204 B Avenue -- 492 Oak Lane -- 10545 Bay Tree Drive 1104 Hardy Avenue -- 11420 Gould Road -- Bayou View West -- Johnson Drive 11099 Sweet Gum (Oakleigh Manor Off Lorraine Road) -- 35th Street And Nunally 8th Avenue And 34th Street --13068 Depew Road -- 2006 43rd Avenue 2323 43rd Avenue -- 4501 Heron Street -- 5305 East Railroad (North Gulfport Area) 102 Ben Place -- 10322 Three Rivers Road -- 15347 Northwood Hills Drive 2006 43rd Avenue -- 14507 O'neal Road -- 125 Bayou Circle -- 115 Brentwood Blvd Polk Street and Railroad Street -- 12473 Crestwood Drive -- Bayou View Elem. 12478 Crestwood Drive -- 4705 Illinois Avenue -- 14420 Gould Rd --101 Ben Place 1104 Hardy Avenue -- 10 Stratford Place -- 2020 North Street -- 14430 Mays Road 5015 Courthouse Road -- 15324 North Wood Drive --

Magnolia off Depew Teagarden Road at Victory Street -- 112 Michael Court -- 8242 Texas Avenue 8246 Texas Avenue -- 719 Tennesse Ave -- 4707 – 4709 Washington Avenue #40 47th Street -- Oakwood (Wood Glen Subdivision) -- 14125 O'neal Road 225 Southern Circle -- Woodward Ave. and Hwy 90 -- 15214 Parkwood Drive North 100 Reservation Dr. and Three Rivers Rd -- 3320 Johnson Drive -- 1713 44th Ave. 2440 Greeview Dr. -- 107 Ralph Drive -- 609 East David Drive -- 1721 30th Avenue 3707 Meadowlark Drive -- 14462 Karen Court -- 1224 32nd Ave.-- 15 Perry Street Broad Avenue (The Boyington Nursing Home)

Harrison County Unincorporated -- Woolmarket Lake Road -- Skeethunt Road River Bluff Road -- Brandon James Drive -- Wells Ferry Landing -- Whetstone Road Road 112 In North Biloxi -- Blackwell/Farm Road (White Plains North ½ Mile) White Plains Road (Posey To Lamey Bridge) -- C.C. Road (Peterson, (East 1 Mile) Old Hwy 15 (New 15 To Dobson) -- Dobson Road --- Tux River Circle Lamey Bridge (Johnson Still To Lickskillet) -- Riverside Road -- Riverbend Drive Longwood Circle -- Johnson Still Road -- Lickskillet Road -- Paradise Lane Audubon Trail -- Doctor's Lane -- Roads 109, 107, 110, 106, 108 And H Street Brandon James Drive -- Wells Ferry Cove -- Rue Sanchez -- 28th Street Beatline Road -- Bells Ferry Road -- Big Creek Road -- Carlton Cuevas Road Mennonite Road -- Shaw Road -- Old Hwy 49 @ Little Biloxi Bridge Shaw Road @ Bridge & Between Morgan Lane & Shaw Pit) -- - Tucker Road Herman Ladner Road @ Little Biloxi Bridge & @ Mortar Creek Riverline Road Between Saucier Lizana Road & The Dead End Canal Road @ Smith Road -- Landon Road From Hutter Road To New Hope Road Hickman Road @ Big Biloxi Bridge --- Fred Diamond Road @ Biloxi River McHenry Road @ Little Biloxi Bridge & Between Wortham & Hickman Road Pete Hickman Road @ Biloxi River & Hickory Creek -- Feller Drive White Star Road -- Ramsey Lane -- Martha Road

JACKSON COUNTY POTENTIAL ROAD FLOODING

Major roadways subject to fresh water flooding in Jackson County are:

Beachview Road in Gulf Park Estates, Bellefountaine Road in Fountain Bleau, Hickory Hills / Martin Bluff Road in North Gautier, Franklin Creek Road in East Jackson County, Hwy 613 / Main Street Moss Point south of the Bridge.

EMERGENCY TRANSPORTATION NEEDS

Evacuation preparedness plans should consider all persons who do not have access to a private vehicle and therefore would have to rely on public transportation for evacuation. Local government should attempt to arrange for adequate resources to meet the demand for public transportation. Planning for adequate special needs emergency transportation for residents in private homes is often the responsibility of local emergency management officials, while transportation for those in health-related facilities should be the responsibility of the individual facilities. Although detailed information concerning residents of private homes may be difficult to obtain, each local government should develop procedures for maintaining an up-to-date roster of persons likely to need special assistance. Non-ambulatory patients will require transportation that can easily accommodate wheelchairs, stretchers, and, possibly, life-sustaining equipment. Lack of resources for these needs could result in critical evacuation delays and increased hazards for the evacuees. The Special Needs population for each county changes from year to year and requires public cooperation and assistance to maintain an up-to-date listing.

MOBILE HOME AND RV PARKS

The location and capacity of existing mobile home parks and recreational vehicle (RV campers) facilities is also critical because it is recommended that all of them be evacuated for any storm threat that would result in hurricane force winds. A list of these facilities for each county is shown below.

HANCOCK COUNTY MOBILE HOME AND RV PARKS

Mobile Home Park Name	**Address**	**Phone**
Bay Marina and RV Park	100 Bay Marina Drive, Bay Saint Louis, MS 39520	(228) 466-4970
Wheel-Inn Mobile Home Park	Highway 90, Bay Saint Louis, MS 39520	(228) 467-6169
Aloha Park	916 Old Spanish Trail, Waveland	
Bayou Talla	16145 Hwy 603, Pass Christian	
Ideal Park	308 Ruella Street, Bay St. Louis	
Elaine Trailer Park	616 Elaine Street, Waveland	
Casino Magic	711 Casino Drive, Bay St. Louis	(228) 467-9257
Buccaneer State Park	1150 S. Beach Blvd., Waveland	(228) 467-3822
KOA	814 Hwy 90, Bay St. Louis	(228) 467-2080
Ladner's Trailer Park	2319 Henderson Street, Waveland	(228) 467-5366
McCloud Park	8100 Texas Flat, Kiln	(228) 467-1894
Sunrise Mobile Home	Hwy 90, Pearlington	(228) 533-7001
Z-Haven Mobile Home Park	10041 Chapman Rd., Waveland, MS	(228) 467-6120

HARRISON COUNTY MOBILE HOME AND RV PARKS

Mobile Home Park Name	Address	Phone
Apartment Rentals	1500 28th Street, Gulfport, MS 39501	(228) 863-5313
Bayou Oaks Mobile Home Park	1901 Switzer Road, Gulfport, MS 39507	(228) 896-1405
Bienville House Apartments	1545 Popps Ferry Road, Biloxi, MS 39532	(228) 392-7067
Biloxi Trailer Park	1750 Pass Road, Biloxi, MS 39531	(228) 432-7623
Blairs Trailer Park	2055 Pass Road, Biloxi, MS 39531	(228) 388-3725
Bond Thomas E	2018 Popps Ferry Road, Biloxi, MS 39532	(228) 388-3865
Cedar Lake Mobile Home Village	880 Cedar Lake Road, Biloxi, MS 39532	(228) 392-5324
Century Oaks	1718 Pass Road, Biloxi, MS 39531	(228) 435-0055
Cook John H	14324 Highway 15, Biloxi, MS 39532	(228) 392-6540
Country Living Mobile Home Village	Highway 67, Biloxi, MS 39530	(228) 392-3051
Daughdrill James A	Highway 67, Biloxi, MS 39530	(228) 392-3051
Destination Park Inc	14324 Highway 15, Biloxi, MS 39532	(228) 392-6540
Hidden Acres Trailer Court	15538 Touriel Road, Gulfport, MS 39503	(228) 832-4574
Imperial Mobile Estates	1907 Popps Ferry Road, Biloxi, MS 39532	(228) 388-7719
Jones Enterprises	1545 Popps Ferry Road, Biloxi, MS 39532	(228) 392-7067
Mallard Marsh	1545 Popps Ferry Road, Biloxi, MS 39532	(228) 392-7067
Oaklawn Mobile Home Park	Gulfport, MS 39501	(228) 896-3233
Pine Grove Trailer Park	2018 Popps Ferry Road, Biloxi, MS 39532	(228) 388-3865
Poolside Mobile Home Village	2800 19th Avenue, Gulfport, MS 39501	(228) 863-1876
Richmar Mobile Home Park	15505 Richmar Drive, Gulfport, MS 39503	(228) 832-7212
Ridgecrest Estates	Hughes Road, Gulfport, MS 39501	(228) 832-4151
Roche Daniel E	1750 Pass Road, Biloxi, MS 39531	(228) 432-7623
Rolling Heights Mobile Estate	3221 Race Track Road, Biloxi, MS 39532	(228) 392-9517
Rolling Hills Estates	4457 Popps Ferry Road, Biloxi, MS 39532	(228) 392-7786
San Beach RV Park & Apartments	1020 Beach Avenue, Gulfport, MS 39501	(228) 896-7551
Sherwood Village Mobile Home Park	1501 Popps Ferry Road, Biloxi, MS 39532	(228) 392-2975
Southern Oaks Mobile Home Comm.	10530 3 Rivers Road, Gulfport, MS 39503	(228) 832-5528
Thomas Ellen	560 Magnolia Street, Gulfport, MS 39507	(228) 896-3233
Tropical Mobile Home Park	1835 East Pass Road, Gulfport, MS 39507	(228) 896-1028
Woodridge Estates	4240 Reece Drive, Biloxi, MS 39532	(228) 392-1869
Woolmarket Mobile Home Park	217 Iroquois Street, Biloxi, MS 39530	(228) 374-2016

JACKSON COUNTY MOBILE HOME AND RV PARKS

Mobile Home Park Name	Address	Phone
Anchor Trailer Park	1600 Highway 90, Gautier, MS 39553	(228) 497-2475
Bluff Creek Mobile Home Park	8716 Pine Grove Road, Gautier, MS 39553	(228) 497-1658
Clay Johnson Auto Sales	3615 Bienville Blvd. Ocean Springs, MS 39564	(228) 875-2222
Coast Meadows Mobile Estate	2101 Ladnier Road, Gautier, MS 39553	(228) 497-2402
Highland Park	4708 Gibson Road, Ocean Springs, MS 39564	(228) 875-4845
Isle of Pines Mobile Home Village & Kampers KOVE	Highway 90, Gautier, MS 39553	(228) 497-4186
Simmons Mobile Home Park	504 Mawaka Drive, Gautier, MS 39553	(228) 497-4400
Spanish Oak Mobile Home Park	3621 Bienville Blvd. Ocean Springs, MS 39564	(228) 875-2222
Woodland Park Mobile Home Village	5801 Orange Grove Road, Moss Point, MS 39563	(228) 475-5682

MARINAS AND BOAT STORAGE

The location and capacity of existing Marinas and boat storage facilities is also critical because many boat owners will attempt to move their boat to safety. This is particularly true if the boat can be loaded on a trailer. Emergency managers must consider the magnitude of these efforts and plan for possible impacts to evacuation routes and evacuation times. The marina facilities should also estimate the number of users planning to obtain their boats and the time it will take to retrieve and load the boats and secure their facilities. They should plan to complete this effort prior to the arrival of gale force winds. A list of these facilities for each county is shown below.

HANCOCK COUNTY MARINAS

MARINA NAME	LOCATION	PHONE
Bay Waveland Yacht Club	666 N Beach Blvd., Bay St. Louis	601-467-4592
Bayou Caddy Marina	5200 Shipyard Road, Lakeshore	228-467-4332
Casino Magic Marina	711 Casino Magic Dr., Bay St. Louis	601-467-9257
Hancock County Marina	5005 Pleasure St., Lakeshore	228-463-0368
La France's Fishing Camp	Bay St. Louis MS	601-467-9180
Joe's Bayou Marina	Bay St. Louis MS	601-467-5287
Diamondhead Marina	Bay St. Louis MS	601-255-7055
Bay Cove Marina	Bay St. Louis MS	601-467-9257

HARRISON COUNTY MARINAS

MARINA NAME	LOCATION	PHONE
Rivers Bend Marina	Gulfport MS	601-896-8300
President Casino Broadwater Marina	Biloxi MS	601-388-2211
Pass Christian Small Craft Harbor	Pass Christian MS	601-452-3315
Misco Marine	Gulfport MS	601-864-1492
Long Beach Small Craft Harbor	Long Beach MS	601-863-4795
Kremer Marine	Gulfport MS	601-896-1629
Casino Magic Inn	Biloxi MS	800-562-4425
Broadwater Beach Marina	Biloxi MS	601-388-2211
Biloxi Small Craft Harbor	Biloxi MS	601-374-6600
Best Jonse Yacht Harbor	Gulfport MS	601-868-5713
Beau Rivage Resort and Casino	Biloxi MS	228-386-7580

JACKSON COUNTY MARINAS

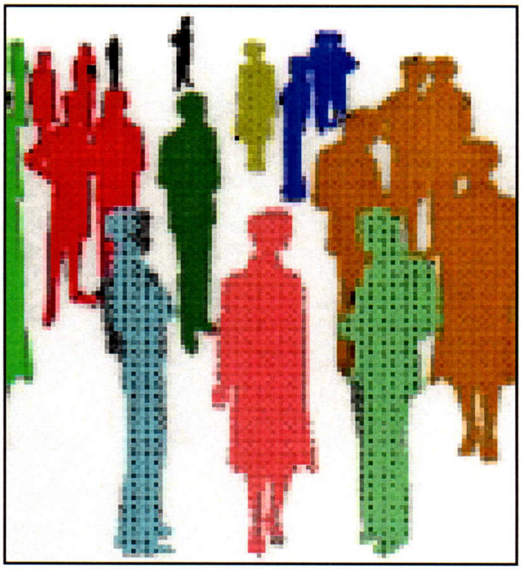
MARINA NAME	LOCATION	PHONE
Singing River Yacht Club	Pascagoula MS	228-769-1876
Poticaw Fishing Camp	Van Cleave MS	601-826-9961
Old Oak Marina	Gautier MS	601-497-4229
Ocean Springs Small Craft Harbor	Ocean Springs MS	601-875-4545
Mary Walker Marina	Gautier MS	601-497-3141
John's Bayou Marina	Van Cleave MS	601-826-4482
Indian Point Campground & Marina	Gautier MS	601-497-5191
Indian Point Campground & Marina	Gautier MS	601-497-5191
Harbor Pointe Apts. & Marina	Ocean Springs MS	601-875-8801
Gautier Marina	Gautier MS	601-497-4074
Ferguson's Fishing Camp	Pascagoula MS	601-475-9915

BEHAVIORAL ANALYSIS

CHAPTER FOUR - BEHAVIORAL ANALYSIS

INTRODUCTION

The behavioral analysis is conducted to provide estimates of public response to a variety of hurricane threats. These estimates are used in the shelter analysis and transportation analysis, and as guidance in emergency decision-making and public awareness efforts.



OBJECTIVES

The specific objective of the behavioral analysis is to answer the following questions:

1. What percentage of the population will evacuate under a range of hurricane threat situations or in response to evacuation advisories?

2. When will the evacuating population leave in response to an evacuation order given by local officials?

3. How many vehicles will the evacuating population use during a hurricane evacuation?

4. How many evacuating vehicles will be towing boats, camper trailers, or other vehicular equipment?

5. What are the destinations of the evacuees and what type shelter will they be heading for?

6. How will the threatened population respond based upon forecasts of hurricane intensity or other information provided during a hurricane emergency.

METHODOLOGY

Every evacuation plan must contain estimates and assumptions about how people will react when a hurricane evacuation is implemented. Behavioral assumptions for the Mississippi coastal counties were developed by statistical analysis of data, which was gathered from, telephone interviews and actual response data from previous hurricane evacuations.

Actual behavior in a single event can be documented and compared to the estimated behavioral characteristics for a specific location. It is tempting to over generalize from a single evacuation, however, we know that people will respond differently in different sets of circumstances and at different points in time. We are fortunate to have amassed actual response data from many hurricane evacuations spanning a wide geographical area and a variety of hurricane threat circumstances over a period of roughly three decades.

Part of this analysis includes telephone interviews in which residents of the region were asked how they responded during Hurricane Georges in 1998. Data from an earlier survey regarding response in Hurricane Georges is also employed in the study. Older data concerning responses in Hurricanes Camille and Frederic were also available. Another major component of this current behavioral analysis involved a sample survey documenting residents' beliefs about their exposure to hurricanes, their intentions to respond in future hurricane threats, and demographic information, which could be related to their behavior.

MISSISSIPPI SAMPLE SURVEYS

In 1999 a survey was conducted in several Gulf Coast locations documenting response in Hurricane Georges. As part of that study 200 telephone interviews were conducted in Mississippi. All of the respondents lived in areas of coastal counties advised by officials to evacuate in Hurricane Georges.

In the summer of 2000 an additional telephone survey was performed in Mississippi. A total of 300 interviews were completed in the three coastal counties, with the respondents equally divided among three risk areas. The three risk areas are shown in the Table 4-1 below.

TABLE 4-1
HURRICANE RISK AREAS

High Risk Area	Medium Risk Area	Low Risk Area
Category 1-2 Surge Area	Category 3-5 Surge Area	Upland Non-surge Area
Evacuation Zone A	Evacuation Zone A, B&C	Mobile Home Evacuation

The new survey gives a better indication of how responses, perceptions, and response intentions vary among the evacuation zones. The earlier post-Georges survey responses came from an area roughly the same as the category 1-2 area in the newer survey, but smaller in some communities. Interviews were divided between the Mississippi coastal counties proportionally by population in each of the risk zones.

Two hundred interviews were also conducted in the Jefferson and Orleans Parishes in Louisiana. It is anticipated that a significant number of evacuees from those parishes will travel into and through Mississippi, and the interviews were performed to estimate that number.

ANALYSIS OF SURVEYS

Behavioral studies are statistical. In general, the larger the number of people in the sample, the closer the sample value will be to the true value. A sample of 100 will provide estimates which one can be 90 percent "confident" that they are within 5 to 8 percentage points of the true values. With a sample of 50, one can be 90 percent "confident" of being within 7 to 11 percentage points of the actual population value.

RESPONSE RATES IN HURRICANE GEORGES

The post-Hurricane Georges survey indicated that almost half the respondents left their homes in the category 1-2 evacuation zones in Hurricane Georges, and about 40 percent left in other parts of the coastal counties (Table 4-2). The 1999 survey found that 60 percent of the Mississippi respondents evacuated in Hurricane Georges, but the 1999 interviews were restricted to the areas explicitly directed by officials to evacuate in that storm.

TABLE 4-2
PERCENT OF RESPONDENTS
EVACUATING IN HURRICANE GEORGES, BY RISK ZONE

	Cat 1-2 Zone (N=99)	Cat 3-5 Zone (N=94)	Non-Surge Zone (N=106)
Evacuees	48	42	40

Almost half the category 1-2 zone respondents who stayed in their homes in Hurricane Georges said they would have evacuated if they had felt the threat posed by the storm had been greater (Table 4-3). More than a third of the stayers in the category 3-5 and non-surge areas gave that response. Eighty-five percent of those who didn't evacuate in Hurricanes Georges from the high-risk zone said they had made preparations to do so in case the threat worsened, as did more than 60 percent in the other two risk zones (Table 4-4).

TABLE 4-3
PERCENT OF STAYERS IN HURRICANE GEORGES SAYING THEY WOULD HAVE LEFT IF THREAT WERE GREATER, BY RISK ZONE

	Cat 1-2 Zone (N=52)	Cat 3-5 Zone (N=55)	Non-Surge Zone (N=64)
Yes	48	36	39
No	44	53	53
Do not Know	8	11	8

TABLE 4-4
PERCENT OF STAYERS IN HURRICANE GEORGES SAYING THEY HAD MADE PREPARATIONS TO LEAVE IF NECESSARY, BY RISK ZONE

	Cat 1-2 Zone (N=52)	Cat 3-5 Zone (N=55)	Non-Surge Zone (N=64)
Yes	85	62	69
No	14	35	28
Do not Know	2	4	3

When those who did not evacuate in Hurricane Georges were asked why they did not, the great majority indicated that Hurricane Georges was not severe enough or its track was not the sort to pose a threat to their safety (Table 4-5). No one said they failed to leave because they had no transportation, but four percent in the category 1-2 surge zone said they had no place to go.

TABLE 4-5
REASONS GIVEN FOR NOT EVACUATING
(PERCENT OF STAYERS) BY RISK AREA

	Cat 1-2 Zone (N=51)	Cat 3-5 Zone (N=54)	Non-Surge Zone (N=64)
House Safe	77	74	91
Officials Said OK	4	4	0
Media Said OK	6	6	0
Friends Said OK	8	6	6
Officials Didn't Say Go	14	6	2
Low Probabilities	26	6	14
Other Low Chance of Hit	12	6	0
No Place to Go	4	2	2
Protect Against Looters	10	2	0
Protect Property from Storm	8	7	3
Past False Alarm	14	4	8
Job	4	6	5
Waited Too Long	4	4	0
Traffic Bad	6	0	5
Tried, Returned	2	2	2
No Place for Pets	0	0	2
Other	8	4	3
Do not Know	2	4	2

In the category 1-2 evacuation zone 85 percent of those who did not evacuate in Georges said they had a concern about being trapped on evacuation routes as the storm arrived, and 75 percent from the category 3-5-evacuation zone gave that same response (Table 4-6). This is even higher than responses to that question in places like New Orleans and the Florida Keys. More than a third gave that response in non-surge areas of Mississippi. At least half of the respondents expressing those concerns said they would probably be willing to evacuate if officials could monitor the progress of the evacuation and ensure that they did not begin evacuating without adequate time to reach safety (Table 4-7).

TABLE 4-6
PERCENT OF STAYERS IN HURRICANE GEORGES SAYING THEY WERE CONCERNED ABOUT BEING CAUGHT ON THE ROAD DURING EVACUATION, BY RISK ZONE

	Cat 1-2 Zone (N=52)	Cat 3-5 Zone (N=55)	Non-Surge Zone (N=64)
Yes	85	75	36
No	14	22	63
Do not Know	2	4	2

TABLE 4-7
PERCENT OF STAYERS IN HURRICANE GEORGES CONCERNED ABOUT BEING CAUGHT ON THE ROAD WHO WOULD PROBABLY LEAVE IF GUARANTEED ADEQUATE TRAVEL TIME, BY RISK ZONE

	Cat 1-2 Zone (N=45)	Cat 3-5 Zone (N=43)	Non-Surge Zone (N=24)
Yes	56	51	67
No	38	33	25
Do not Know	7	16	8

When evacuees were asked what convinced them to go someplace safer, most expressed concerns about the strength of the storm and its effects, followed by appeals from friends and relatives (Table 4-8). Few said they left because officials called for their evacuation.

TABLE 4-8
REASONS GIVEN FOR EVACUATING (PERCENT OF EVACUEES) BY RISK AREA

	Cat 1-2 Zone (N=52)	Cat 3-5 Zone (N=38)	Non-Surge Zone (N=41)
Officials Said Go	6	5	7
NWS Said Go	4	5	7
Police/Fire Said Go	11	5	2
Media Said Go	4	5	5
Friend/Relative Said Go	28	26	34
Storm Severe	47	45	46
Storm Increased in Strength	4	16	15
Concerned about Flooding	26	18	10
Concerned about Wind	28	29	20
Concerned about Road Flooding	6	0	5
Concerned Storm Would Hit	15	24	12
Heard Probability	6	3	12
Other	11	5	7

When asked specifically whether they heard, either directly or indirectly, that officials had called for them to evacuate, a majority (69 percent) said they did not, even in the category 1-2 risk area (Table 4-9). In the earlier Hurricane Georges survey slightly more said they heard evacuation notices (41 percent), and that survey was targeted specifically at areas told by officials to evacuate in Hurricane Georges. Only about 10 percent in the category 1-2 area and five percent in the other zones said they heard mandatory evacuation orders.

TABLE 4-9
PERCENT OF RESPONDENTS IN HURRICANE GEORGES HEARING EVACUATION NOTICES FROM PUBLIC OFFICIALS, BY RISK ZONE

	Cat 1-2 Zone (N=99)	Cat 3-5 Zone (N=94)	Non-Surge Zone (N=106)
Heard Must	11	5	4
Heard Should	20	17	13
Heard Neither	69	78	83

In the surge zones hearing official evacuation notices increased the likelihood of evacuation substantially (Table 4-10). Over 90 percent of those in surge zones said they evacuated if they heard mandatory orders, although there were very few respondents who said they heard those orders. Taken collectively, averaging over both surge zones to increase sample size and statistical reliability, respondents who said they heard official evacuation notices of one kind or another were at least twice as likely to evacuate as those who said they heard no evacuation notices.

TABLE 4-10
PERCENT EVACUATING, BY EVACUATION NOTICE HEARD BY RISK ZONE (SAMPLE SIZE VARIES BY CELL – SEE TABLE 4-9)

	Cat 1-2 Zone	Cat 3-5 Zone	Non-Surge Zone
Heard Must	91	100	50
Heard Should	65	64	80
Heard Neither	33	30	32

Most respondents, even in the category 1-2 risk area said their homes would not experience dangerous flooding from storm surge and waves in a 125-mph hurricane (Table 4-11). Barely half in any of the risk areas said their homes would be unsafe in a 125-mph hurricane, considering both wind and water (Table 4-12).

TABLE 4-11
PERCENT OF RESPONDENTS BELIEVING THEIR HOMES WOULD FLOOD DANGEROUSLY FROM STORM SURGE AND WAVES IN 125 MPH HURRICANE, BY RISK ZONE

	Cat 1-2 Zone (N=99)	Cat 3-5 Zone (N=94)	Non-Surge Zone (N=106)
Would Flood	34	35	24
Would Not Flood	59	55	73
Do not Know	7	10	4

TABLE 4-12
PERCENT OF RESPONDENTS BELIEVING THEIR HOMES WOULD BE SAFE IN 125-MPH HURRICANE CONSIDERING BOTH WIND AND WATER, BY RISK ZONE

	Cat 1-2 Zone (N=99)	Cat 3-5 Zone (N=94)	Non-Surge Zone (N=106)
Safe	39	39	46
Not Safe	51	52	50
Do not Know	10	9	5

Sixty-three percent of the residents of the category 1-2 surge area said their homes would flood dangerously in a category 5 hurricane like Hurricane Camille, but in the category 4-5 zone only half believed they would be at risk to flooding (Table 4-13). Twenty percent in the category 1-2 risk area and approximately 30 percent in the other risk areas said their homes would be unsafe in a category 5 storm like Hurricane Camille (Table 4-14).

TABLE 4-13
PERCENT OF RESPONDENTS BELIEVING THEIR HOMES WOULD FLOOD DANGEROUSLY FROM STORM SURGE AND WAVES IN CATEGORY 5 HURRICANE LIKE HURRICANE CAMILLE, BY RISK ZONE

	Cat 1-2 Zone (N=99)	Cat 3-5 Zone (N=94)	Non-Surge Zone (N=106)
Would Flood	63	50	46
Would Not Flood	30	47	48
Do not Know	7	3	6

TABLE 4-14
PERCENT OF RESPONDENTS BELIEVING THEIR HOMES WOULD BE SAFE IN CATEGORY 5 HURRICANE LIKE HURRICANE CAMILLE CONSIDERING BOTH WIND AND WATER, BY RISK ZONE

	Cat 1-2 Zone (N=99)	Cat 3-5 Zone (N=94)	Non-Surge Zone (N=106)
Safe	19	32	31
Not Safe	71	66	65
Do not Know	10	2	4

People who believe their homes would be unsafe in a 125-mph hurricane were much more likely than others to evacuate in Hurricane Georges (Table 4-15). The effect was present in all three of the risk zones.

TABLE 4-15
PERCENT EVACUATING, BY BELIEF HOME WOULD BE SAFE IN 125 MPH HURRICANE, BY RISK ZONE (SAMPLE SIZES VARY BY CELL - SEE TABLE 4-12)

	Cat 1-2 Zone	Cat 3-5 Zone	Non-Surge Zone
Safe	26	14	27
Not Safe	62	67	54
Do not Know	60	13	20

What people say they will do often fails to match what they actually do in real hurricane threats. Nevertheless, interviewees were asked a number of hypothetical questions. First, respondents were asked if they would do anything differently in the future if faced with another threat like Hurricane Georges. Most people said they would do the same thing they did in Hurricane Georges. Of those who did not evacuate from the category 1-2 zone in Hurricane Georges, however, 38 percent said they would leave in the future, as did 29 percent of the stayers in the category 3-5 zone and 19 percent in the non-surge area (Table 4-16). Fewer of the evacuees in each area said they would stay in the future.

TABLE 4-16
RESPONDENTS SAYING THEIR RESPONSE IN HURRICANE GEORGES WOULD DIFFER IN THE FUTURE

	Cat 1-2 Zone	Cat 3-5 Zone	Non-Surge Zone
Stayers Who Would Leave	38	29	19
Leavers Who Would Stay	11	5	7

Those who did not evacuate in Hurricane Georges were asked where they would have gone if they did evacuate in a hurricane like Hurricane Georges. Four percent from the category 1-2 zone, 15 percent from the category 3-5 zone, and 10 percent from the non-surge zone insisted that they would not have left at all (no table).

All respondents were asked whether they would evacuate in a category 5 hurricane similar to Hurricane Camille. The great majority in each of the three risk areas said they would leave (Table 4-17). When asked where they would go if they did evacuate in a category 5 storm like Hurricane Camille, three percent from the category 1-2 area, nine percent from the category 3-5 zone, and seven percent from non-surge areas insisted that they would not leave at all.

TABLE 4-17
INTENDED RESPONSE IN CATEGORY 5 HURRICANE LIKE HURRICANE CAMILLE

	Cat 1-2 Zone (N=98)	Cat 3-5 Zone (N=94)	Non-Surge Zone (N=106)
Evacuate	87	78	84
Stay	8	18	13
Do not Know	5	4	3

Several variables were tested to see if they were associated with whether respondents evacuated in Hurricane Georges:

1. Mobile home residents were much more likely to leave than other respondents were (81 percent versus 39 percent overall).
2. People between the ages of 40 and 65 were less likely to evacuate than people both younger and older.
3. People who had lived in the region 30 years are more were less likely than others to evacuate.
4. People living alone were more likely than others to evacuate.
5. Renters were more likely than homeowners to leave.
6. Wealthier respondents were slightly less likely than others to evacuate.
7. Women were more likely than men to go.
8. These variables were not related to evacuation in Hurricane Georges:
    a. Number of years lived in one's present home.
    b. Presence of children in the home
    c. Pet ownership
    d. Race
    e. Education

RESPONSE RECOMMENDATIONS

There is considerable perceived safety in the surge zones of the study area, and in Hurricane Georges relatively few respondents believed that evacuation notices applied to them. Even in the 1999 survey, which was targeted specifically at areas included in official evacuation notices, 60 percent of the interviewees said they did not hear evacuation notices from officials. Variation in response among the three risk areas was smaller than one should expect. Hurricane Georges had sustained winds of 105 mph during most of its threat to Mississippi, so the threat was not especially severe, although it was within the realm of forecast uncertainty for the storm to become have become a category 3 before landfall. The high incidence of non-evacuees saying they were concerned about being caught on roads is troubling and puzzling.

On the encouraging side, those who said they did hear evacuation notices were much more likely than others to evacuate in Hurricane Georges, especially if they thought the notices were mandatory. Also, the great majority of stayers said they had made preparations for leaving in case the threat had worsened. Mobile home residents were much more likely than others to have evacuated.

For an area ravaged by Hurricane Camille in 1969, evacuation response appears to be more of a problem in Mississippi than it should be. If officials are more aggressive about issuing evacuation notices and communicating them to the relevant population, response should be better than that which was observed in Hurricane Georges. The rates in Table 4-18 are recommended for planning, assuming that evacuation notices are issued and communicated successfully.

TABLE 4-18
EVACUATION PARTICIPATION RATES FOR PLANNING

Category 3 Storm			**Category 1 Storm**		
Evacuation Ordered in Beach and Mainland Surge Areas and in Mobile Homes			Evacuation Ordered in Beach and Category 1 Surge Areas Only but in All Mobile Homes		
Risk Area			**Risk Area**		
Cat 1/2 Surge Zone	Cat 3/5 Surge Zones	Non-Surge Zones	Cat 1/2 Surge Zone	Cat 3/5 Surge Zones	Non-Surge Zones
Housing Other Than Mobile Homes					
85%	70%	20%	70%	40%	10%
Mobile Homes					
95%	90%	70%	90%	70%	50%

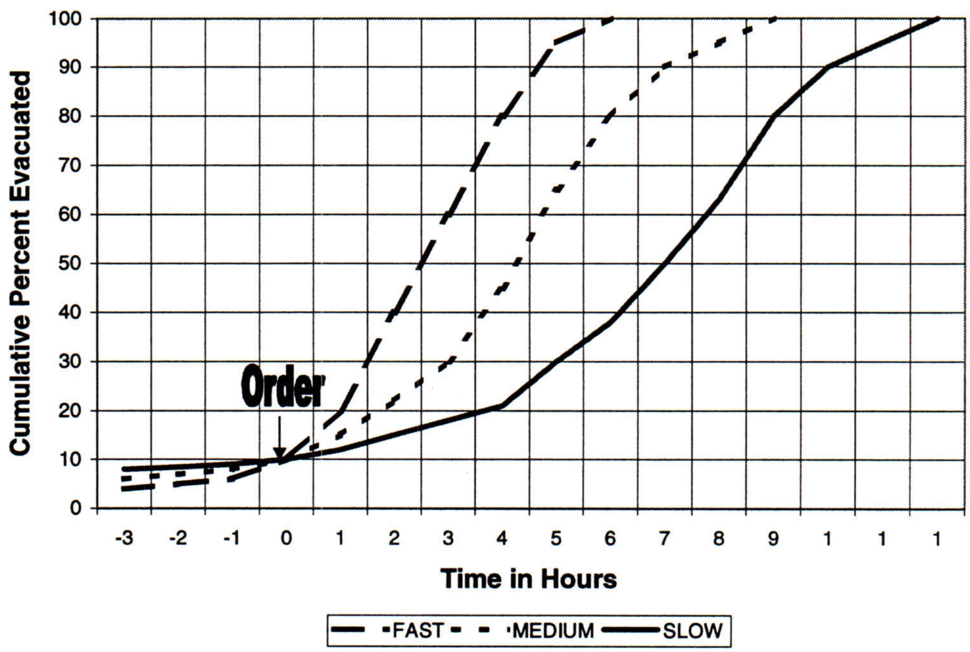
EVACUATION TIMING

Empirical evidence in evacuation after evacuation demonstrates emphatically that the very same people will leave promptly or gradually, depending upon the circumstances of the particular threat. When people believe they have the luxury of taking their time to depart, most tend to do so, even to the point of waiting until the following day to leave rather than travel at night. However, when the urgency of immediate response is successfully communicated to people, they respond very swiftly, even leaving between midnight and daybreak. That was demonstrated in Hurricane Eloise in Panama City, Florida in 1975 and in Hurricane Elena in the Tampa Bay area in 1985. In Hurricane Opal officials in some Panhandle counties called for evacuation the evening before the storm made landfall, but the evacuation did not commence in earnest until the following morning because residents did not perceive the urgency of leaving earlier. One other factor is also clear: very few evacuees (less than 20 percent) leave before officials issue an evacuation notice. Therefore, people are not going to leave in substantial numbers until someone in a position of authority tells them to and then they will leave as promptly as they are told they must. The urgency of evacuations varies because of the error inherent in hurricane forecasting. If a storm intensifies, increases forward speed, or changes course unexpectedly, it usually becomes more necessary for evacuees to leave quickly, as in Hurricanes Eloise and Opal.

The most recent survey in Mississippi did not ask Hurricane Georges evacuees the time of day and date they departed because of the length of time which had passed since the evacuation. However, the earlier post-Hurricane Georges survey in Mississippi did ask that question, and responses conformed to the generalizations stated above. Few evacuees left prior to the first evacuation notices being issued by public officials on Friday afternoon, and then proceeded gradually during the available time frame (18 percent on Friday, 49 percent on Saturday, and 26 percent on Sunday).

For planning, the three different timing response curves shown in Figure 4-1 should be evaluated, because eventually the region will experience all three. In each threat scenario occupants of inland areas will tend to wait longer to evacuate than those living in surge-prone locations. The actual number of hours over which the evacuation will occur can vary from place to place, depending upon the number of hours before anticipated landfall officials believe the evacuation must begin in order to allow time for completion.

Figure 4-1 Evacuation Response Curves



The curves in Figure 4-1 do not include a response being spread over a period of more than 24 hours such as, that which occurred in Hurricane Georges. If officials issue evacuation notices more than a full day prior to landfall the evacuation will be distributed over the entire time frame. When this occurs roughly 75 percent of the evacuation takes place in the first 12 daylight hours after the notice, and the remaining 25 percent take place in the following daylight hours.

TYPE OF REFUGE

Most evacuees go to the homes of friends and relatives when they evacuate, and that was clearly the case in Hurricane Georges in Mississippi (Table 4-19). There appears to have been a downward trend in reliance on public shelters during hurricane evacuations, starting at least with Hurricane Hugo in 1989. In Hurricane Georges only four percent of the evacuees from the category 1-2 and non-surge areas went to public shelters, although 16 percent went to public shelters in the category 3-5-hurricane zone. However, all the samples were small and statistically unreliable when the sample is divided into three separate risk areas. The earlier post-Hurricane Georges survey in Mississippi had a larger number of evacuees (N=120), all from the area actually told in Hurricane Georges to evacuate, and only three percent of the evacuees went to public shelters.

TABLE 4-19
PERCENT OF EVACUEES IN HURRICANE GEORGES GOING TO DIFFERENT TYPES OF REFUGE, BY RISK ZONE

	Cat 1-2 Zone (N=47)	Cat 3-5 Zone (N=38)	Non-Surge Zone (N=42)
Public Shelter	4	16	5
Friend/Relative	62	66	79
Hotel/Motel	23	8	7
Other	11	11	10

Those who did not evacuate in Hurricane Georges were asked where they would have gone if they had evacuated (Table 4-20). It is common for respondents to overstate their likelihood of going to public shelters, compared to actual subsequent behavior, and that is probably the case in the present survey also. The larger number of people saying they would go to hotels and motels might reflect naiveté about the availability of vacancies at such accommodations.

TABLE 4-20
REFUGES STAYERS IN HURRICANE GEORGES SAID THEY WOULD HAVE USED IF THEY HAD EVACUATED, BY RISK ZONE (PERCENT OF STAYERS)

	Cat 1-2 Zone (N=50)	Cat 3-5 Zone (N=43)	Non-Surge Zone (N=57)
Public Shelter	10	11	14
Friend/Relative	42	60	49
Hotel/Motel	36	16	16
Other	8	7	16
Do not Know	4	14	5

Interviewees were also asked what sort of refuge they would seek if they evacuated in a category 5 hurricane such as Hurricane Camille (Table 4-21). There was an increase in the number saying they would go to public shelters, possibly reflecting the belief that the homes of friends and relatives would not be safe enough in a storm like Hurricane Camille.

TABLE 4-21
INTENDED REFUGE FOR RESPONDENTS SAYING THEY WOULD EVACUATE IN A CATEGORY 5 HURRICANE LIKE HURRICANE CAMILLE BY RISK ZONE (PERCENT OF INTENDED EVACUEES)

	Cat 1-2 Zone (N=96)	Cat 3-5 Zone (N=86)	Non-Surge Zone (N=98)
Public Shelter	15	17	16
Friend/Relative	49	51	47
Hotel/Motel	25	11	20
Other/Do not Know	11	20	16

REFUGE TYPE RECOMMENDATIONS

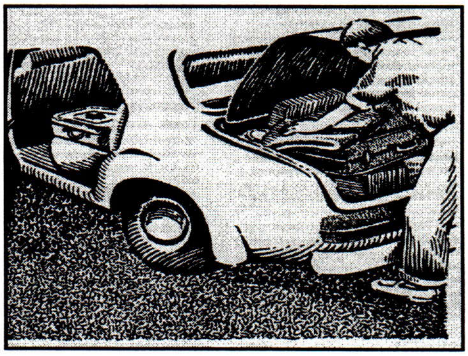
There appears to have been a trend nationwide for fewer evacuees to rely on public shelters over the past decade or more. Certainly the shelter use in Hurricane Georges was substantially lower than in Hurricane Camille, for example. The planning recommendations in Table 4-22 are broken down into nine sets of circumstances, so that planners can tailor assumptions to shelters based on the nature of evacuees being served by the shelter. In general, evacuees from high-risk areas and wealthier evacuees tend to rely less than others on public shelters.

TABLE 4-22
PLANNING ASSUMPTIONS FOR PERCENT OF EVACUEES SEEKING REFUGE IN PUBLIC SHELTERS

	Risk Area		
Income	Cat 1-2 Surge Zone	Cat 3-5 Surge Zone	Non-Surge Zone
High	5	5	5
Moderate	5	10	10
Low	10	20	20

EVACUATION DESTINATIONS

a. Refuge Locations



In Hurricane Georges approximately half the evacuees said they left their own county, with the percentage increasing slightly from the category 1-2 zone to the non-surge zone (Table 4-23). However, all the figures are based on samples with fewer than 50 respondents evacuating. Taken collectively (averaging across the three risk areas), it is safe to say that more than half the evacuees left their own county. The earlier post-Hurricane Georges survey in Mississippi indicated 55 percent of the evacuees going out of county from the areas ordered to evacuate. At least a third of the evacuees went no farther than their own neighborhood.

TABLE 4-23
LOCATION OF REFUGES USED BY EVACUEES IN HURRICANE GEORGES, BY RISK ZONE (PERCENT OF EVACUEES)

	Cat 1-2 Zone (N=46)	Cat 3-5 Zone (N=38)	Non-Surge Zone (N=42)
Own Neighborhood	33	42	33
Other Own County	24	3	7
Out of County	43	55	60

Of those who went out of county, most (70 percent to 76 percent) went to destinations in Mississippi (Table 4-24). Louisiana and Alabama were the next most popular destinations.

TABLE 4-24
LOCATION OF OUT-OF-COUNTY REFUGES USED BY EVACUEES IN HURRICANE GEORGES BY RISK ZONE (PERCENT OF OUT-OF-COUNTY EVACUEES)

	Cat 1-2 Zone (N=20)	Cat 3-5 Zone (N=21)	Non-Surge Zone (N=25)
Mississippi	70	71	76
Louisiana	15	14	4
Alabama	10	14	8
Other	1	0	12

Of those who didn't evacuate in Hurricane Georges, at least 60 percent said they would have gone out of county if they had evacuated (Table 4-25). Most of the rest said they would have gone someplace in their own neighborhood. Of those saying they would have gone out of county, most said they would have gone to places in Mississippi (Table 4-26).

TABLE 4-25
LOCATION OF REFUGES TO BE USED BY STAYERS IN HURRICANE GEORGES WHO SAID THEY WOULD EVACUATE IN THE FUTURE, BY RISK ZONE (PERCENT OF INTENDED EVACUEES)

	Cat 1-2 Zone (N=49)	Cat 3-5 Zone (N=47)	Non-Surge Zone (N=57)
Own Neighborhood	29	21	26
Other Own County	2	2	5
Out of County	65	68	60
Do not Know	4	9	7

TABLE 4-26
LOCATION OF OUT-OF-COUNTY REFUGES TO BE BY STAYERS IN GEORGES WHO SAID THEY WOULD EVACUATE IN THE FUTURE BY RISK ZONE (PERCENT OF INTENDED OUT-OF-COUNTY EVACUEES)

	Cat 1-2 Zone (N=34)	Cat 3-5 Zone (N=36)	Non-Surge Zone (N=38)
Mississippi	59	67	68
Louisiana	3	3	3
Alabama	21	0	3
Georgia	3	3	3
Florida	3	3	3
Texas	3	6	0
Arkansas/Tennessee	6	6	0
Other	0	8	8
Do not Know	3	6	13

When interviewees were asked where they would go if they evacuated for a category 5 hurricane like Hurricane Camille, most said they would go out of county, but there was more uncertainty expressed (Table 4-27). Among those saying they would go out of county, slightly fewer than in Hurricane Georges said they would go to Mississippi destinations, and about 15 percent said they did not know where they would go (Table 4-28).

TABLE 4-27
LOCATION OF REFUGES TO USED BY INTENDED EVACUEES IN CATEGORY 5 HURRICANE BY RISK ZONE (PERCENT OF INTENDED EVACUEES)

	Cat 1-2 Zone (N=94)	Cat 3-5 Zone (N=84)	Non-Surge Zone (N=98)
Own Neighborhood	22	21	29
Other Own County	10	4	7
Out of County	56	65	54
Do not Know	12	10	10

TABLE 4-28
LOCATION OF OUT-OF-COUNTY REFUGES TO BE USED BY INTENDED EVACUEES IN CATEGORY 5 HURRICANE BY RISK ZONE (PERCENT OF INTENDED OUT-OF-COUNTY EVACUEES)

	Cat 1-2 Zone (N=65)	Cat 3-5 Zone (N=63)	Non-Surge Zone (N=63)
Mississippi	46	54	56
Louisiana	8	10	3
Alabama	8	5	6
Georgia	6	3	2
Florida	3	2	2
Texas	5	5	0
Arkansas/Tennessee	6	5	6
Other	5	5	4
Don't Know	14	13	21

In Hurricane Georges 16 percent of the evacuees from Orleans and Jefferson Parishes in Louisiana said they went to destinations in Mississippi (Table 4-29), which was consistent with the 14 percent giving that response in the earlier post-Hurricane Georges survey in Louisiana. However, three percent said they went to places in Alabama, and nine percent went to Arkansas and Tennessee destinations, most of whom would have passed through Mississippi. The earlier post-Hurricane Georges survey found one percent of the New Orleans area evacuees going to Florida and two percent to Georgia, which would also have affected Mississippi. It appears that at least 25 percent of the New Orleans area evacuees in Hurricane Georges either went to destinations in Mississippi or passed through Mississippi.

When respondents in New Orleans who didn't evacuate in Hurricane Georges were asked where they would have gone if they had evacuated, the pattern was similar in terms of its impact on Mississippi (Table 4-29). It was also comparable when New Orleans respondents were asked where they would go in a category 5 hurricane (Table 4-29).

TABLE 4-29
NEW ORLEANS VICINITY EVACUEES IMPACTING MISSISSIPPI

	Hurricane Georges Evacuees (N=104)	Hurricane Georges Stayers Hypothetical (N=77)	Category 5 Hypothetical (N=163)
Mississippi	16	10	17
Alabama	3	4	2
Georgia		4	2
Florida			1
Arkansas/Tennessee	9	8	7

People in Louisiana who went out of parish were asked why they went where they did, and those saying they would go out of parish in the future were asked why they would do so. The overwhelming majority either said they went to their chosen destinations because that's where they had friends or relatives and/or that's where they felt safe (Table 4-30). Many of those in Hurricane Georges also said the "evacuation route" went to those places.

TABLE 4-30
REASONS GIVEN BY NEW ORLEANS RESPONDENTS
FOR CHOICE OF OUT-OF-COUNTY DESTINATIONS (PERCENT)

	Hurricane Georges Evacuees (N=104)	Hurricane Georges Stayers Hypothetical (N=71)	Category 5 Hypothetical (N=167)
Friend/Relative	60	53	53
Safe	31	42	40
Evacuation Route	18	2	1

DESTINATION RECOMMENDATIONS

Although the differences in percent of evacuees going to destinations outside their own counties varied little among the three risk zones in Hurricane Georges, it is common for there to be variation in most hurricane evacuations. This is partly because evacuees from the more dangerous locations tend to leave earlier and therefore go farther. Therefore in Table 4-31 slightly higher out-of-county evacuation destinations are recommended for planning in the more hazardous areas. Stronger storms will result in more of the evacuees leaving the local area.

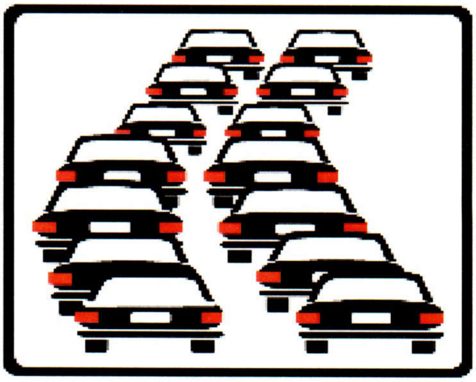
TABLE 4-31
PLANNING ASSUMPTIONS FOR PERCENT OF EVACUEES LEAVING THEIR OWN COUNTY

	Category 3 Storm	Category 1 Storm
Cat 1-2 Surge Zone	65	50
Cat 3-5 Surge Zone	60	45
Non-Surge Zone	55	40

Planners should assume that 25 percent to 30 percent of evacuees from the New Orleans vicinity would pass into or through Mississippi, with more coming from Jefferson Parish than Orleans. Anticipating the percentage of New Orleans residents that will actually evacuate is more complicated however. Approximately half the respondents from the New Orleans area left their homes to go someplace safer in Hurricane Georges, and that was notably more than in Hurricanes Andrew in 1992 and Elena in 1985. It was also in the absence of mandatory evacuation orders. It appears reasonable to expect that in some severe threat scenarios 75 percent of the New Orleans vicinity population could evacuate.

VEHICLE USAGE

Transportation modeling requires knowledge of the number of vehicles evacuating, more than the number of people. Also some vehicles such as trailers and motor homes impact traffic flow more than other vehicles. Finally emergency management officials need to anticipate the number of people who will need their assistance in order to evacuate.



Not all vehicles available to households are actually taken in evacuations. The normal range is 65 percent to 75 percent, and that was the case in Hurricane Georges in Mississippi (Table 4-32). The actual number of vehicles per household varied from 1.15 in the category 1-2 zone to 1.49 in the category 3-5 zone. An average of five percent of the evacuating households took motor-homes or pulled trailers or campers.

TABLE 4-32
VEHICLE USE IN HURRICANE GEORGES

	Cat 1-2 Zone (N=47)	Cat 3-5 Zone (N=39)	Non-Surge Zone (N=42)
Percent of Available Vehicles	68%	74%	65%
Vehicles per Household	1.15	1.49	1.29
Trailer, Camper, Motorhome	7%	3%	5%

No one who failed to evacuate in Hurricane Georges said it was due to a lack of available transportation. When asked directly, however, eight percent of the non-evacuating households included someone who would have required assistance in order to evacuate. More than half of those involved someone with a special care need, rather than just needing transportation. A third of those needing assistance said they would require help from an outside agency, rather than from within the household or from a friend or relative.

Among evacuating households in Hurricane Georges, four percent said someone in the household required assistance in order to evacuate, about half having a special care need. In 20 percent of those households the assistance was provided by an outside agency.

VEHICLE USE RECOMMENDATIONS

Planners should assume that 70 percent of the available vehicles will be used in evacuations, and that five percent of the evacuating households will pull a trailer or take a motorhome or camper.

VISITOR SURVEY

Face to face interviews were conducted with visitors to Mississippi in July of 2000. They were asked questions about hazard perception, response intentions in hypothetical hurricane threats, and personal characteristics, which might affect their response. The interviews were conducted at welcome centers (on I-10 east and west of the coast), on casino properties, and at the beach as shown in Table 4-33.

TABLE 4-33
LOCATION OF INTERVIEWS (NUMBER)

Welcome centers	85
Casinos	67
Beach	47
Mall	1

Respondents were asked the main purpose or purposes of their trip to the Mississippi Coast. Most mentioned some aspect of the casinos, but most also said they were there for a combination of reasons (Table 4-34). Respondents could state more than one primary purpose for the trip.

TABLE 4-34
PURPOSE OF VISIT (PERCENT)

Casino gambling	20
Casino entertainment	4
Casino, general	37
Beach	25
Other recreation	7
Business	11
Convention	4
Friend/relatives	15
Combination	54

Most visitors said their entire stay would consist of three or fewer days (Table 4-35), and about half had just one day remaining of their stay at the time they were interviewed. This is potentially significant in a hurricane threat. It is likely that a visitor's stay would be near its end if a hurricane threat arose during the visit, and that could mitigate the visitor's reluctance to evacuate, particularly if evacuation meant returning home.

TABLE 4-35
DURATION OF STAY IN DAYS (PERCENT)

	Total Visit	Days Remaining
1	13	48
2	26	20
3	24	14
4	16	11
5	8	3
6	3	4
7 or more	11	1

The great majority of respondents drove to the Mississippi coast, 85 percent in a car (Table 4-36). Five percent were in a motorhome, and two percent pulled a trailer or camper. This indicates that the great majority of visitors have their own vehicle in which to evacuate (rather than being stranded at the airport, for example).

TABLE 4-36
MODE OF TRANSPORTATION TO MISSISSIPPI COAST

Drove car	85
Drove motorhome	5
Pulled trailer	1
Pulled camper	1
Flew, scheduled commercial carrier	5
Flew, charter	1
Flew, private aircraft	1
Tour bus	2

Most respondents were in a small party (Table 4-37). It consisted almost entirely of friends and relatives (Table 4-38).

TABLE 4-37
NUMBER OF PEOPLE IN PARTY (PERCENT OF PARTIES)

1	8
2	47
3	16
4	12
5	5
6	6
More than 6	7

TABLE 4-38
OTHERS IN GROUP (PERCENT OF PARTIES)

Alone	9
Friends	16
Family	69
Friends and family	7

Most visitors (81percent) said they planned to return home after their stay in Mississippi, but 17 percent said they planned to go elsewhere (Table 4-39).

TABLE 4-39
PLANS AT END OF VISIT TO MISSISSIPPI COAST (PERCENT)

Return home	81
Go elsewhere	17
Do not know	2

Six states account for the homes of 85 percent of the visitors interviewed. Louisiana and Florida had the largest number of visitors (Table 4-40), but the distribution varied depending upon where the interviews were conducted. Florida visitors were less likely than others to go be at the beach, for example, and the I-10 welcome centers included no visitors from Mississippi.

TABLE 4-40
PERCENT OF VISITORS BY HOME STATE

	Interview Location		
	Beach	**Casino**	**Welcome Center**
Alabama	11	15	8
Arkansas	5	0	0
Florida	4	19	15
Georgia	4	6	7
Louisiana	26	21	28
Mississippi	19	19	0
Tennessee	6	2	1
Texas	11	3	16
Other	14	15	25

Most respondents were staying at casino hotels, and another 26 percent were at other hotels and motels (Table 4-41). A third of the accommodations were on the beach or bay, and more than half were either on or less than a block from the water (Table 4-42). At least half, and probably more, of the visitors interviewed were staying in places having more than 3 stories (Table 4-43).

TABLE 4-41
TYPE OF ACCOMMODATIONS (PERCENT)

Casino hotel	56
Other hotel/motel	26
Condominium	4
Beach house	1
Campground	5
Friend/relative	6
Other	4

TABLE 4-42
LOCATION OF ACCOMMODATIONS (PERCENT)

Beach/Bayfront	34
< 1 block from waterfront	26
1 block from waterfront	5
> 1 block from waterfront	17

TABLE 4-43
NUMBER OF FLOOR (STORIES) OF ACCOMMODATIONS (PERCENT)

1	14
2	15
3	4
More than 3	49
Do not know	19

Most people said they did not have to make any sort of advance payment for their accommodations, and most of the remainder said it was just a deposit for the first night's stay or to secure a reservation (Table 4-44). There should be little concern about advance payments deterring visitors from evacuating. Table 4-45 shows the nightly room cost of by percent of those interviewed.

TABLE 4-44
MADE ADVANCE PAYMENT FOR ACCOMMODATIONS (PERCENT)

None	67
First night deposit/reservation guarantee	20
Full amount	10
Do not know	3

TABLE 4-45
COST OF ACCOMMODATIONS PER NIGHT (PERCENT)

Free	20
< $50	17
$50 to $100	32
> $100	7
Declined to answer	2
Do not know	24

Eighteen percent said this was their first visit to the Mississippi coast, and another six percent said it was their second (Table 4-46). Half the sample said they had visited at least five times before. This suggests a high level of familiarity by most visitors with the area and probably with evacuation route options.

TABLE 4-46
NUMBER OF PREVIOUS VISITS TO MISSISSIPPI COAST (PERCENT)

0	18
1	6
2	10
3	8
4	3
5	7
More than 5	50

A third of the sample was under the age of 40, and 21 percent were over 60 (Table 4-47). Half the respondents were male and half female (Table 4-48).

TABLE 4-47
AGE OF RESPONDENT (PERCENT)

< 21	3
21 to 40	29
41 to 60	44
Over 60	21
Declined to answer	3

TABLE 4-48
GENDER OF RESPONDENT (PERCENT)

Male	49
Female	51

HAZARD PERCEPTION

Perceived safety of one's residence is a strong predictor of evacuation behavior among residents. Visitors were asked whether the places they were staying while on the Mississippi coast would be safe in a 90 mph category 1 hurricane. Almost half (40 percent) said their accommodations would be safe (Table 4-49). Respondents were then asked whether their lodging would be safe in a more powerful category 3 hurricane with winds of 125 mph. Only 12 percent said their accommodations would be safe (Table 4-50). The implication is that in a weak hurricane many visitors would be unlikely to leave if their decision were made strictly on the basis of perceived safety. In a strong storm few would be inclined to stay, even without mandatory evacuation orders. There were no associations between perceived safety and visitor characteristics discussed earlier. Even proximity of one's lodging to water was not correlated with perceived safety.

TABLE 4-49
BELIEF ACCOMMODATIONS WOULD BE
SAFE IN 90 MPH HURRICANE (PERCENT)

Safe	40
Unsafe	52
Depends on storm	1
Do not know	9

TABLE 4-50
BELIEF ACCOMMODATIONS WOULD BE SAFE IN 125 MPH HURRICANE (PERCENT)

Safe	12
Unsafe	79
Depends on storm	2
Do not know	8

INTENDED RESPONSE

Interviewees were asked whether they had considered what they would do if a hurricane threatened the area while they were visiting. Most said they had, but a third said they had not (Table 4-51). This would not necessarily prevent visitors from evacuating, but might inhibit a prompt, definite response.

TABLE 4-51
CONTEMPLATED RESPONSE TO HURRICANE THREAT (PERCENT)

Yes	65
A little	4
No	32

Three hypothetical hurricane threats were posed to visitors, and they were asked how they would respond in each. The first scenario was a category 1 hurricane with winds of 90 mph. A hurricane watch was in effect from New Orleans to Pensacola, local officials and casino and hotel management had not said anything about whether guests should evacuate, and the weather was still good. Respondents could give more than one answer to the question.

Twenty-eight percent said they would leave at that time and go home (Table 4-52). At total of 47 percent said they would leave and either go home, to another vacation area, or inland. Most said they would stay put and wait for more information. Residents are known to overstate their likelihood of evacuating early in a scenario such as this. There is no comparative data for visitors, but visitors have less reason to stay than residents, especially given the relatively short duration of their planned stays.

TABLE 4-52
INTENDED RESPONSE IN 90 MPH HURRICANE
WATCH, NO EVACUATION ORDER, GOOD WEATHER (PERCENT)

Leave for other vacation area	2
Leave for home	28
Leave for nearby destination inland	6
Go north/inland	11
Check with management for advice	7
Wait for more information	31
Stay put	31
Do not know	8
Depends on storm	2

Perceived safety of one's accommodations was a good predictor of intended response in the scenario. People who said their lodging would be unsafe in either a category 1 or 3 hurricane were more likely than others to say they would leave in the hypothetical threat scenario.

Interviewees were next asked what they would do in a much stronger hurricane, a category-3 storm with winds of 125 mph. Again, there was a hurricane watch, no evacuation notices, and good weather. In this instance 45 percent said they would head for home, and a total of 72 percent would leave to go someplace else (Table 4-53). Note, however, that respondents were permitted to give more than one response, so there is some double counting. A fifth of those saying they would go north or inland, for example, also said they would go home.

TABLE 4-53
INTENDED RESPONSE IN125 MPH HURRICANE, WATCH,
NO EVACUATION ORDER, GOOD WEATHER (PERCENT)

Leave for other vacation area	5
Leave for home	45
Leave for nearby destination inland	6
Go north/inland	16
Check with management for advice	7
Wait for more information	19
Stay put	14
Do not know	7
Depends on storm	4

People who said they had considered what they would do in a hurricane threat were more likely than others to say they would leave in this threat scenario, as were those who said their accommodations would be unsafe in category 1 and 3 hurricanes. Visitors who said they had been to the area 3 or more times were also more likely than others to say they would leave in this scenario.

The final scenario posed a category-3 hurricane with winds of 125 mph, but with a hurricane warning in effect and mandatory evacuation orders including hotels and motels. Casinos were being closed for business, the storm was closer, and the weather was starting to become windy and rainy. Most respondents (61 percent) said they would leave for home, and 98% said they would leave to go someplace (Table 4-54). Again, however, there was some double counting among the "leave" categories. Only eight percent said they would wait for more information and/or check with management for advice. Clearly almost everyone anticipated leaving, but not necessarily for home.

TABLE 4-54
INTENDED RESPONSE IN 125 MPH HURRICANE, WARNING, EVACUATION ORDER, CASINOS CLOSED, STORM CLOSER, WEATHER BAD (PERCENT)

Leave for other vacation area	5
Leave for home	61
Leave for nearby destination inland	10
Go north/inland	22
Check with management for advice	4
Wait for more information	4
Find safer place	3
Go where told	7
Depends on storm	3

When asked specifically where they would go when they evacuated for a 125 mph hurricane, 55 percent said they would go home (Table 4-55). However, excluding the "do not know" and "would not leave" responses, 63 percent of those saying they would leave and who knew where they would go said they would go home. Eight percent said they would go to public shelters, which could create difficulties for shelter providers. Residents are known to exaggerate their likelihood of using public shelters, but it isn't known whether this is true of visitors. Twelve percent would seek hotels and motels, but demand could exceed supply.

TABLE 4-55
INTENDED DESTINATION EVACUATION
FOR 125 MPH HURRICANE (PERCENT)

Home	55
Public shelter	8
Hotel/motel	12
Friend/relative	9
Other	6
Do not know	11
Wouldn't evacuate	2

Visitors were asked specific geographical destinations to which they would go, and those responses were provided to transportation analysts working on the hurricane evacuation study. Respondents were also asked the routes they would use in reaching their destinations. The most striking figure is that 40 percent said they did not know which routes they would use. (Note: Excluding the "do not know" responses from calculations almost doubles the percentages in Table 4-56.) The "do not know" responses could have been prompted by a lack of thought about how to respond to such a threat, or it could indicate recognition that route decisions would need to wait until road congestion could be assessed.

TABLE 4-56
INTENDED ROADS TO USE IN
EVACUATION FOR 125 MPH HURRICANE (PERCENT)

I-10 East	19
I-10 West	24
I-49 North	15
I-59 North	5
I-55 North	5
I-65 North	12
I-12 West	4
US 90 West	2
Do not know	40

RESPONSE IN PAST HURRICANE THREATS

Visitors were asked if they had ever been on the Mississippi Coast in the past when a hurricane threatened, and 14 percent said they had, but no more than three percent mentioned any single storm (Hurricane Georges). Taken all together (and some threats would have been greater than others, some virtually non-existent), 26 percent said they evacuated home. Half said they did not evacuate, and four percent said they went to a local public shelter.

OVERALL PLANNING RECOMMENDATIONS

Participation Rate. There is little to suggest that visitors to the Mississippi coast will be reluctant to evacuate in a hurricane threat if officials order evacuation. There is little motive for visitors to remain and little cost to their leaving. In most scenarios visitor evacuation will probably be higher than that by residents. In strong storms with official evacuation orders, at least 90 percent of the visitors will leave their accommodations to go someplace safer. In weak storms it is especially important for officials to issue evacuation orders if they want visitors to leave from category 1-2 surge areas. Without such notices, most visitors will stay or attempt to leave late during the threat.

Timing. Visitors will leave at least as early as residents, and few will leave before evacuation notices are issued. The same timing curves used for residents should be used for visitors.

Refuges. When asked where they would go when they evacuated in a category 3 hurricane eight percent of the respondents said they would go to a public shelter. Residents typically overstate their likelihood of going to public shelters, but it is not known whether this is also true of visitors. Most would leave for home, but many would not. A third of the respondents said they hadn't given much thought to what they would do in a hurricane threat, 18 percent were visiting for the first time, at least 15 percent live in states far enough away to make returning home an attractive option, and 40 percent do not know what route they would take in evacuating. Many of the 12 percent who intend to go to hotels and motels might be unable to find vacant accommodations. The greatest potential demand for public shelters will come from visitors who wait too long to leave. Officials can minimize that number by ordering evacuation early and communicating the message aggressively. It would be prudent to plan for 10 percent of the evacuating visitors to seek refuge in public shelters unless officials take explicit action to discourage that response, although the most probable figure is five percent.

Destinations. In a threat from a strong hurricane most evacuating visitors will return home, and 90 percent of the evacuees will go to destinations outside the three coastal Mississippi counties.

Transportation. Almost all the visitors to the Mississippi coast have their own transportation available to them (90 percent). Others have chartered buses or planes. Five percent of the respondents said they flew into the area on scheduled commercial flights. Many of those have to potential to be stranded, although some have rented vehicles. Five percent have motorhomes or trailers.

SHELTER ANALYSIS

CHAPTER FIVE - SHELTER ANALYSIS

PURPOSE

The general purpose of the shelter analysis is to estimate the number of evacuees that will seek public shelter and determine the number of shelter spaces available. County and State emergency management offices use this information to develop shelter management plans to insure that evacuees seeking public shelter will have adequate and safe shelter space.

SHELTER ANALYSIS

The shelter analysis discusses shelter locations, vulnerability, capacity, and demand. Data developed in the hazards, vulnerability and behavioral analyses were used to evaluate shelter criteria. It is important to note that the identification of a shelter in this report does not indicate that the facility will be used in a given hurricane evacuation. The choice of public shelters for a specific evacuation is a County and State emergency management decision. County and municipal authorities will open shelters based on a variety of circumstances including season, storm intensity, storm direction, and availability of qualified shelter operators. Furthermore, shelter designation may change based on new construction, structure modifications, ownership changes or other factors impacting shelter selection. The following paragraphs will discuss shelter vulnerability, shelter demand (number of evacuees seeking public shelter) and shelter inventories and capacities. County or State offices will periodically update this portion of the report to reflect current shelter inventories.

SHELTER VULNERABILITY

Criteria contained in the American Red Cross (ARC) publication 4496, Guidelines for Hurricane Evacuation Shelter Selection, dated July 1992, are used to evaluate shelters within the study area. The ARC offices of emergency management only open shelters located outside hurricane surge areas unless special circumstances apply. It is vitally important that any government or private entity intending to operate a public hurricane shelter carefully consider the ARC guidelines and ensure that the shelter is above any storm surge elevations.

SHELTER DEMAND

Public shelter demand is the number of evacuees expected to seek public shelter. This demand has been estimated for several hurricane evacuation scenarios for each county. Evacuation zone scenarios for each county are discussed in Chapter 3. Generally the percent of evacuees planning to use public shelters ranges from five to15 percent depending upon their risk zone, the storm intensity and their income. Table 5-1 shows the maximum shelter demand for each evacuation scenario by county. No out-of-county evacuees are expected to seek shelter in the coastal counties. The analysis assumes an adequate warning period for an approaching hurricane and sufficient public knowledge concerning the locations of shelters.

TABLE 5-1
SHELTER USE DATA BY EVACUATION SCENARIO

	Total Evacuees	Tourist Occupancy	Maximum Public Shelter demand	Shelter space available
HANCOCK				
Category 1-2	28,845	Low	1,982	3,248
Category 3	38,588	Low	3,335	1,399
Category 4-5	50,589	Low	5,352	450
Category 1-2	38,721	High	2,079	3,248
Category 3	50,134	High	3,452	1,399
Category 4-5	62,367	High	5,352	450
HARRISON				
Category 1-2	78,247	Low	5,185	18,305
Category 3	120,487	Low	10,852	14,800
Category 4-5	203,540	Low	20,577	7,150
Category 1-2	98,403	High	5,293	18,305
Category 3	147,820	High	11,001	14,800
Category 4-5	231,728	High	20,577	7,150
JACKSON				
Category 1-2	98,684	Low	6,726	5,950
Category 3	130,631	Low	11,336	2,950
Category 4-5	141,375	Low	12,877	1,300
Category 1-2	110,726	High	6,849	5,950
Category 3	145,590	High	11,488	2,950
Category 4-5	156,580	High	12,877	1,300

SHELTER INVENTORIES AND CAPACITIES

Tables 5-2 through 5-4 provide an inventory of potential hurricane evacuation shelters and capacities in the three coastal counties that might be used during an evacuation. The tables show the shelter name, address, capacity of evacuees it can accommodate, the hurricane category it is located in and the floodplain zone it is in. The "Storm Cat." Column gives the storm category 1-5 or a "0" meaning they are not in a hurricane surge area. The American Red Cross helps to manage these shelter facilities during and after an evacuation. None of the shelters will allow pets.

TABLE 5-2
LIST OF POTENTIAL HURRICANE SHELTERS IN HANCOCK COUNTY

No.	Shelter	Address	Capacity	Storm Cat.	NFIP
1	Bay High School	750 Blue Meadow Rd.	800	3	X
2	Bay Middle School	400 North Second St.	350	3	X
3	Hancock Elementary	6122 Cuevas Town Rd.	450	0	X
4	Hancock High School	7084 Stennis Airport Dr.	1,250	2	X
4	Methodist Day Care	126 Main St.	100	4	X
6	Waveland Elementary	1101 St. Joseph St.	400	3	X
7	St. Rose School	301 Necaise Ave.	400	4	X
8	Civic Center	3066 Longfellow Dr.	500	2	AE
9	Senior Citizen Center	601 Bookter St.	150	5	X
10	East Hancock Elementary	4221 Kiln Delisle Rd.	299	4	X
11	Hancock Middle School	7084 Stennis Airport Dr.	299	3	X
		Total Capacity	4,998		

TABLE 5-3
LIST OF POTENTIAL HURRICANE SHELTERS IN HARRISON COUNTY

No.	Shelter	Address	Capacity	Storm Cat.	NFIP
2	Harrison Central High School	15600 School Road	1,200	0	X
4	Lizana Elementary School	15341 Lizana School Road	400	0	X
5	Lyman Elementary School	14222 Old Highway 49	550	0	X
7	N. Woolmarket Elem. School	16237 Old Woolmarket Road	900	0	X
8	Orange Grove Elem. School	11391 Old Highway 49	600	0	X
9	Three Rivers Elem. School	13500 Three Rivers Road	700	0	X
10	Saucier Elementary School	Hwy 49 North - P.O. Box 46	350	0	X
11	West Wortham Elem. School	20199 West Wortham Road	900	0	X
12	Woolmarket Elem. School	12513 John Lee Road	400	0	X
16	Central Elementary School	1043 Pass Road & Broadmore	800	0	X
25	Harrison Central Elem.	15451 Dedeaux Road	350	0	X
28	North Bay Elementary	1825 Popps Ferry Rd., Biloxi, MS	635	0	X
1	D'Iberville High School	3320 Warrior Drive	1,100	3	X
21	Biloxi High School	1424 Father Ryan Avenue	1,300	3	X
22	DuKate Elementary School	580 Howard Avenue	365	3	X
26	Pineville Elementary	5192 Menge Ave – P.C	105	3	X
6	N. Gulfport 7th & 8th Grade	4715 Illinois Avenue	950	4	X
13	Delisle Elementary School	6303 West Wittman	300	4	X
14	Quarles Elementary School	111 Quarles Street	400	4	X
18	Gulfport High School	100 Perry Street	1,500	4	X
19	West Elementary School	4051-15th Street	600	4	X
20	Beauvior Elem. School	2003 Lawrence Road	400	4	X
27	Bayou View Middle	212 43rd Ave GPT.	950	4	X
3	Harrison Central 9th Grade	10453 Klein Road	450	5	X
15	Reeves Elementary School	214 St. Augustine Drive	400	5	X
17	Central Middle School	1310 42nd Avenue	600	5	X
23	Jeff Davis Elem. School	340 St. Mary Boulevard	250	5	X
24	Popps Ferry Elem. School	364 Trafalgar Drive	250	5	X
29	Good Deeds Community Ctr.	15101 Madison Avenue Gpt.	600	5	X
		Total Capacity	18,305		

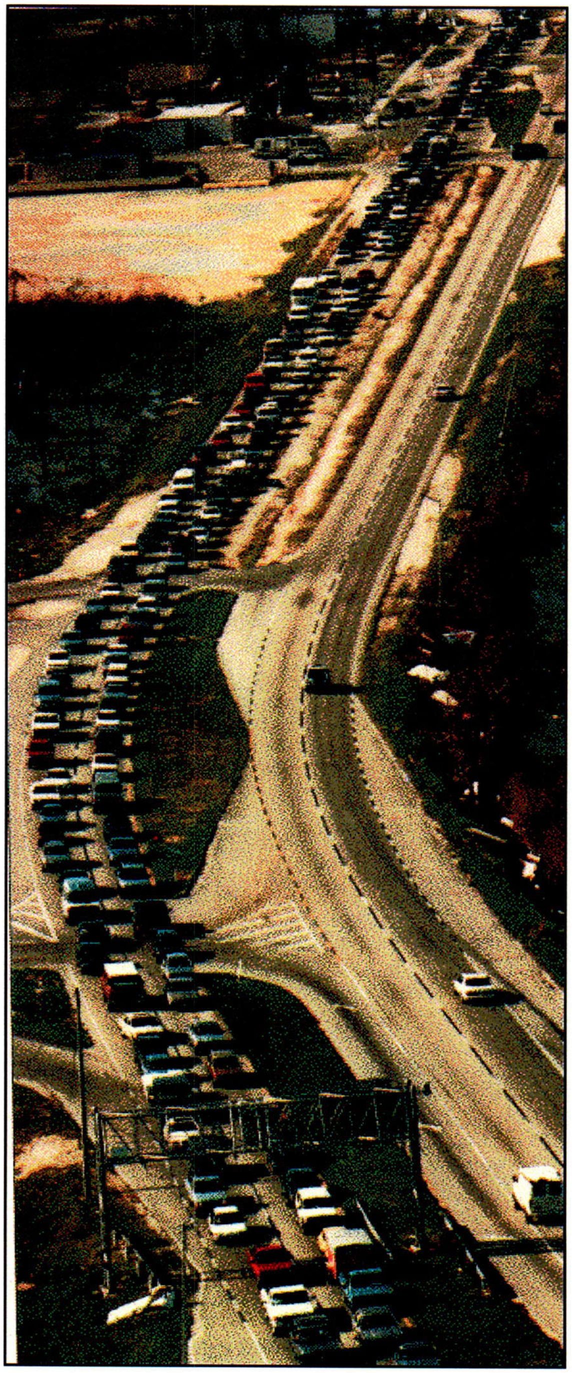
TABLE 5-4
LIST OF POTENTIAL HURRICANE SHELTERS IN JACKSON COUNTY

No.	Shelter	Address	Capacity	Storm Cat.	NFIP
1	Eastlawn Elementary	2611 Ingalls Avenue	600	2	X
2	Singing River Elementary	4601 Gautier/Vancleave Rd	350	4	X
3	Moss Point High School	4913 Weems St.	800	5	X
4	Ocean Springs Middle School	3600 Hanshaw Road	300	3	X
5	Vancleave High School	12412 Highway 57	400	0	X
6	St. Martin High School	10800 Yellow Jacket Road	800	3	X
7	East Central High	21700 Slider Rd.	200	0	X
8	Trent Lott Middle School	2234 Pascagoula St.	400	2	X500
9	Colmer Middle School	3112 Eden St.	400	3	X
10	Charlotte Hyatt	4524 Welch St.	400	3	X
11	Escatawpa Elementary	4208 Jamestown Rd.	800	3	X
12	Ocean Springs High School	Holcomb Road	200	4	X
13	St. Martin East Elementary	7508 Rose Farm RD	700	0	X
14	Gautier High School	4307 Gautier/Vancleave Rd.	300	3	X
15	Ms. Gulf Coast Comm. College	Hwy 90, Gautier, MS	300	4	X
		Total Capacity	6,950		

TRANSPORTATION ANALYSIS

CHAPTER SIX - TRANSPORTATION ANALYSIS

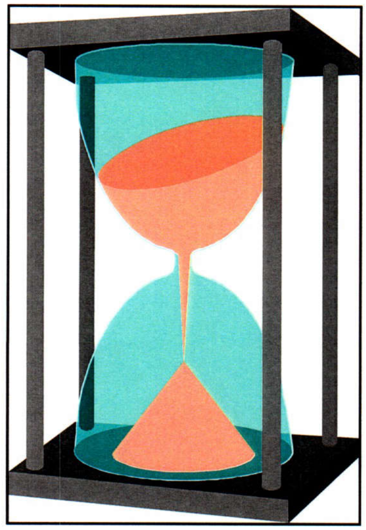
INTRODUCTION



During a hurricane evacuation in Mississippi significant number of vehicles have to be moved on the road network in a relatively short period of time. With limited sheltering available for a major hurricane in the coastal counties, most evacuees will go to inland counties and beyond to seek shelter. This often creates traffic backups and long travel times.

The magnitude of evacuating vehicles will vary depending upon; the intensity of the hurricane, publicity and warnings given about the storm, and certain behavioral response characteristics of the population. During a typical evacuation, vehicles enter the road network at different times depending on the evacuee's response relative to an evacuation order or storm advisory. Conversely, vehicles leave the road network depending on both the planned destinations of evacuees and the availability of acceptable destinations such as public shelters, hotel/motel units and friend's or relative's in non-surge prone areas. Vehicles move across the road network from trip origin to destination at a speed dependent on the rate of traffic flowing on various roadway segments and the ability of the segments to handle a certain volume of vehicles each hour. Estimates of evacuation clearance times for the study area include the effects of evacuation traffic generated by neighboring counties that will use Hancock, Harrison and Jackson Counties' roadways.

ANALYSIS OBJECTIVES



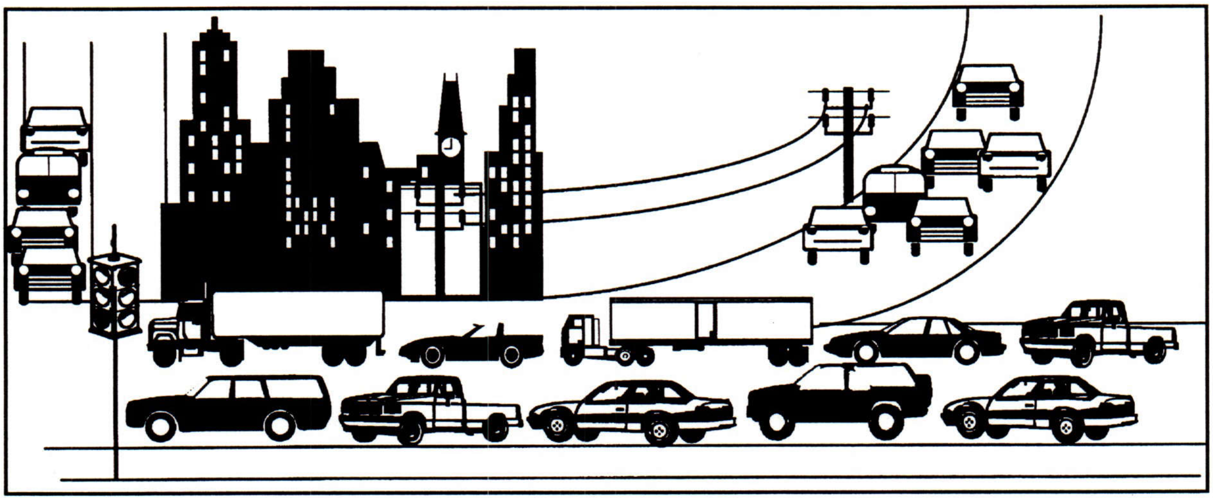
The main objective of the transportation analysis is to estimate evacuation clearance times, (the time it takes to clear a county's roadway of all evacuating vehicles). To estimate clearance times the evacuation road network had to be defined and general traffic control issues had to be examined. Clearance time is a value resulting from transportation engineering analysis performed under a specific set of assumptions. It must be coupled with pre-landfall hazards data to determine when an evacuation advisory must be issued to allow all evacuees time to reach safe shelter. Pre-landfall hazards are sustained gale force winds and/or roadway flooding prior to landfall of the eye of the hurricane. Factors that influence clearance time must be studied intensively to determine which factors have the strongest influence. Therefore, a sensitivity analysis was performed and a range of clearance times calculated for each county by varying key input parameters.

The transportation analysis task initially identified traffic movements associated with a hurricane evacuation. Basic assumptions for the transportation analysis were related to storm scenarios, population-at-risk, behavioral and socioeconomic characteristics, and the roadway system and traffic control. A separate transportation model and an evacuation roadway system were developed for each county to facilitate model application and development of clearance times. General information and data related to the transportation analysis are presented in summary form in this report. A separate Transportation Analysis Update Report and Transportation Model Support Document were printed in February 2001. These documents include detailed transportation modeling statistics and zone by zone data listings for each county.

STATE AND COUNTY ASSISTANCE

A critical element in performing the study tasks was the coordination with each county and the State of Mississippi. Meetings were held with the county emergency management offices to coordinate the various technical inputs and to review graphics and evacuation statistics developed in the study. Counties were provided with draft data throughout the process so that final results would be more credible and usable. The counties and the Gulf Regional Planning Council assisted in the development of the dwelling unit database.

EVACUATION TRAVEL PATTERNS



The movements associated with hurricane evacuation have been identified for the purposes of this analysis by five general patterns as follows:

a. In-County Origins to In-County Destinations. Trips made from the storm surge vulnerable areas and mobile home units in an individual county to destinations within the same county, such as public shelters, hotel and motel units, churches, and friends or relatives outside the storm surge vulnerable areas.

b. In-County Origins to Out-Of-County Destinations. Trips made from the individual coastal county to destinations in other counties of the study area or outside the study area entirely. This is a significant category for the Mississippi Region as many coastal evacuees seek safe destinations in Alabama and inland counties in Mississippi.

c. Out-Of-County Origins to In-County Destinations. Trips made from adjoining counties that enter coastal counties to reach their shelter destinations.

d. Out-of-County Origins to Out-of-County Destinations. Trips passing through coastal counties trying to reach their shelter destinations in other counties in the study area or outside the study area entirely.

e. Background Traffic. Trips made by persons preparing for the arrival of hurricane conditions; which are primarily shopping trips to gather supplies or secure property. Along the Mississippi coast, trips from work to home to assist the family in evacuation could impact evacuation of coastal evacuees. Background traffic can also include transit vehicles (vans/buses) used to pick up evacuees without personal transportation.

Figure 6-1 graphically depicts these traffic movement patterns associated with hurricane evacuation situations in the region. It is important to recognize that three of the five defined patterns involve traffic movement patterns outside the county's boundaries. It is evident that, depending on the track of the storm these inter-county movements can and do result in a number of regional traffic impacts. During the transportation analysis, these movements were quantified to estimate the traffic demand on roadway segments and resulting clearance times required to get all evacuating vehicles to safety.

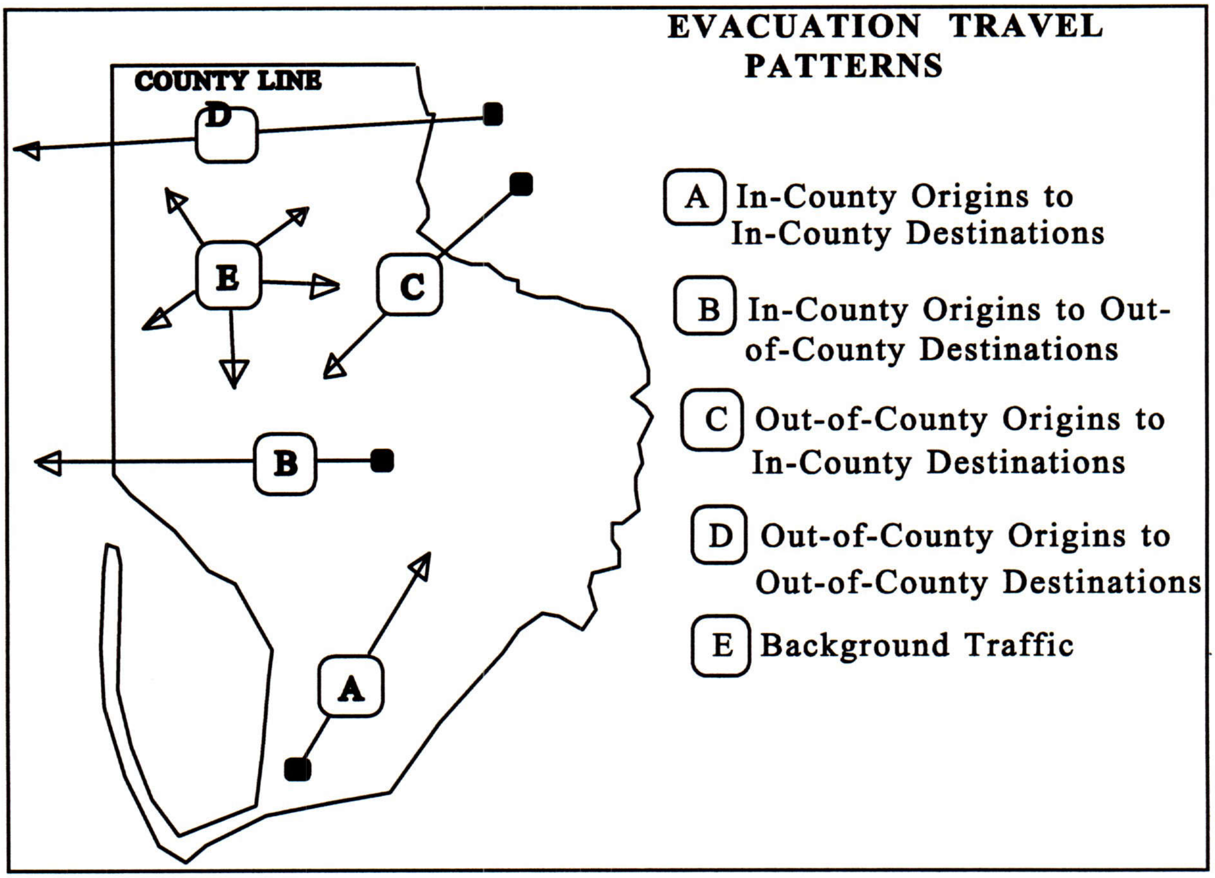


FIGURE 6-1 EVACUATION TRAVEL PATTERNS

TRANSPORTATION ANALYSIS INPUT ASSUMPTIONS

Since all hurricanes differ from one another, it becomes necessary to set clear assumptions about storm characteristics and evacuees' expected response before transportation modeling can begin. Not only does a storm vary in its track, intensity and size, but also in the way residents in potentially vulnerable areas perceive it. These factors cause a wide variance in the behavior of the vulnerable population. Even the time of day that a storm makes landfall influences the time parameters of an evacuation.

The transportation analysis computes clearance times based on a set of assumed conditions and behavioral responses. It is likely that an actual storm will differ from a simulated storm for which clearance times are calculated in this report. Therefore, a sensitivity analysis was performed. Those variables having the greatest influence on clearance time were identified and then varied to establish the logical range within which the actual input assumption values might fall.

Key information guiding the transportation analysis is grouped into five areas.

1. Storm Surge Areas and Evacuation Zones
2. Traffic Analysis Zones
3. Housing and Population Data
4. Behavioral Characteristics of the Evacuating Population
5. Roadway Network and Traffic Control Assumptions

These five areas and their assumed parameters are described in the following paragraphs.

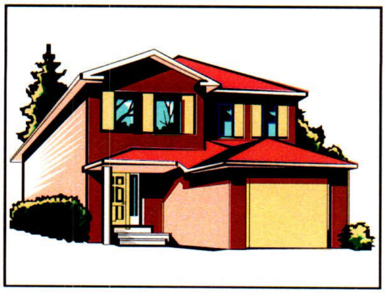
a. Surge Areas and Evacuation Zones

The first building block of the transportation model was the development of evacuation zones. As discussed in Chapter 3, the new surge inundation maps were used to determine the evacuation zone boundaries. Each of the three coastal counties adopted three evacuation scenarios, which were shown on Figure 3-1 through 3-3. The evacuation zone boundaries follow roadways to make it easier for residents to determine what zone they live in.

b. Traffic Analysis Zones

Each evacuation zone is made up of smaller areas called traffic analysis zones, which are used by the transportation model to determine how many vehicles will use each roadway. The traffic analysis zones for each coastal county are shown on Figures 6-2 through 6-4. The traffic model uses dwelling unit data for each traffic analysis zone to estimate the number of vehicles that will be used during an evacuation. The traffic analysis zones used for each county vary in shape and size but conform to the evacuation zones.

c. Dwelling Unit and Population Data



Dwelling units and population were estimated for each traffic analysis zone for the year 2000. Data from the 1990 Census was supplemented with information from the Gulf Regional Planning Council to develop these estimates. Tables 6-1 through 6-3 give a breakdown of dwelling unit and population data by traffic zone and evacuation for each county.

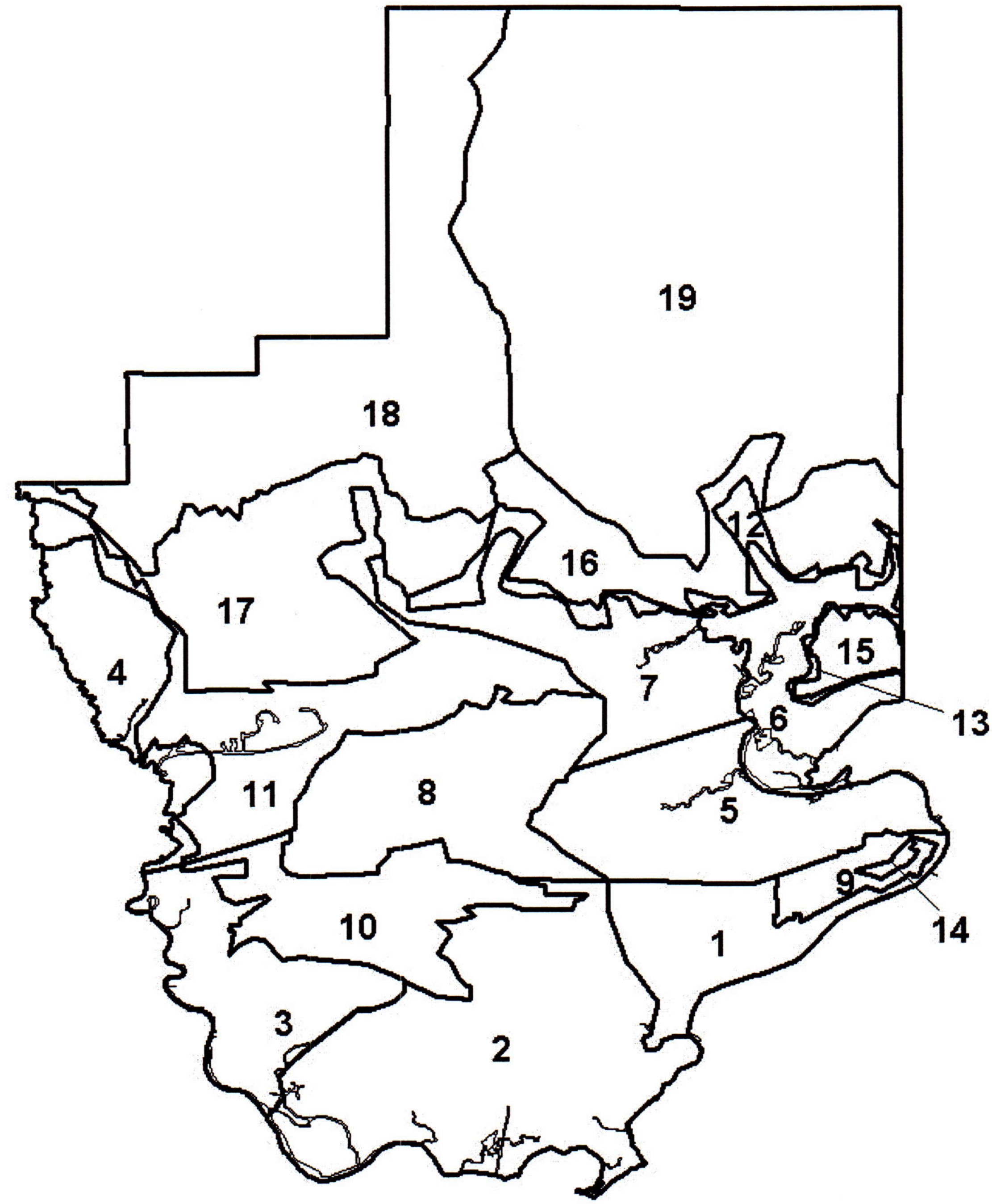


FIGURE 6-2 HANCOCK COUNTY TRAFFIC ANALYSIS ZONES

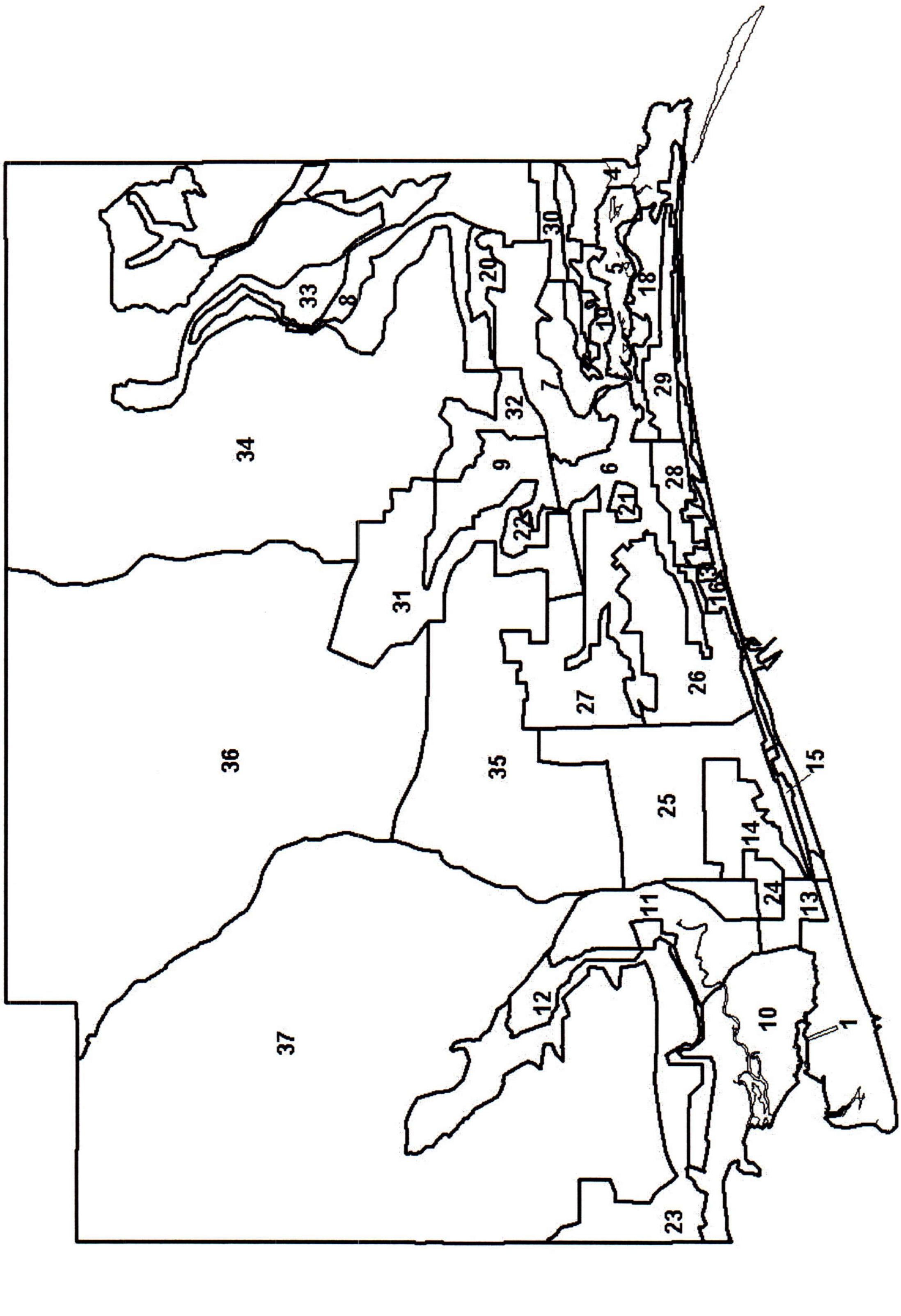


FIGURE 6-3 HARRISON COUNTY TRAFFIC ANALYSIS ZONES

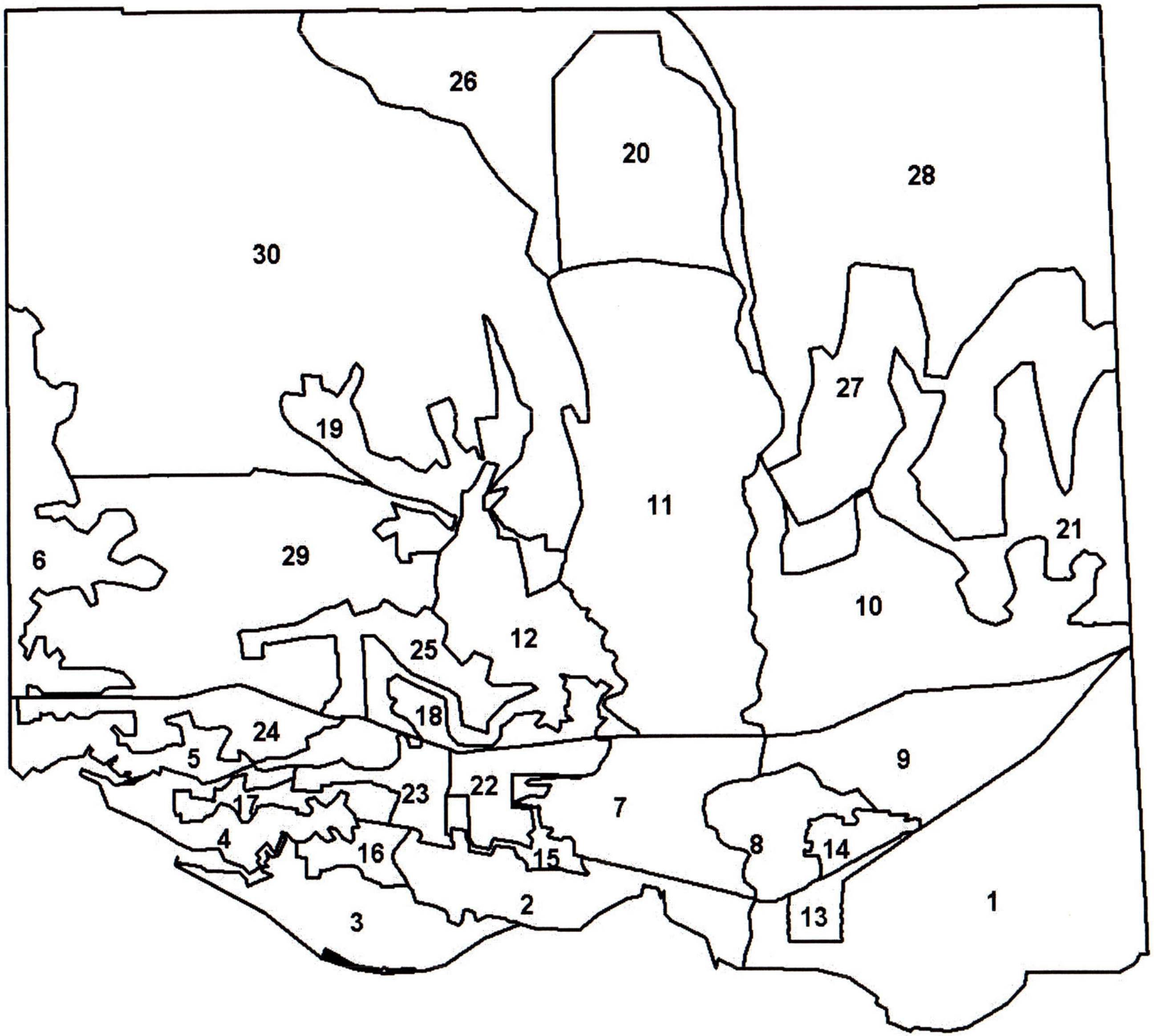


FIGURE 6-4 JACKSON COUNTY TRAFFIC ANALYSIS ZONES

TABLE 6-1
HANCOCK COUNTY TRAFFIC ANALYSIS ZONE DATA
FOR THE BASE YEAR 2000

	Dwelling Units			Population		
	Permanent	Mobile	Seasonal	Permanent	Mobile	Seasonal
Traffic	Occupied	Home	Tourist		Home	
Zone(TZ)	Units	Units	Units			
1	3,111	483	1,505	9,333	1,449	4,515
2	320	8	269	960	24	807
3	8	8	0	24	24	0
4	76	49	10	228	147	30
5	2,711	274	2,270	8,133	822	6,810
6	569	59	253	1,707	177	759
7	196	98	112	588	294	336
8	52	52	9	156	156	27
9	2,290	248	633	6,870	744	1,899
10	28	6	2	84	18	6
11	123	98	18	369	294	54
12	144	49	35	432	147	105
13	279	3	143	837	9	429
14	349	3	56	1,047	9	168
15	1,279	18	746	3,837	54	2,238
16	386	98	116	1,158	294	348
17	229	98	31	687	294	93
18	1,102	147	145	3,306	441	435
19	1,321	245	189	3,963	735	567
Total	14,573	2,044	6,542	43,719	6,132	19,626
Evac Zone						
A - TZ 1-8	7,043	1,031	4,428	21,129	3,093	13,284
B - TZ 1-13	9,907	1,435	5,259	29,721	4,305	15,777
C - TZ 1-17	12,150	1,652	6,208	36,450	4,956	18,624

Note: All evacuation zones includes the recommended evacuation of all mobile homes throughout the County in all traffic zones. Also the permanent dwelling units and the permanent population include the mobile home units and mobile home population.

TABLE 6-2
HARRISON COUNTY TRAFFIC ANALYSIS
ZONE DATA FOR THE BASE YEAR 2000

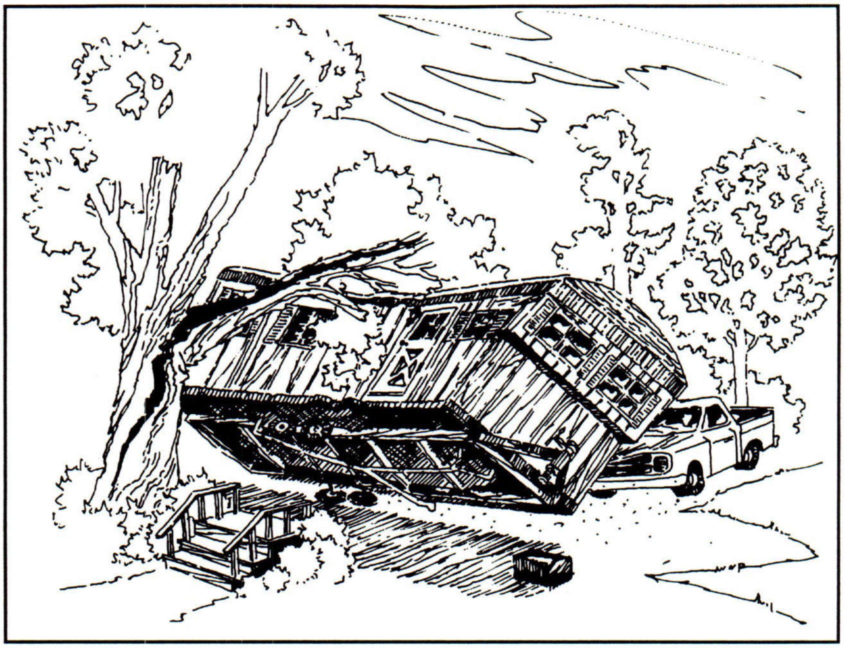
	Dwelling Units			Population		
	Permanent	Mobile	Seasonal	Permanent	Mobile	Seasonal
Evac	Occupied	Home	Tourist		Home	
Zone	Units	Units	Units			
1	2,453	130	1,152	6,427	342	3,456
2	1,529	42	394	4,007	109	1,182
3	1,669	100	626	4,372	261	1,878
4	6,771	428	3,147	17,741	1,121	9,441
5	2,914	338	214	7,636	885	642
6	3,560	473	631	9,327	1,240	1,893
7	826	183	79	2,165	481	237
8	622	215	224	1,630	563	672
9	802	54	82	2,102	141	246
10	683	58	133	1,789	151	399
11	440	153	52	1,154	402	156
12	360	111	25	943	290	75
13	458	58	36	1,199	151	108
14	1,401	10	90	3,670	26	270
15	541	15	191	1,416	40	573
16	2,283	114	743	5,982	297	2,229
17	1,523	123	1,089	3,990	322	3,267
18	4,322	213	1,862	11,325	558	5,586
19	759	177	62	1,989	463	186
20	253	54	12	663	141	36
21	409	78	31	1,073	203	93
22	391	67	34	1,025	177	102
23	770	221	53	2,018	580	159
24	687	14	40	1,801	38	120
25	4,155	274	563	10,886	719	1,689
26	6,230	389	813	16,324	1,019	2,439
27	2,408	192	1,107	6,310	504	3,321
28	2,667	59	273	6,988	153	819
29	3,755	178	583	9,839	467	1,749
30	1,006	252	96	2,636	660	288
31	1,531	310	135	4,011	811	405
32	493	107	29	1,292	281	87
33	408	107	34	1,070	281	102
34	2,198	215	164	5,758	563	492
35	5,064	497	472	13,267	1,303	1,416
36	2,617	435	209	6,858	1,139	627
37	2,448	654	180	6,415	1,715	540
Total	71,411	7,098	15,660	187,098	18,596	46,980
Evac Zone						
A - TZ 1-11	22,270	2,174	6,734	58,349	5,695	20,202
B - TZ 1-22	34,971	3,192	10,909	91,624	8,363	32,727
C - TZ 1-33	59,084	5,297	14,635	154,800	13,877	43,905

Note: All evacuation zones include the recommended evacuation of all mobile homes throughout the County in all traffic zones. Also the permanent dwelling units and the permanent population include the mobile home units and mobile home population.

TABLE 6-3
JACKSON COUNTY TRAFFIC ANALYSIS ZONE DATA
FOR THE BASE YEAR 2000

	Dwelling Units			Population		
	Permanent	Mobile	Seasonal	Permanent	Mobile	Seasonal
Evac	Occupied	Home	Tourist		Home	
Zone	Units	Units	Units			
1	6,858	287	803	19,340	809	2,409
2	2,796	236	417	7,885	666	1,251
3	2,075	196	310	5,852	553	930
4	4,828	143	585	13,615	402	1,755
5	3,292	65	449	9,283	183	1,347
6	1,083	101	214	3,054	283	642
7	1,546	52	337	4,360	147	1,011
8	3,267	55	422	9,213	154	1,266
9	1,225	295	667	3,455	832	2,001
10	2,941	697	487	8,294	1,966	1,461
11	237	50	37	668	142	111
12	733	101	208	2,067	283	624
13	3,159	7	1,136	8,908	19	3,408
14	2,562	144	241	7,225	405	723
15	476	67	156	1,342	188	468
16	332	84	78	936	237	234
17	1,902	126	152	5,364	355	456
18	673	64	166	1,898	180	498
19	374	151	46	1,055	425	138
20	146	39	26	412	110	78
21	942	201	152	2,656	565	456
22	560	379	69	1,579	1,069	207
23	527	124	76	1,486	350	228
24	1,892	30	313	5,335	83	939
25	192	132	37	541	373	111
26	615	89	97	1,734	252	291
27	657	117	116	1,853	331	348
28	1,314	313	232	3,705	882	696
29	985	201	251	2,778	567	753
30	1,345	302	166	3,793	850	498
Total	49,534	4,845	8,446	139,686	13,664	25,338
Evac Zone						
A - TZ 1-12	30,881	2,277	4,936	87,084	6,421	14,808
B - TZ 1-21	41,447	3,158	7,089	116,881	8,906	21,267
C - TZ 1-27	45,890	4,030	7,797	129,410	11,364	23,391

Note: All evacuation zones include the recommended evacuation of all mobile homes throughout the County in all traffic zones. Also the permanent dwelling units and the permanent population include the mobile home units and mobile home population.



Past experience shows that mobile homes can be severely damaged and totally destroyed by hurricane force winds. Intense fast moving hurricanes can also cause severe wind damage in inland counties more than a hundred miles from the coast. Mobile home evacuations in non-surge areas and inland counties can substantially increase the number of vehicles that will be on the roadways during an evacuation. The transportation analysis focuses on dwelling units within the potential storm surge flooded areas of a county and inland mobile homes which would be vulnerable to hurricane force winds.

d. Behavioral Assumptions

Any hurricane evacuation of the Mississippi Coast involves the coordinated action of thousands of individuals. Information from the behavioral analysis described in Chapter 4 was used to derive the assumptions for the transportation analysis. The following behavioral variables were used in the transportation analysis:

- Participation rates - what percent of the population in different areas will evacuate their dwelling units for hurricane threats?
- Response rates (rapidity of response) - how quickly will evacuees respond to what local officials are telling them to do?
- Destination percentages - what percent of the population by county sub-area will evacuate to local public shelters, local hotel/motels, local friends' and relatives' homes, or out of the county entirely?
- Vehicle usage - of the vehicles available to the households, what percent of those vehicles will be used in an evacuation?

(1) Participation Rates

The behavioral analysis in Chapter 4 discusses many of the variables that a person considers to make a decision on whether to evacuate or not. For this analysis we assumed that there would be 100 percent participation rate in all storm surge zones ordered to evacuate. It was assumed that all mobile homes (100 percent) in inland zones would evacuate. A portion of the non-surge population was also assumed to evacuate. This percentage will be higher for more intense hurricanes (1 percent - 15 percent). The 100 percent participation rates were used as a matter of public safety to allow those who are vulnerable to storm surge the opportunity to evacuate whether they choose to or not. Actual participation rates are usually less than 100 percent.

(2) Response Rates

Another critical behavioral aspect of the transportation analysis is the response rate of the evacuating population. Behavioral data shows that actual departures of the evacuating population occur over a period of many hours or sometimes a very brief time. In the Hurricane Opal evacuation, evacuees loaded the road network in a very short period of time since most evacuees waited until the morning of the storm to leave. For this study, clearance times were tested for three evacuation response rates (slow, medium and fast) represented by different behavioral response curves as shown in Figure 6-5.

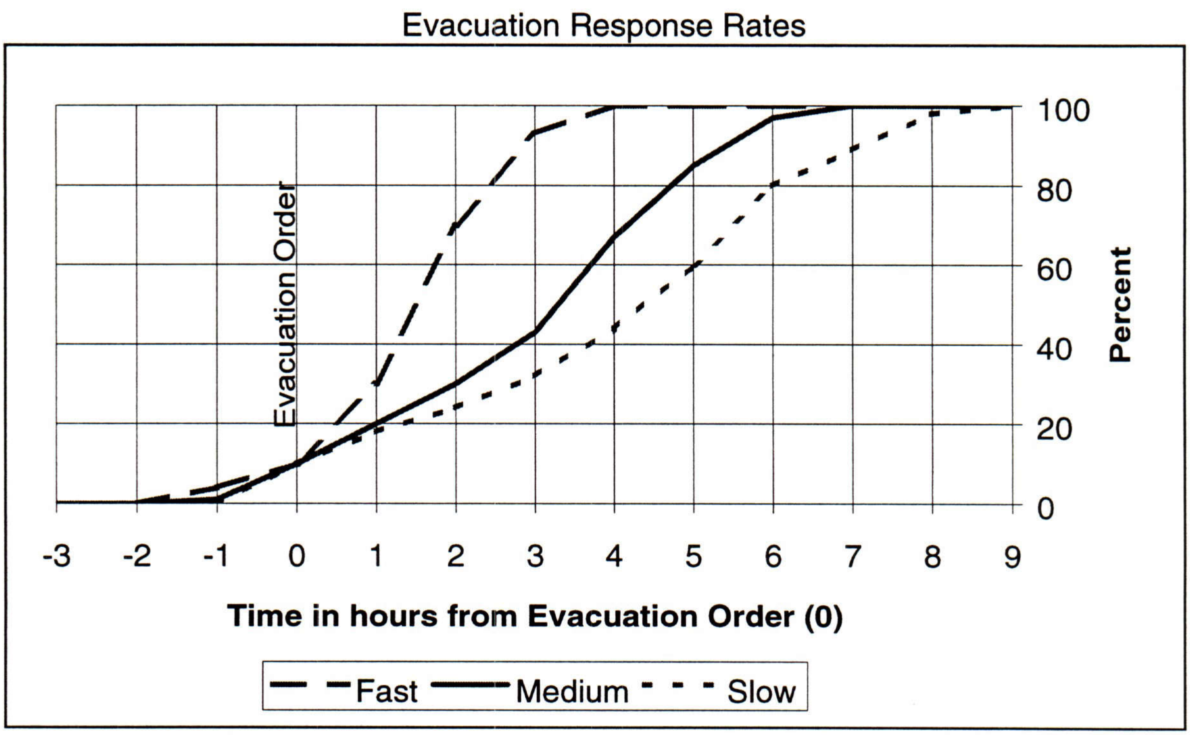


FIGURE 6-5 EVACUATION RESPONSE CURVES

(3) Destination Types

The percentage of evacuees assumed to go to one of four general destination types was another important behavioral input to the transportation analysis. The destination types were discussed with emergency management staff and include local public shelters, hotel/motel units, the home of a friend or relative in-county, or out-of-county. Out-of-county evacuees would also use friends/relatives, public shelters and hotels/motels. When in-county shelter space was insufficient it was assumed that these evacuees would have to leave the county to find shelter. It should be noted that a larger percentage of evacuees would leave the county as the storm intensity increases. Table 6-4 displays evacuee destinations used in the study.

TABLE 6-4
ASSUMED EVACUEE SHELTER DESTINATIONS
BY PERCENT

SHELTER TYPE	HANCOCK COUNTY		HARRISON COUNTY		JACKSON COUNTY	
	Permanent People (%)	Tourists (%)	Permanent People (%)	Tourists (%)	Permanent People (%)	Tourists (%)
Shelter	5-20	0-1	5-20	0-1	5-20	0-1
Hotel/Motel	0-5	0	0-5	0	0-5	0
Friend/Relative	25-50	0	25-50	0	25-50	0
Out-of-county	25-60	99-100	25-60	99-100	25-60	99-100

(4) Vehicle Usage

Vehicle usage percentages refer to the percentage of vehicles available at the home origin that would be used in the evacuation. Vehicle usage percentages were approximately 65 percent to 75 percent (depending on distance from the coastline). The percent of households expected to pull a boat, trailer or RV was approximately 5 percent in the immediately coastal area zones.

e. Roadway Network and Traffic Control Assumptions

A final group of assumptions used for input to the transportation analysis is related to the roadway system chosen for the evacuation network and traffic control measures considered for traffic movement. Although the assumptions developed for the transportation analysis are general, the efforts at county and municipal levels regarding traffic control and roadway selection must be quite detailed. In heavily urbanized areas most intersections will be controlled by existing traffic signals. However, as resources permit, traffic control officers will be stationed at bottlenecks identified in this study as well as other local locations of concern. Detailed law enforcement assignments to major bottlenecks involve extensive coordination among local and state officials. This study does not presume to replace those efforts, but seeks to quantify the time elements within which such personnel would operate.

In choosing roadways to be used for the evacuation network, an effort was made to include street facilities with sufficient elevations, little or no adjacent tree coverage, substantial shoulder width and surface, and roadways already contained in existing hurricane evacuation plans.

In order to determine the routing of evacuation, a representation of the roadway system was developed. A "link-node" system was developed to identify roadway sections. Nodes are used to identify the intersection of two roadways or changes in roadway characteristics. Links are the roadway segments. Each link is identified by a letter designation. Figures 6-6 through 6-8 show the evacuation network with link names and zone connections to the links shown by open circles and dashed lines. Table 6-5 shows the Link name and road names.

Once the links and nodes were established for the evacuation routes, directional traffic service volumes at Level of Service D were established for each link for the Year 2000. This was accomplished by ascertaining number of lanes, facility type, and area type information from available mapping and field inspections. Tables were then used to specify a directional, level of service D service volume based on link characteristics.

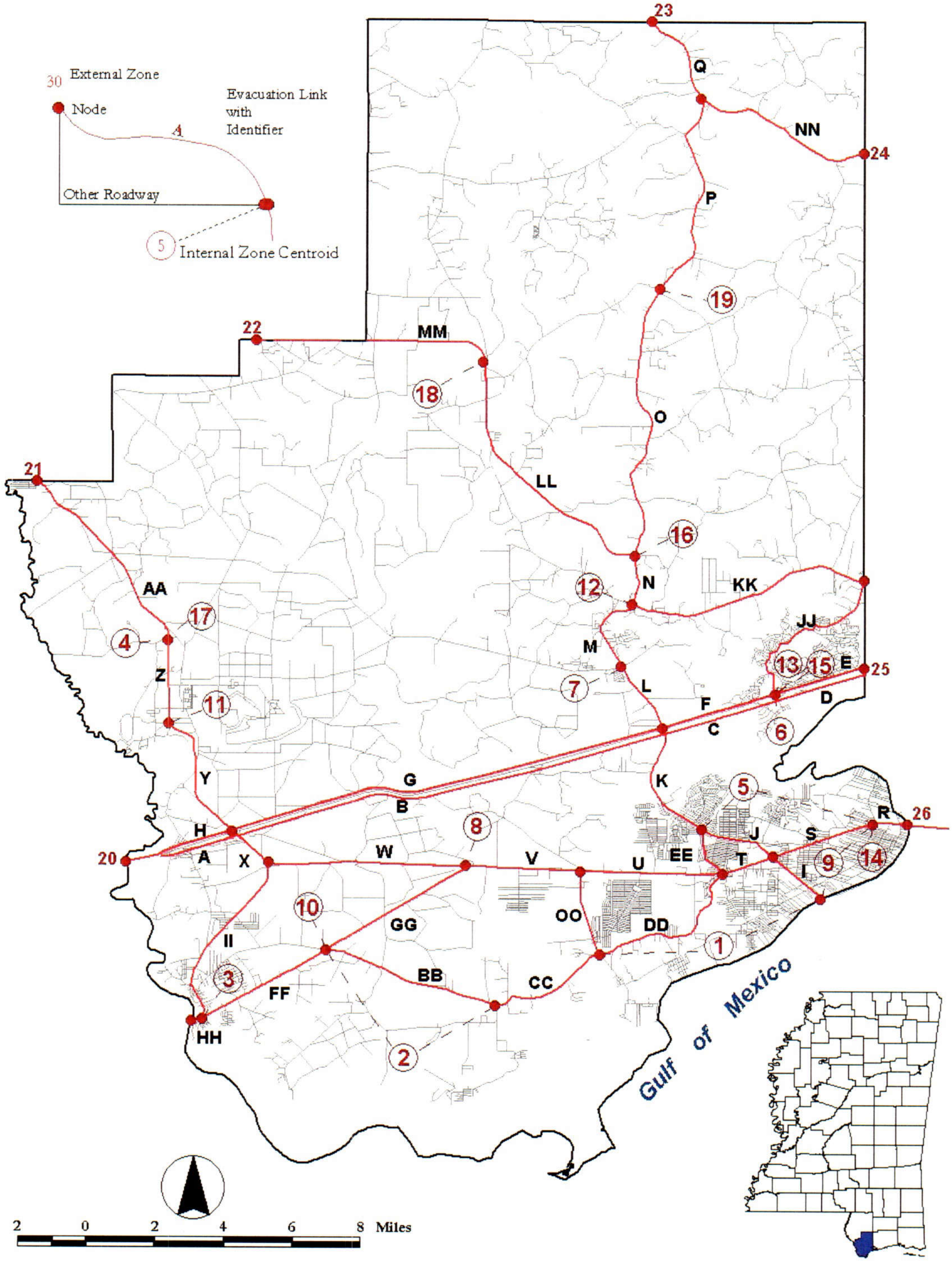
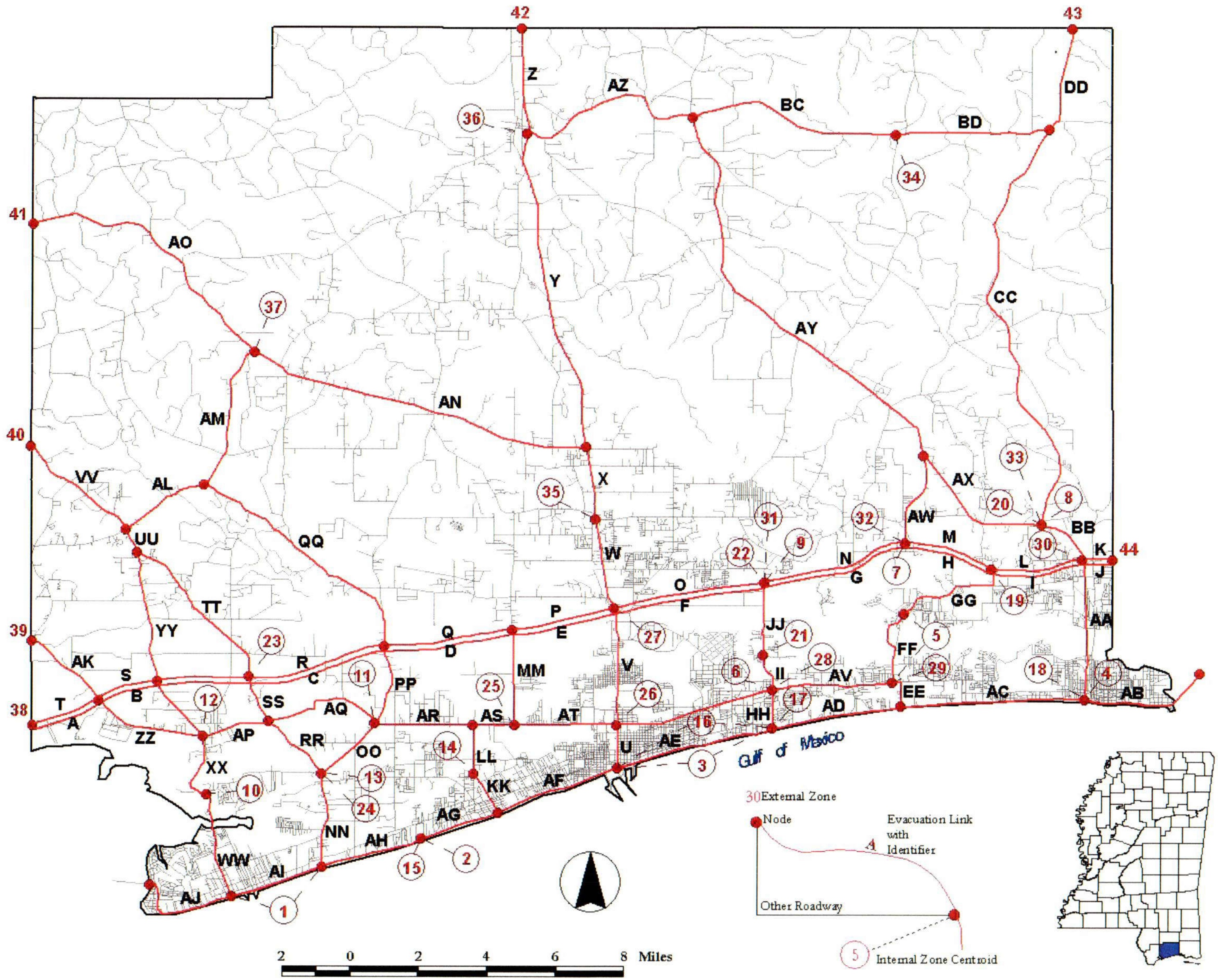


FIGURE 6-6 HANCOCK COUNTY EVACUATION ROUTE MAP

FIGURE 6-7 HARRISON COUNTY EVACUATION ROUTE MAP



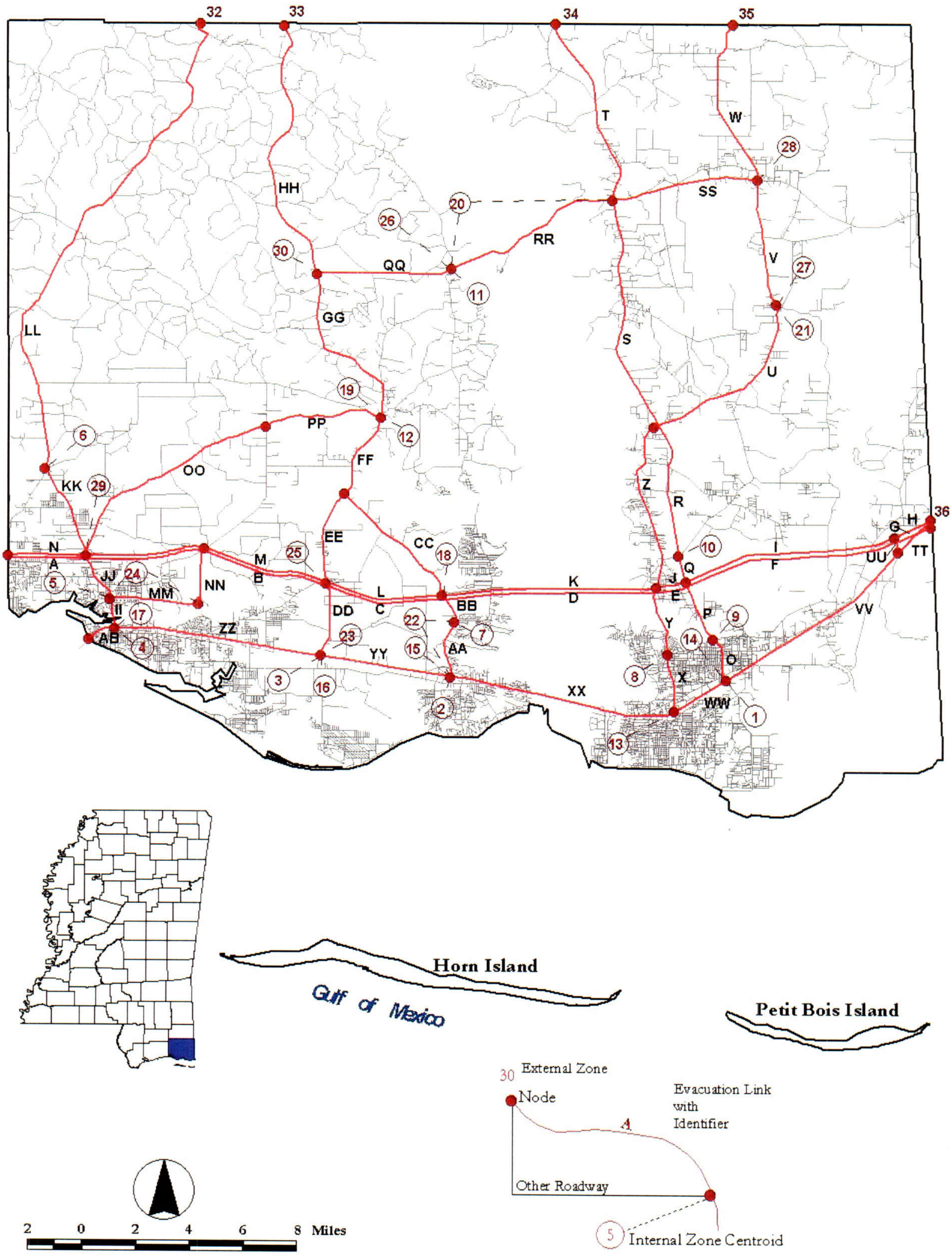


FIGURE 6-8 JACKSON COUNTY EVACUATION ROUTE MAP

TABLE 6-5
LINK NAMES AND ROAD NAMES

HANCOCK COUNTY		HARRISON COUNTY				JACKSON COUNTY	
Link Name	Road Name	Link Name	Road Name	Link Name	Road Name	Link Name	Road Name
OO	Co. Hwy 101	AS	28th St	DD	State Hwy 15	A	I-10 East
JJ	Diamondhead Kapalama Dr.	AR	28th St	CC	State Hwy 15	B	I-10 East
S	Hwy 90	AT	28th St	BB	State Hwy 15	C	I-10 East
U	Hwy 90	AQ	Bells Ferry Rd.	AO	State Hwy 53	D	I-10 East
A	I 10 East	BD	Bethel Rd	AN	State Hwy 53	E	I-10 East
B	I 10 East	BC	Bethel Rd	AX	State Hwy 67	F	I-10 East
C	I 10 East	AL	Cable Bridge Rd	AW	State Hwy 67	G	I-10 East
D	I 10 East	MM	Canal Rd	AY	State Hwy 67	H	I-10 West
E	I 10 West	FF	Cedar Lake Rd	AZ	State Hwy 67	I	I-10 West
F	I 10 West	GG	Cedar Lake Rd	X	Us Hwy 49	J	I-10 West
G	I 10 West	NN	County Hwy 1101	Y	Us Hwy 49	K	I-10 West
H	I 10 West	PP	Co. Hwy Farm Rd	U	Us Hwy 49	L	I-10 West
KK	Kiln Delisle Rd	QQ	Co. Hwy Farm Rd	V	Us Hwy 49	M	I-10 West
EE	Kiln Waveland Rd.	HH	Cowan Rd	Z	Us Hwy 49	N	I-10 West
CC	Lower Bay Rd	AU	E Pass Rd	W	Us Hwy 49	O	State Hwy 63
DD	Lower Bay Rd	TT	Firetower Rd	AJ	Us Hwy 90	P	State Hwy 63
I	Nicholson Ave	SS	Firetower Rd	AI	Us Hwy 90	Q	State Hwy 63
BB	Pearlington Rd.	RR	Firetower Rd	AE	Us Hwy 90	R	State Hwy 63
J	State Hwy 43	XX	Hampton Dr	AD	Us Hwy 90	S	State Hwy 63
K	State Hwy 43	WW	Henderson Ave	AC	Us Hwy 90	T	State Hwy 63
L	State Hwy 43	AA	I 110	AB	Us Hwy 90	U	State Hwy 613
LL	State Hwy 43	A	I-10 East	AF	Us Hwy 90	V	State Hwy 613
M	State Hwy 43	B	I-10 East	AG	Us Hwy 90	W	State Hwy 613
MM	State Hwy 43	C	I-10 East	AH	Us Hwy 90	X	State Hwy 613
N	State Hwy 43	D	I-10 East	UU	Vidalia Rd	Y	State Hwy 613
NN	State Hwy 53	E	I-10 East	VV	Vidalia Rd	Z	State Hwy 613
Q	State Hwy 53	F	I-10 East	YY	Vidalia Rd	AA	Gautier-Vancleave
O	State Hwy 603	G	I-10 East			BB	Gautier-Vancleave
P	State Hwy 603	H	I-10 East			CC	Gautier-Vancleave
II	State Hwy 604	I	I-10 East			DD	State Hwy 57
AA	State Hwy 607	J	I-10 East			EE	State Hwy 57
W	State Hwy 607	K	I-10 West			FF	State Hwy 57
X	State Hwy 607	L	I-10 West			GG	State Hwy 57
Y	State Hwy 607	M	I-10 West			HH	State Hwy 57
Z	State Hwy 607	N	I-10 West			II	State Hwy 609
FF	Us Hwy 90	O	I-10 West			JJ	State Hwy 609
GG	Us Hwy 90	P	I-10 West			KK	Tucker Road
HH	Us Hwy 90	Q	I-10 West			LL	Daisy Vestry Road
R	Us Hwy 90	R	I-10 West			MM	Cambridge Blvd
T	Us Hwy 90	S	I-10 West			NN	Elgin Road
V	Us Hwy 90	T	I-10 West			OO	Seaman Road
		AP	Kiln Delisle Rd			PP	Seaman Road
		AK	Kiln Delisle Rd			QQ	Wade Vancleave
		ZZ	Kiln Delisle Rd			RR	Wade Vancleave
		LL	Klondike Rd			SS	State Hwy 614
		KK	Klondike Rd			TT	Us Hwy 90
		II	Loraine Rd			UU	Us Hwy 90
		JJ	Loraine Rd			VV	Us Hwy 90
		AM	N Cuevas Rd			WW	Us Hwy 90
		AV	Pass Rd			XX	Us Hwy 90
		EE	Pass Rd			YY	Us Hwy 90
		OO	Red Creek Rd			ZZ	Us Hwy 90
						AB	Us Hwy 90

Important analysis assumptions concerning the evacuation road network are:

- The evacuation of all vehicles should occur prior to the arrival of sustained tropical storm winds (39 mph) and storm inundation of evacuation routes.

- Provisions will be made for the removal of vehicles in distress on the network through aggressive incident management and agreements worked out with tow truck operators.

- Signal timings will be "actuated" to provide the most green light time for northbound movements away from the coast.

- The U.S. Coast Guard will be contacted to "lock down" draw bridges once evacuation orders or advisories are issued.

In summary, data inputs to the transportation analysis can be classified into one of four categories as shown in Table 6-6.

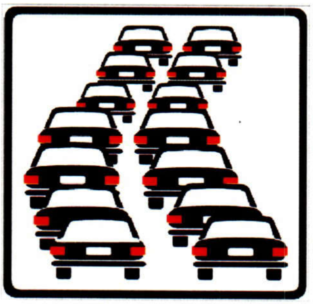
TABLE 6-6
TRANSPORTATION ANALYSIS DATA INPUTS

Hazards Data	**Socioeconomic Data**
Areas Flooded for each Hurricane Category	Housing Unit Data
Shelter Usability by Hurricane Category	People Per Housing Unit
Time of Arrival of Tropical Storm Winds	Vehicles Per Housing Unit
Roadway Inundation	Occupancy Assumptions
	Presence of Tourists/Visitors
Behavioral Data	**Roadway Network**
Rapidity of Response	Number of Lanes by Link
Participation Rates	Facility types by Link
Vehicle Usage	Elevation - "Low Spots"
Percent Pulling Trailer/Boat	Critical Links / Capacity Data
Destination Percentages	Traffic Count Data

f. Toll Bridge/Road Operations During Evacuations

Tollbooth operations during an evacuation are critical to the timing of the evacuation. A clear understanding must be made between the Tollbooth operators and the State and County prior to the evacuation to prevent traffic congestion and delays. The toll booth operations should be suspended when an evacuation order is made.

TRANSPORTATION MODELING METHODOLOGY



The transportation modeling methodology developed for this study involved a number of manual and computer techniques. The methodology, while very technical, was designed to be consistent with the accuracy level of the modeling inputs and assumptions. The methodology is unique in that it is sensitive to behavior of evacuees.

A summary of the six major steps of the transportation analysis are briefly described below:

SIX MAJOR STEPS OF THE TRANSPORTATION ANALYSIS

1. Evacuation Zone Data Development - Data gathered by census tract and block-groups were stratified by traffic/evacuation zone. Numbers of permanent residential dwelling units, mobile homes, and seasonal units were compiled by zone for the base year 2000.

2. Evacuation Road Network Preparation - This step identifies which roadways will be used for evacuation and includes the assignment of reasonable vehicle carrying capacities during an evacuation. This includes number of lanes and roadway type.

3. Trip Generation - Calculates the total evacuating people and vehicles originating from each evacuation zone.

4. Trip Destination - Determines where evacuees will go. (Shelter, hotel/motel, friends/relatives, out-of-county, etc.)

5. Trip Assignment - Determines what route(s) evacuees will take to get from their origin to their destination.

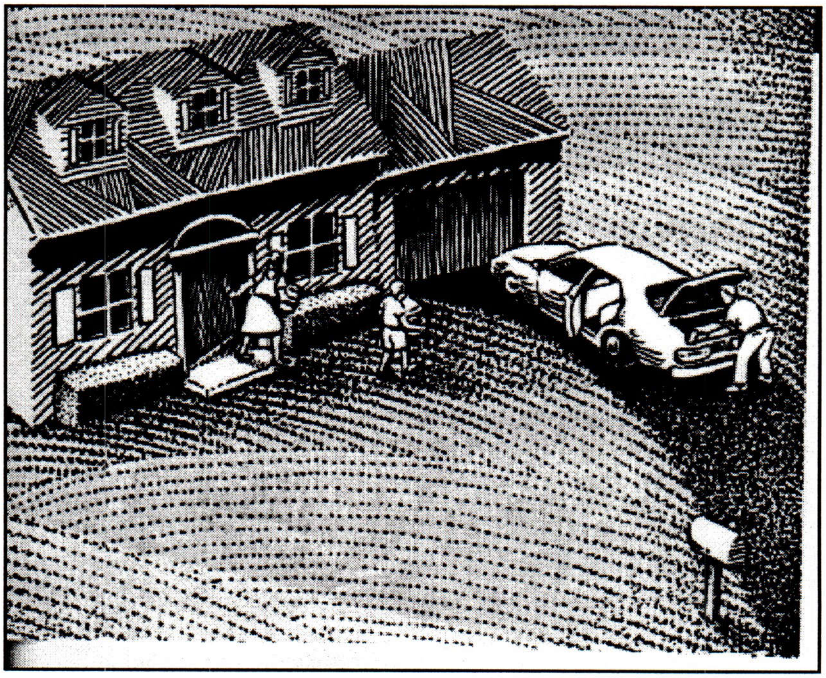
6. Calculation of Clearance Times - Determines how much time it will take for all evacuees to clear the evacuation network. The end product of this major step is a set of clearance times for all storm scenarios.

TRANSPORTATION MODEL RESULTS

The transportation modeling was set up for the Year 2000 base year. The items listed below are the most critical outputs for planning for shelter needs, anticipating bottlenecks, and defining the timing requirements of an evacuation.

- Evacuating people and vehicles.
- Destinations and shelter demand.
- Traffic volumes and critical roadway segments.
- Estimated clearance times.

a. Evacuating People and Vehicles



The evacuating vehicles and people produced by each evacuation scenario were split up by destination type. The four general destination types are in-county public shelter, in-county hotel/motels, in-county home of a friend or relative, and out-of-county. This was accomplished for each evacuation scenario and for high and low tourist occupancy. Table 6-7 shows the numbers of vehicles expected to evacuate by county and evacuation scenario. Numbers of vehicles involved in an actual evacuation will most likely be less than these figures because 100 percent participation of units in storm surge areas and all mobile homes were assumed for most scenarios. Even with door-to-door evacuation notification, it will be difficult to convince all to leave that should leave.

TABLE 6-7
HANCOCK, HARRISON AND JACKSON COUNTIES
EVACUATING VEHICLES BY DESTINATION AND EVACUATION SCENARIO

	Total Evacuating Vehicles	Vehicles Going to Shelters	Vehicles Going to friends	Vehicles Going to Motel	Vehicles Going out of County
HANCOCK COUNTY					
Low Tourist Occupancy					
Category 1-2	12,832	914	5,195	499	6,224
Category 3	17,162	1,528	5,911	499	9,224
Category 4-5	22,111	2,366	6,142	499	13,104
High Tourist Occupancy					
Category 1-2	16,285	949	5,195	499	9,642
Category 3	21,204	1,567	5,911	499	13,227
Category 4-5	26,233	2,366	6,142	499	17,226
HARRISON COUNTY					
Low Tourist Occupancy					
Category 1-2	39,503	2,956	17,189	1,576	17,782
Category 3	58,963	5,725	21,743	1,576	29,919
Category 4-5	98,177	12,172	30,072	1,576	54,357
High Tourist Occupancy					
Category 1-2	46,554	3,025	17,189	1,576	24,764
Category 3	68528	5820	21,743	1,576	39,389
Category 4-5	108038	12172	30,072	1,576	64,218
JACKSON COUNTY					
Low Tourist Occupancy					
Category 1-2	48194	3320	22189	2187	20,498
Category 3	62078	5343	23593	2187	30,955
Category 4-5	66784	6029	19320	2187	39,248
High Tourist Occupancy					
Category 1-2	52408	3361	22189	2187	24,671
Category 3	67313	5396	23593	2187	36,137
Category 4-5	72107	6029	19320	2187	44,571

b. Destinations and Shelter Demand

The potential public shelters shown in Chapter 5 include shelter locations and capacities. Local churches and other civic groups may help with public sheltering needs. Mobile home residents typically have a higher propensity to use local public shelter space than other residents do. Table 5-1 in Chapter 5 provides the calculated public shelter demand and available capacity by storm scenario for all coastal counties. Each county provided shelter locations and capacities.

Estimates of destinations for vehicles leaving the county were also made from behavioral data. Table 6-8 lists destination percentages by state for evacuees leaving coastal counties, and Table 6-9 breaks down the percentage of evacuees staying within Mississippi by cities.

Table 6-8
DESTINATION PERCENTAGES BY STATE*
MISSISSIPPI TRANSPORTATION ANALYSIS

Florida	Georgia	Alabama	Mississippi	Louisiana	Texas	Arkansas
1.6%	1.6%	9.5%	66.7%	14.3%	3.2%	3.2%

Source: Data obtained from behavioral analysis conducted by Hazards Management Group (HMG) for this study.

Table 6-9
DESTINATION PERCENTAGES WITHIN MISSISSIPPI*
MISSISSIPPI TRANSPORTATION ANALYSIS

Destinations Within Mississippi	Percent
Jackson	11.1%
Gulf Port	6.4%
Meridian	6.3%
Hattiesburg	4.8%
Wiggins	3.2%
Diamond Head	3.2%
Other Cities within Mississippi	31.7%

Source: Data obtained from behavioral analysis conducted by Hazards Management Group (HMG) for this study.

c. Traffic Volumes And Critical Roadway Segments

The Transportation Model estimates the number of evacuating vehicle on each roadway segment for each storm scenario by county. The model then compares the number of evacuating vehicles to the service volume of each roadway segment. Those segments with the highest ratio of evacuation vehicles to service volume were considered to be critical links for evacuation. These congested areas control the flow of evacuation traffic during a hurricane evacuation and are key areas for traffic control and monitoring. Table 6-10 lists the critical roadway segments in each county that will control the flow of evacuation traffic. Critical roadways are listed in order of severity. Some of the regions most congested roadway segments are well inland. Table 6-11 provides estimated numbers of evacuating vehicles that will exit the coastal Counties at key roadways.

TABLE 6-10
CRITICAL ROADWAY LOCATIONS

Hancock County
SR 43 from I-10 to SR 603

Harrison County
US 49 northbound (SR 53 intersection)
SR 15 northbound from I-110 to out of county
Lorraine Road from Pass Road to I-10
Pass Road and US 49 intersection
I-110 and US 90 interchange
US 90 (East Beach Blvd) and US 49 intersection

Jackson County
SR 63/SR 613 intersection at Lucedale in George County
SR 57 North of Ramsay Road
SR 609 from US 90 to I-10
Tucker Road from I-10 to Daisy Vestry Road
SR 63 bridge (high level bridge subject to early winds)

Inland Counties
US 49 interchanges with US 98 and I-59
US 49 intersection with US 11 in Hattiesburg
SR 63 and SR 613 intersection at Lucedale
SR 607 interchange with I-59 (northbound on ramp)
SR 53 interchange with I-59 (northbound on ramp)

TABLE 6-11
OUT-OF-COUNTY TRAFFIC VOLUMES BY ROADWAY SEGMENT

Road Description	Roadway Volume Low Tourist Occupancy			Roadway Volume High Tourist Occupancy		
	Cat. 1-2	Cat. 3	Cat. 4-5	Cat. 1-2	Cat. 3	Cat. 4-5
Hancock						
SR 607 from Santa Rosa to County Line	1,256	2,109	4,462	1,762	2,772	5,035
SR 43 from Lee Town Road to County Line	2,076	3,272	4,574	3,108	4,493	5,826
SR 53 from SR 603 to County Line	2,595	4,224	6,731	3,838	5,747	8,439
SR 53 from SR 603 Eastbound to County Line	100	207	572	167	311	640
I-10 from SR 607 to County Line	862	1,424	2,194	1,273	1,922	2,729
Harrison						
SR 15 North from Bethel Road	9,130	14,841	23,290	12,511	19,109	27,659
US 49 North of SR 67	7,808	14,169	30,463	10,403	18,003	34,488
SR 53 from Northrup-Cuevas Road to County Line	1,204	2,357	6,861	1,682	3,089	7,649
Kiln-Delisle Road from I-10 to County Line	845	1,183	1,784	1,142	1,495	2,101
Vadalia Road from JP Lander Road to County Line	845	1,183	1,784	1,142	1,495	2,101
I-10 Eastbound from I-110 to County Line	2,588	4,323	7,821	3,628	5,658	9,218
US 90 from I-110 to County Road	1,706	2,922	5,814	2,335	377/	6,703
US 90 from County Line to Henderson Avenue	1,249	1,916	2,441	1,831	2,568	3,185
I-10 Westbound from Kiln-Deslisle Road to County Line	2,127	3,614	6,944	2,864	4,612	7,979
Jackson						
Daisy Vestry Road from Tucker Road	5,185	7,845	10,176	5,925	8,692	11,040
SR 57 North of Wade Vancleave Road	5,370	8,197	11,523	6,560	9,664	13,030
SR 63 North of SR 614	5,162	8,671	10,899	6,300	10,077	12,326
SR 613 North of SR 614	4,546	8,142	9,932	5,489	9,354	11,153
I-10 Eastbound from Exit 75 to County Line	2,675	4,259	5,292	3,221	4,923	5,970
US 90 Exit 75 to County Line	2,312	3,665	4,827	2,703	4,183	5,305

d. Estimated Evacuation Clearance Times

The most important product of the transportation analysis is the clearance times developed by storm scenario and by behavioral characteristics for each county. Clearance time is one of two major considerations involved in issuing an evacuation or storm advisory. Clearance time must be weighed with respect to the arrival of sustained tropical storm winds to make a prudent evacuation decision. Figure 6-9 illustrates these two timing issues of evacuation and their relation.

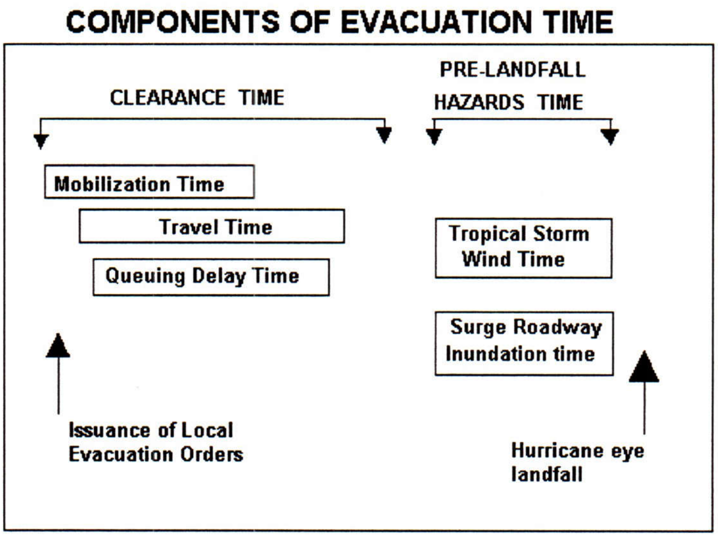


Figure 6-9 Components of Evacuation Time

Clearance time is the time required to clear the roadway of all vehicles evacuating in response to a hurricane situation. Clearance time begins when the first evacuating vehicle enters the road network (as defined by a hurricane evacuation behavioral response curve) and ends when the last evacuating vehicle reaches an assumed point of safety. Clearance times include the time required by evacuees to secure their homes and prepare to leave (referred to as mobilization time). Clearance time also includes the time spent by evacuees traveling along the road network (referred to as travel time), and the time spent by evacuees waiting along the road network due to traffic congestion (referred to as queuing delay time). Clearance time does not relate to the time any one vehicle spends traveling on the road network and does not include time needed for local officials to assemble and make a decision to evacuate.

Table 6-12 presents the hurricane evacuation clearance times developed for each county for the Year 2000 storm scenarios. Clearance times generally fall between 8-31 hours. Clearance times shown in Table 6-12 reflect the effects of adjacent county traffic impacts and in that regard assumes that consistent evacuation decisions will be made and coordinated between adjacent jurisdictions and the State of Mississippi. The worst individual commute times range from 4-26 hours.

TABLE 6-12
CLEARANCE TIMES (IN HOURS) YEAR 2000

Scenario	Response Rate	Hancock		Harrison				Jackson	
		Low Seasonal Occupancy	High Seasonal Occupancy	Low Seasonal Occupancy light background traffic	Low Seasonal Occupancy heavy background traffic	High Seasonal Occupancy light background traffic	High Seasonal Occupancy heavy background traffic	Low Seasonal Occupancy	High Seasonal Occupancy
Cat. 1-2									
	Rapid Response	8 ¼	11 ¼	6 ¾	7 ¾	8 ½	9 ¾	13 ½	16
	Medium Response	9	11 ¼	9	9	9	10 ½	13 ½	16
	Long Response	12	12	12	12	12	12	13 ¾	16 ¼
worst individual commute time			6				4 ½		10 ¾
Cat. 3									
	Rapid Response	12 ¾	16 ½	11	12	13 ¾	14 ¾	22 ½	25 ¾
	Medium Response	12 ¾	16 ½	11 ¼	13	13 ¾	15 ¾	22 ½	25 ¾
	Long Response	13	16 ¾	12	14	14 ¼	16 ¾	22 ½	25 ¾
worst individual commute time			11				9 ¼		20 ½
Cat. 4-5									
	Rapid Response	20 ¼	24 ¼	23 ¾	24 ¾	26 ½	27 ½	27 ½	30 ¾
	Medium Response	20 ¼	24 ¼	23 ¾	25 ¼	26 ½	28	27 ½	30 ¾
	Long Response	20 ½	24 ¾	23 ¾	26 ¼	26 ¾	29 ¼	27 ½	30 ¾
worst individual commute time			19				22		25 ¾

TRAFFIC CONTROL MEASURES

Some general recommendations concerning traffic control are as follows:

1. Where the state and local counties have sufficient personnel resources, officers should be stationed at critical intersections to facilitate traffic flow. Where intersections will continue to have signalized control, signal patterns providing the most "green time" for the northbound evacuation travel should be activated.

2. If possible, arrangements should be made with tow truck operators so that they are pre-positioned along key travel corridors and critical roadway facilities such as bridges.

3. All draw/swing bridges needed for evacuation should be locked in the "down" position during a hurricane warning, if possible. Boat owners must be made aware of flotilla plans and time requirements for securing vessels.

4. The state and counties should jointly work on a statewide evacuation and shelter monitoring system which would monitor travel flow at key locations, report traffic tie-ups and shelter and hotel availability to the general public as they evacuate.

5. Coordination with the State of Louisiana regarding traffic flow and sheltering requirements will be critical. As this report is being published both states Departments of Transportation have undertaken a joint study effort to address these critical concerns.

6. High level bridges must be monitored for early wind vulnerability as sustained tropical storm winds will arrive earlier on these structures than at ground level. Trucks, RV's and other high profile vehicles will be especially vulnerable to these conditions.

DECISION ARCS

CHAPTER SEVEN - DECISION TOOLS

PURPOSE

This chapter describes the Decision Arc Method and the HURREVAC computer program. Both are hurricane evacuation decision-making tools that use clearance times in conjunction with National Hurricane Center advisories to help determine when and if evacuations should begin.

BACKGROUND

Hurricanes do not always approach land from a direction perpendicular to the coastline and frequently enter the mainland on an angular track. When a hurricane is still 24 hours off the coast an error of 10 degrees in predicting the hurricane track can easily mean a 100-mile difference on either side of the predicted point of landfall. The average error of landfall positions in a 12-hour forecast is roughly 50-60 miles on either side of the predicted point of landfall.

When a hurricane approaches a coastline at an acute angle, an error in forecast landfall position will increase or decrease the distance to landfall, possibly resulting in a significant error in forecast time of landfall. The forward motion of hurricanes can also accelerate and decelerate, causing the time of landfall to be even more unpredictable. Since hurricane evacuation decision-making and mobilization have typically been dependent upon forecast landfall position and time of landfall, a method was needed that would help compensate for forecast errors by relating evacuation operations to hurricane position.

It is recommended that emergency management offices review all available hurricane evacuation decision-making software in use today. These programs usually incorporate hurricane evacuation study data, including some form of the Decision Arc Method presented in this chapter. Computer assistance can be very useful in speeding needed calculations and displaying important information and relationships. Even if a computer program is used, emergency management officials should be familiar with the concepts presented in this chapter. This will promote confidence in the software and ensure that decision-making can proceed despite power outages or computer failure.

DECISION ARC EQUIPMENT

The Decision Arc Method employs two separate but related components which, when used together, present a graphic depiction of the hurricane situation. A specialized hurricane-tracking chart called the Decision Arc Map is used with a transparent two-dimensional hurricane graphic called the STORM TOOL, to describe the approaching hurricane and its relation to the area considering evacuation.

a. Decision Arc Map

To properly evaluate the last reported position and forecast track of an approaching hurricane, a special hurricane-tracking chart has been developed for the study area. Superimposed on an ordinary tracking chart is a series of concentric arcs centered on the southernmost boundary of the study area and spaced at 20-nautical-mile intervals. These arcs are labeled alphabetically and in nautical miles measured from their center as shown on Plate 7-1

b. Storm Tool

The Special Tool for Observing Range and Motion (STORM) is used as a two-dimensional depiction of an approaching hurricane. It is a transparent disk with concentric circles spaced at 20-nautical-mile intervals, their center representing the hurricane eye. These circles form a scale used to note the radii of 34-knot (gale force) winds reported by the National Hurricane Center in the Marine Advisory. Plate 7-2 included at the end of this Chapter is an example of the STORM tool.

c. National Hurricane Center Tropical Cyclone Advisory

Marine advisories on tropical storms are normally issued by the National Hurricane Center every six hours: 0400CDT, 1000CDT, 1600CDT, and 2200CDT. At times, supplementary intermediate advisories are also issued. These advisories contain information on present and forecast position, intensity, size, and movement that is used in the Decision Arc Method.

DECISION ARC CONCEPT

A hurricane evacuation should be completed prior to the arrival of sustained 34-knot (gale force) winds or the onset of storm surge inundation, whichever occurs first. Along the Mississippi coast, the limiting factor for hurricane evacuation is primarily the arrival of sustained 34-knot winds.

The clearance time is the time required to clear the roadways of all evacuating vehicles. It therefore determines the minimum time period, in hours prior to the arrival of sustained 34-knot winds, necessary for a safe evacuation. Clearance times are based on three variables: (1) the Saffir/Simpson hurricane category, (2) the expected evacuee response rate, and (3) the tourist occupancy situation (where applicable).

Decision Arcs are clearance times converted to distance by accounting for the forward speed of the hurricane. To translate a clearance time into nautical miles (a Decision Arc distance) for use with the Decision Arc Map, a simple calculation of multiplying the clearance time by the forward speed of the hurricane in knots is necessary. This calculation yields the distance in nautical miles that the 34-knot wind field will move while the evacuation is underway.

a. Should Evacuation be Recommended

Probability values shown in the National Hurricane Center's (NHC) Probability Advisory describe in percentages the chance that the center of a storm will pass within 65 miles of the listed locations. The maximum probability the NHC uses for predicting a direct hit varies with the length of time before landfall. Table 7-1 shows these maximums. The total probability value for your location, shown on the right side of the Marine Advisory probabilities table, should be compared to other locations and to the maximums shown in Table 7-1. This will indicate the relative vulnerability of your location as compared with adjacent locations and with the maximum possible probability.

TABLE 7-1
MAXIMUM PROBABILITY VALUES BY FORECAST PERIOD

Forecast period Hours	72	60	48	42	36	30	24	18	12
Maximum probability %	10	11	13	16	20	27	35	45	60

b. When Evacuation Should Begin

As a hurricane approaches, the Decision Arc Method requires officials to make an evacuation decision prior to the time at which the radius of sustained 34-knot winds touches the appropriate Decision Arc (the Decision Point). For example, with a clearance time of 15 hours, and a hurricane forward speed of 10 knots, the evacuation should be initiated before the sustained 34-knot winds get within 150 nautical miles (15 hours x 10 knots = 150 nautical miles)of the area being evacuated. This would correspond to Arc "H" on the decision arc map. For convenience, a Decision Arc Table (Table 7-2) has been developed that converts an array of clearance times and forward speeds to respective Decision Arcs. Once the sustained 34-knot winds move across the Decision Arc, there may not be sufficient time to safely evacuate the vulnerable population.

TABLE 7-2
DECISION ARC TABLE

Estimated Clearance Time	Forecast hurricane forward speed (knots)						
	5	10	15	20	25	30	35
4	A	B	C	D	E	F	G
5	A	C	D	E	G	H	I
6	A	C	E	F	H	I	K
7	B	D	F	G	I	K	M
8	B	D	F	H	J	L	N
9	B	E	G	I	L	N	P
10	B	E	H	J	M	O	R
11	C	F	I	K	N	Q	T
12	C	F	I	L	O	R	U
13	C	G	J	M	Q	T	W
14	C	G	K	N	R	U	Y
15	D	H	L	O	S	W	AA
16	D	H	L	P	T	X	BB
17	D	I	M	Q	V	Z	DD
18	D	I	N	R	W	AA	FF
19	E	J	O	S	X	CC	HH
20	E	J	O	T	Y	DD	II
21	E	K	P	U	AA	FF	KK
22	E	K	Q	V	BB	GG	MM
23	F	L	R	W	CC	II	NN
24	F	L	R	X	DD	JJ	PP
25	F	M	S	Y	FF	LL	RR
26	F	M	T	Z	GG	MM	TT
27	G	N	U	AA	HH	OO	UU
28	G	N	U	BB	II	PP	WW

HURREVAC PROGRAM

HURREVAC is a restricted-use US Government program used by official government emergency managers since 1988 to track hurricanes and assist in decision-making for their communities. The program uses the NHC hurricane advisories to plot the hurricane track on a display screen. The program basically uses the decision arc method and clearance time data from hurricane evacuation studies to determine when evacuations should begin.

DECISION ARC PROCEDURE

The following procedure has been developed to assist emergency managers to determine when an evacuation decision must be made and IF you should initiate an evacuation. The National Hurricane Center Tropical Cyclone Advisory is used in this decision-making process. All notes and cautions shown in this procedure should be heeded as appropriate.

There are four basic "tools" you will need in your evacuation decision procedure:

(1) Decision Arc Map (Plates 7-1)
(2) Decision Arc table (Table 7-2)
(3) Transparent STORM disk (Plate 7-2)
(4) The NHC Tropical Cyclone Advisory.

STEPS:

1. From the NHC Tropical Cyclone Advisory, plot the last reported position of the hurricane eye on the Decision Arc Map. Note position with date/time. ZULU time (Greenwich mean time) used in the advisory should be converted to eastern daylight time by subtracting four (4) hours. Plot and note the five forecast positions of the hurricane given in the advisory (i.e., 12, 24, 36, 48, 72 hr).

2. From the Tropical Cyclone Advisory, note the maximum radius of 34-knot winds (observed or forecast), the maximum sustained wind speed (observed or forecast), and the current forward speed. Plot the maximum radius of 34-knot winds onto the STORM disk. See note a. for information on nautical miles/knots.

3. Determine the <u>forecast</u> forward speed of the hurricane in knots. The forecast speed of the hurricane can be determined for each forecast position by dividing the distance between each position by the time interval between each position. Compare these forecast forward speeds to the current forward speed noted in previous advisories. A forecast speed greater than the current or previous forward speed indicates that the hurricane is expected to accelerate, which reduces the time available to the decision-maker.

4. Using the maximum sustained wind speed, determine the category of the approaching hurricane based on the Saffir/Simpson Hurricane Scale. NOTE: Because of potential forecast and SLOSH model inaccuracies, it may be wise to add one category to the forecast landfall intensity.

5. From the clearance time tables in Chapter 6, select the pertinent clearance time. Using that clearance time and the appropriate forecast forward speed of the storm select the appropriate Decision Arc from the Decision Arc Table (Table 7-2). Mark this arc on the Decision Arc Map.

6. Using the center of the STORM disk as the hurricane eye, locate the STORM on the Decision Arc Map at the last reported hurricane position. Determine if the radius of 34-knot winds falls within the selected Decision Arc (the point at which the radius of 34-knot winds crosses into the selected Decision Arc). If so, available traffic control measures should be implemented and public advisories issued in order to ensure a rapid public response and completion of the evacuation prior to the arrival of sustained 34-knot winds (or no evacuation advisory is issued). See note b. for additional evacuation timing information.

7. Move the STORM to the first forecast position. Determine if the radius of 34-knot winds has passed the Decision Point. If so, the Decision Point will be reached prior to the hurricane eye reaching the first forecast position.

8. If the radius of 34-knot winds has not crossed the decision arc you can estimate the hours remaining before a decision must be made by dividing the number of nautical miles between the current radius of 34-knot winds and the Decision Point by the forward speed used for the Decision Arc Table. Determine if the next NHC Tropical Cyclone Advisory will be received prior to the Decision Point.

9. Compare probabilities shown in the Tropical Cyclone Advisory to determine where an evacuation is likely to take place (see note c.). Determine how an evacuation of your jurisdiction would affect the readiness of others and when they should be notified of your evacuation. Check inundation maps to determine where flooding may occur and evacuation zone maps for zones that should prepare to evacuate.

10. At the Decision Point, evacuation decision-makers should compare the latest probabilities for their location with those for surrounding areas and the maximums shown in Table 7-1. In addition to that forecast track information, they should also consider the storm's intensity and the potential inundation.

11. Steps 1 through 10 should be repeated after each NHC advisory until an evacuation decision is made or the hurricane threat has passed.

NOTES

a. Because information given in the Tropical Cyclone Advisory is in nautical miles and knots, the scale of the Decision Arc Maps and STORM is nautical miles. When utilizing hurricane information from sources other than the Marine Advisory, care should be taken to ensure that distances are given in or converted to nautical miles and speeds to knots. Statute miles can be converted to nautical miles by dividing the statute miles value by 1.15. Similarly, miles per hour can be converted to knots by dividing the miles per hour value by 1.15.

b. In the Decision Arc Method, there is no time specifically allocated for evacuation decision-making or mobilizing support personnel. Hurricane readiness operations should progress so that, if evacuation becomes necessary, preparations will be complete and the recommendation to evacuate can be given at the Decision Point.

c. Probability values shown in the Marine Advisory describe in percentages the chance that the center of a storm will pass within 65 miles of the listed locations. To check the relative probability for your particular area, the total probability value for the closest location, shown on the right side of the probability table in the advisory, should be compared to other locations. A comparison should also be made with the possible maximums for the applicable forecast period shown in the table of maximum probability values included in these instructions. These comparisons will show the relative vulnerability of your location to adjacent locations and to the maximum possible probability.

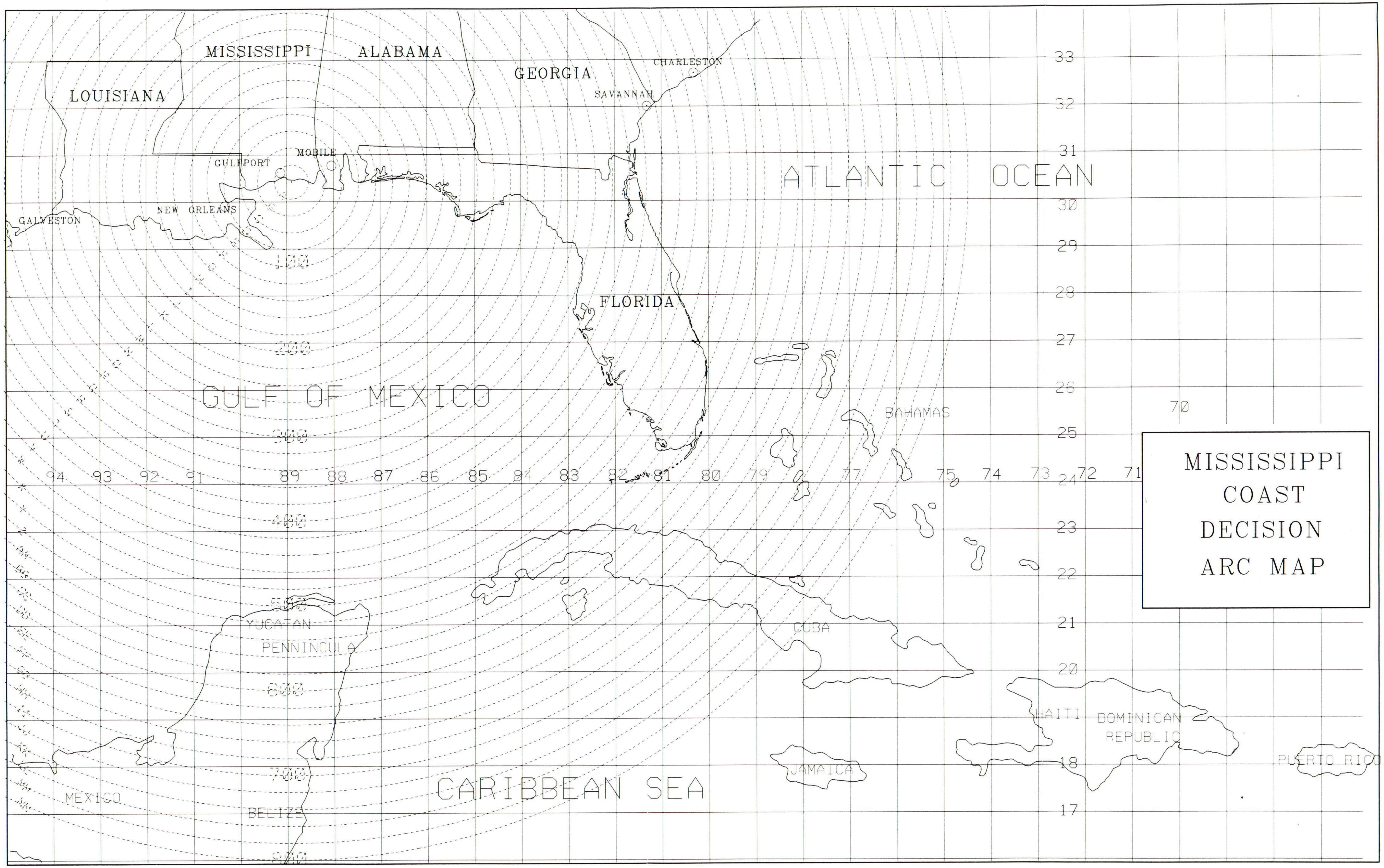
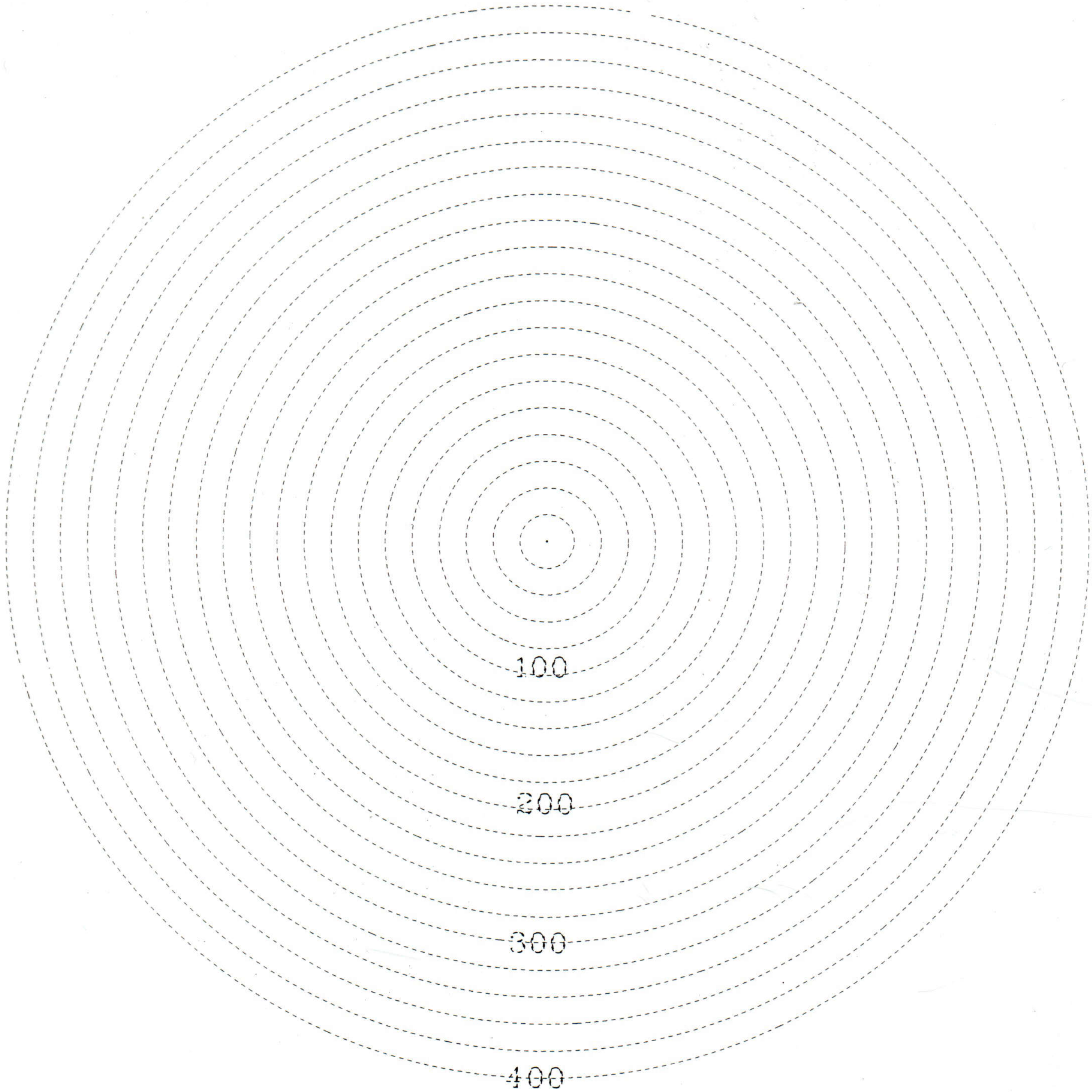

MISSISSIPPI
ALABAMA
GEORGIA
LOUISIANA
CHARLESTON
SAVANNAH
MOBILE
GULFPORT
NEW ORLEANS
GALVESTON
ATLANTIC OCEAN
FLORIDA
GULF OF MEXICO
BAHAMAS
CUBA
YUCATAN
PENNINCULA
HAITI
DOMINICAN
REPUBLIC
JAMAICA
PUERTO RICO
CARIBBEAN SEA
MEXICO
BELIZE
MISSISSIPPI
COAST
DECISION
ARC MAP

FIGURE 7–1



STORM TOOL

DECISION ARCS

Mobile District

U.S. Army Corps of Engineers

Plate 7-2