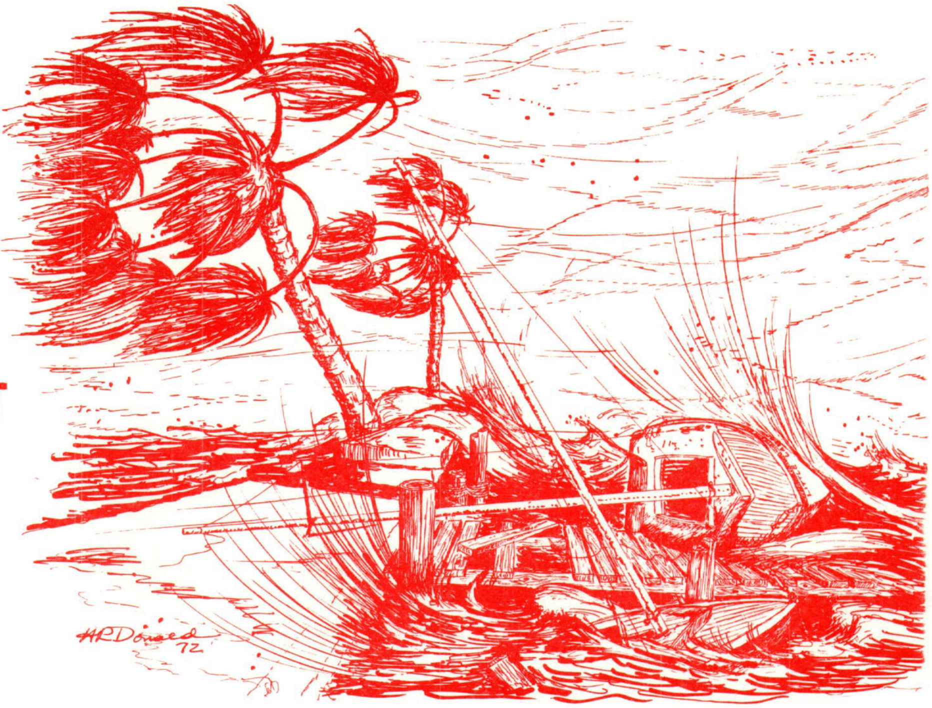
LOWER SOUTHEAST FLORIDA HURRICANE EVACUATION STUDY



TECHNICAL ASSESSMENT

PALM BEACH COUNTY

CORPS OF ENGINEERS
FEDERAL EMERGENCY MANAGEMENT AGENCY
NOAA NATIONAL HURRICANE CENTER
FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS

LOWER SOUTHEAST FLORIDA
HURRICANE EVACUATION STUDY

TECHNICAL ASSESSMENT

A SUMMARY FOR PALM BEACH COUNTY

PREPARED FOR:
PALM BEACH COUNTY
DIVISION OF EMERGENCY MANAGEMENT

PREPARED BY:
CORPS OF ENGINEERS
FEDERAL EMERGENCY MANAGEMENT AGENCY
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FEBRUARY 1991

LOWER SOUTHEAST FLORIDA
HURRICANE EVACUATION STUDY
PALM BEACH COUNTY

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CHAPTER ONE
INTRODUCTION

GENERAL

The threat of a hurricane is real. The destructive potential of hurricanes poses a serious threat to the eastern and gulf coast areas of the United States during the summer and fall months. People seeking new life-styles continue to move to areas vulnerable to the effects of hurricanes. This desire to live in the coastal regions has caused an accelerated rate of growth and development in vulnerable areas.

One of the most hurricane vulnerable areas of the United States is the lower southeast coast of Florida. This area is comprised of Monroe County (the Florida Keys) and the mainland counties of Dade, Broward and Palm Beach. Historically, there have been many hurricanes which have affected this region, either directly or indirectly. This technical report is for the Palm Beach County portion of the study area. The tracks of the primary storms affecting Palm Beach County are shown in Figure 2-3, Chapter Two, Hazard Analysis.

PURPOSE

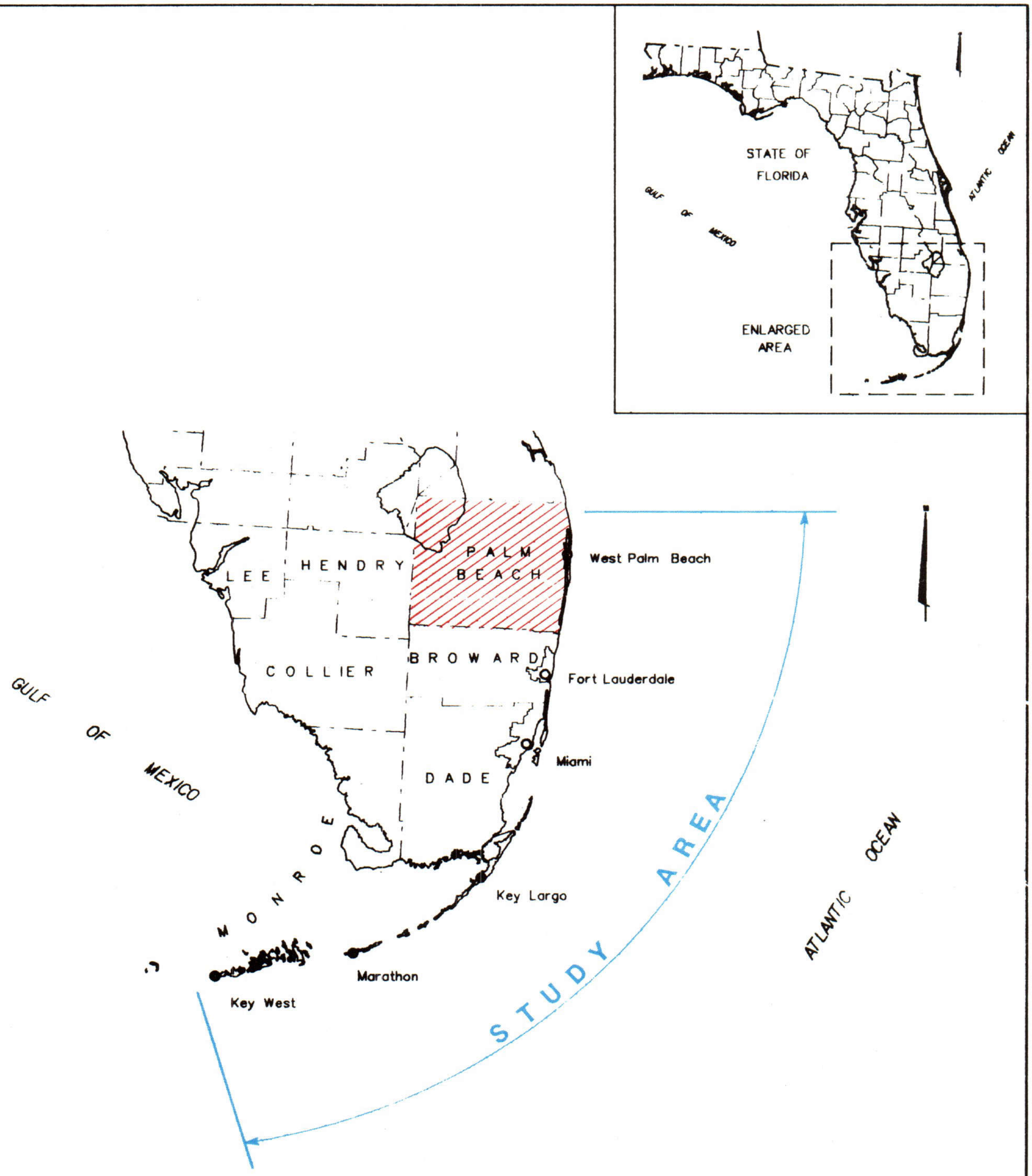
The Lower Southeast Florida Hurricane Evacuation Study is an update of the 1983 regional study for Monroe, Dade, Broward, and Palm Beach counties and is intended to provide emergency management officials with detailed data quantifying the major factors involved in hurricane evacuation decision making. The study area is shown on Figure 1-1. This update utilized the information from the SLOSH (Sea, Lake, Overland Surges from Hurricanes) models for Biscayne Bay and Florida Bay developed by the National Hurricane Center (NHC), National Oceanic and Atmospheric Administration (NOAA). The Biscayne Bay SLOSH Model was appropriate to Palm Beach County. These models were not available when the original study was completed. This fact, coupled with the tremendous development and population growth of the region, necessitated the current work. The primary emphasis of this study was the identification of life-threatening flooding resulting from hurricanes and the safe evacuation of populations from unsafe areas and conditions within the region.

AUTHORITY

The study authority for the Corps of Engineers is Section 206 of the Flood Control Act of 1960 (Public Law 86-645), and study authority for the Federal Emergency Management Agency 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. Authority for State of Florida involvement in the study is established by State Emergency Management Act, Chapter 252 (Sections 252.31 through 252.60), Florida Statutes (F.S.).

FUNDING

The Lower Southeast Florida Hurricane Evacuation Study was funded by the Federal Emergency Management Agency, the U. S. Army Corps of Engineers, and the State of Florida Department of Community Affairs. Local officials and agencies provided their input without direct charge to the study funds.



PALM BEACH COUNTY

LOWER SOUTHEAST FLORIDA HURRICANE EVACUATION STUDY

FIGURE 1-1

GUIDELINES

This study was conducted in accordance with the Corps of Engineers' publication, Technical Guidelines for Hurricane Evacuation Studies, November 1984, and the Federal Emergency Management Agency's publication, CPG-16, A Guide to Hurricane Preparedness Planning for State and Local Officials, December 1984.

STUDY PARTICIPANTS

The Lower Southeast Florida Hurricane Evacuation Study was a joint effort by the Federal Emergency Management Agency (FEMA); the National Oceanic and Atmospheric Administration (NOAA); the U. S. Army Corps of Engineers (Corps); the State of Florida, Department of Community Affairs (DCA) and the Emergency Management directors of Monroe, Dade, Broward and Palm Beach counties. Development of the technical data for the study was coordinated and documented by the Jacksonville District, Corps of Engineers, in conjunction with the various Federal and State agencies and local officials in the study area.

COORDINATION

In late 1987, in response to local concerns, FEMA and DCA requested the Corps to undertake an update for Lower Southeast Florida. The original study had been completed by the Corps in 1983, but local interests had expressed concerns about the rate of population growth occurring in the region and the applicability of the original study results. Specifically noted, were the numerous changes in arterial and major highways that would be used as evacuation routes. In addition, the old SPLASH hurricane model was used in the original study.

a. Study Management. The Jacksonville District, Corps of Engineers had responsibility for coordinating study efforts. Direction for this study was provided by an executive committee.

b. Executive Committee. An "ad hoc" Executive Committee consisted of key members of the Corps of Engineers, the Federal Emergency Management Agency, the State of Florida Department of Community Affairs, and the National Oceanic and Atmospheric Administration. Most of the members had extensive prior experience in conducting hurricane evacuation studies and actual hurricane response situations. The Executive Committee or appropriate representatives met on numerous occasions with the individual county emergency management directors to review the progress of the study, discuss and plan for future study tasks, and to insure that proper interagency and interjurisdictional coordination was accomplished.

DESCRIPTION OF STUDY AREA

a. Geography. The entire study area includes 300-miles of coastline with numerous islands and barrier islands, many of which are densely populated. Palm Beach County is no exception with heavy development at Palm Beach, on Singer Island, in the Jupiter and Jupiter Inlet areas as well as along the Intracoastal waterway throughout the county.

The western interior of Palm Beach County is low and depressional. Much of the western interior has been reserved as a water conservation area. Urban development in the county is rapidly merging previously individual communities into a single giant metropolitan area. This urban sprawl is moving rapidly westward and will have a significant impact on evacuation scenarios developed for the region.

b. Population. The 1980 Census of Population recorded a total population of about 3,300,000 people in the four county area with about 573,000 in Palm Beach County. University of Florida demographic estimates indicate that the area's 1990 population will surpass 4,000,000 people. Table 1-1 shows the population by county for the years 1970 through 1990.

Table 1-1

County	1970	1980	1990*
Dade	1,267,792	1,625,979	1,900,000
Broward	620,100	1,014,043	1,250,000
Palm Beach	348,993	573,125	900,000
TOTAL	2,236,885	3,213,147	4,050,000

*Assumed Base Year Population. Taken from the University of Florida population projections.

There continues to be a very large population of senior citizens, many of whom have special needs, which require additional efforts in the event of an evacuation.

STUDY COMPONENTS

The Lower Southeast Florida Hurricane Evacuation Study consists of several inter-related analyses that develop technical data concerning hurricane hazards, vulnerability of the population, public response to evacuation advisories, time needed to complete evacuation, shelter needs, transportation routes, evacuation zones and decision strategies. The analyses are summarized in this Technical Assessment and task details are contained in separate appendices. The six major analyses comprising this evacuation study and a brief description of each are as follows:

a. Hazards Analysis. The Hazards Analysis identifies and describes the hazards caused by potential hurricanes. The analysis describes the level of threat from storm surge and wind that may be produced by hurricanes of various intensity as described by the Saffir/Simpson Hurricane Scale. The Sea, lake, and Overland Surges from Hurricanes (SLOSH) model was the primary tool used for the development of the surge and wind data. SLOSH model results showing the maximum of maximum envelopes of water (MOMs) are used as input data to determine land areas expected to be inundated under the different category hurricanes. The storm surge MOMs produced for each category of hurricane are displayed as water elevations above mean sea level(MSL). The delineation of land areas, including potential evacuation routes, affected by each category of hurricane is a major part of the hazard analysis. The second part of the hazard analysis consists of estimating the time of arrival of gale force winds and storm surge elevations at pre-selected time/history points. These data are considered, along with advisories, in the process for determining when populated areas expected to be inundated should have their evacuation process finished.

b. Vulnerability Analysis. The Vulnerability Analysis provides a detailed identification of the areas and population vulnerable to specific hurricane threats. This analysis identifies the areas in each county affected by particular hurricane intensities, the population at-risk, potential exposure of medical facilities and other institutions to storm surge, and the time period before hurricane eye landfall when high winds or rising waters would make evacuations dangerous or impossible. Evacuation zones were developed for each of the risk counties. These zones were used to develop evacuation scenarios. A scenario is a group of adjacent evacuation zones that will be threatened by the storm surge from a specific hurricane intensity category. The vulnerability analysis began with a review of established evacuation zones in each county and municipal government area as compared with inundation areas identified in the hazards analysis. Working in conjunction with local emergency management directors and other concerned local government representatives, the existing data were revised and modified to reflect the newly developed data. The planning needs of local officials were considered critical, and all revisions were approved by those officials before being included in the study effort.

c. Behavioral Analysis. The Behavioral Analysis provided quantitative information on how the public can be expected to respond to a hurricane event within each county. The analysis developed locally usable information on the following: (1) the number of people who will evacuate; (2) the number of evacuees who will require transportation assistance; (3) the number of private vehicles that will be used during an evacuation; (4) the number of people who leave or attempt to leave the local area; (5) the number of people who will seek refuge in public shelters; (6) and when people in threatened areas would leave in response to forecast storm conditions, evacuation information or order, or local residential conditions (mobile home, structurally questionable home, seasonal or temporary residence, etc.). Several scenarios incorporating the above parameters were developed to reflect early (quick), average (median), and late (slow) responses to an evacuation order.

The methodology employed to develop this data consisted of telephone sample surveys and personal interviews within the study area; and data from other hurricane evacuation studies and from post-hurricane evacuation studies.

d. Shelter Analysis. The Shelter Analysis provided a county by county inventory of existing public shelter facilities, capacities of the shelters, vulnerability of shelters to both storm surge flooding and rainfall flooding, and identified the range of potential shelter demand for each county. Inventories of existing shelters were provided by the emergency management directors of the individual counties in conjunction with the American Red Cross. Potential shelter demands for ranges of hurricane threats were developed using data from the Behavioral Analysis.

e. Transportation Analysis. The Transportation Analysis utilized all of the above mentioned analyses to complete a reevaluation of the required clearance times. Clearance time is the time required to move evacuees along the roadways from their residences to places of safety. This was accomplished for a number of situations or scenarios. Because this report is an update, the transportation analysis required depiction of necessary changes to evacuation route networks used in the participating counties. New bridges, roads, and the current state of projected roadway improvements (which are massive and on-going in the study area) were included in this analysis.

f. Decision Information. Decision arcs were constructed at West Palm Beach as a center and tables were constructed to relate clearance times to distances from West Palm Beach. Utilizing the appropriate storm speed each decision arc then defined the needed clearance time. These arcs will then be used with real time data from the marine advisories defining the extent of tropical force winds in miles from the storm center. A computer model called HURREVAC was developed for Palm Beach County to enable the emergency management officials to automatically determine their decision thresholds utilizing the study generated data and the NOAA marine advisories.

STORM SURGE ATLAS

A Storm Surge Atlas for Palm Beach County was financed by the State of Florida Department of Community Affairs. This effort was undertaken by contract and completed in January 1990. This document was published separately from the study components and Technical Assessment and delineates pictorially the storm surge inundation associated with the various categories of hurricanes. It also identifies the related storm surge elevations above MSL for each of those categories at selected locations.

CHAPTER TWO
HAZARD ANALYSIS

GENERAL

Hazard analyses for Palm Beach County were developed by the National Hurricane Center at Coral Gables, utilizing the SLOSH Model. Biscayne Bay SLOSH Model data and historical information combined are very accurate in identifying the risks. However, the ultimate direction of approach of the storm, its impact area, and its intensity when it strikes are much more elusive in definition. The major threats generally stay in warm waters, have characteristic abrupt changes of direction and maintain inconsistent probabilities of land fall even within 12 hours of landfall. With such uncertainties, Palm Beach County poses a very serious risk.

Figures 2-1 and 2-2 depict the grid and selected headings and tracks for the SLOSH analysis. The two headings shown are the two most likely ones for the county. The summary tables and grid results depict the worst case situation for each category storm utilizing the maximum of maximums (MOMs) for any heading or track. Remaining headings and tracks are included in the Hazard Appendix. A SLOSH atlas was prepared for Palm Beach County and was completed in January 1990. Since that effort was done apart from this data assembly, there may be some minor variations in the data presented here and displayed on the atlas maps. Any differences would be inconsequential to the basic objective of the hazard application. When much of the community near the coast is either severely threatened or significantly flooded by the most dangerous storms, it is not important to distinguish areas that may have small differences in predicted flood levels. In addition, there are limitations in accuracy for the SLOSH Model results.

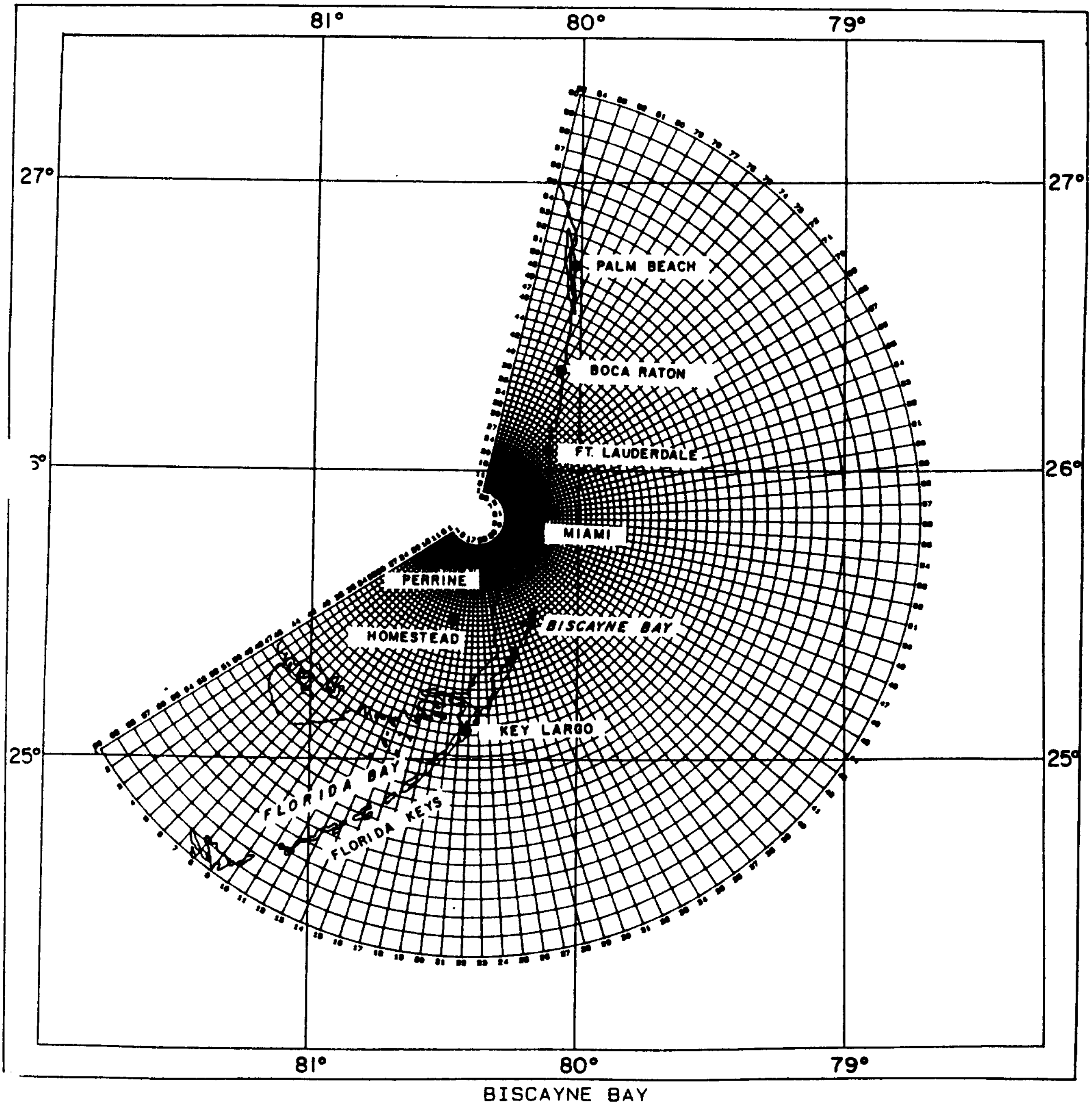
The major risks and hazards issues for Palm Beach County are as follows:

1. Wind and storm tide impacts on the barrier islands (e.g. Palm Beach, Singer Island and Delray Beach). For the most part, the barrier islands are flooded from the backside (or waterway side).

2. Unusually high storm tide effects and flooding by very large storms in the Jupiter and Jupiter Inlet areas.

3. Extreme wind activity threatening the many high rise structures particularly on the barrier islands.

Any intense storm following a track through the Bahamas and generally bounded by the 270 and 292.5 degree lines, as shown on Figure 2-3, would offer extreme concern for the Palm Beach County area. In the past these storms followed a west or west northwest heading and generally occur in late August or the first part of September. Because many of these storms stay north of Cuba, the Dominican Republic and, in some cases, Puerto Rico, they would not have been impeded by the significant land masses of these islands. One exception was Hurricane King (1950) which began near Honduras and proceeded north. Also the 1947 storm approached in a westerly direction after passing along the northern perimeter of the Bahamas. The two exiting 1948 storms originated in the Jamaica/Honduras area.



Biscayne Bay SLOSH Grid

FIGURE 2-1

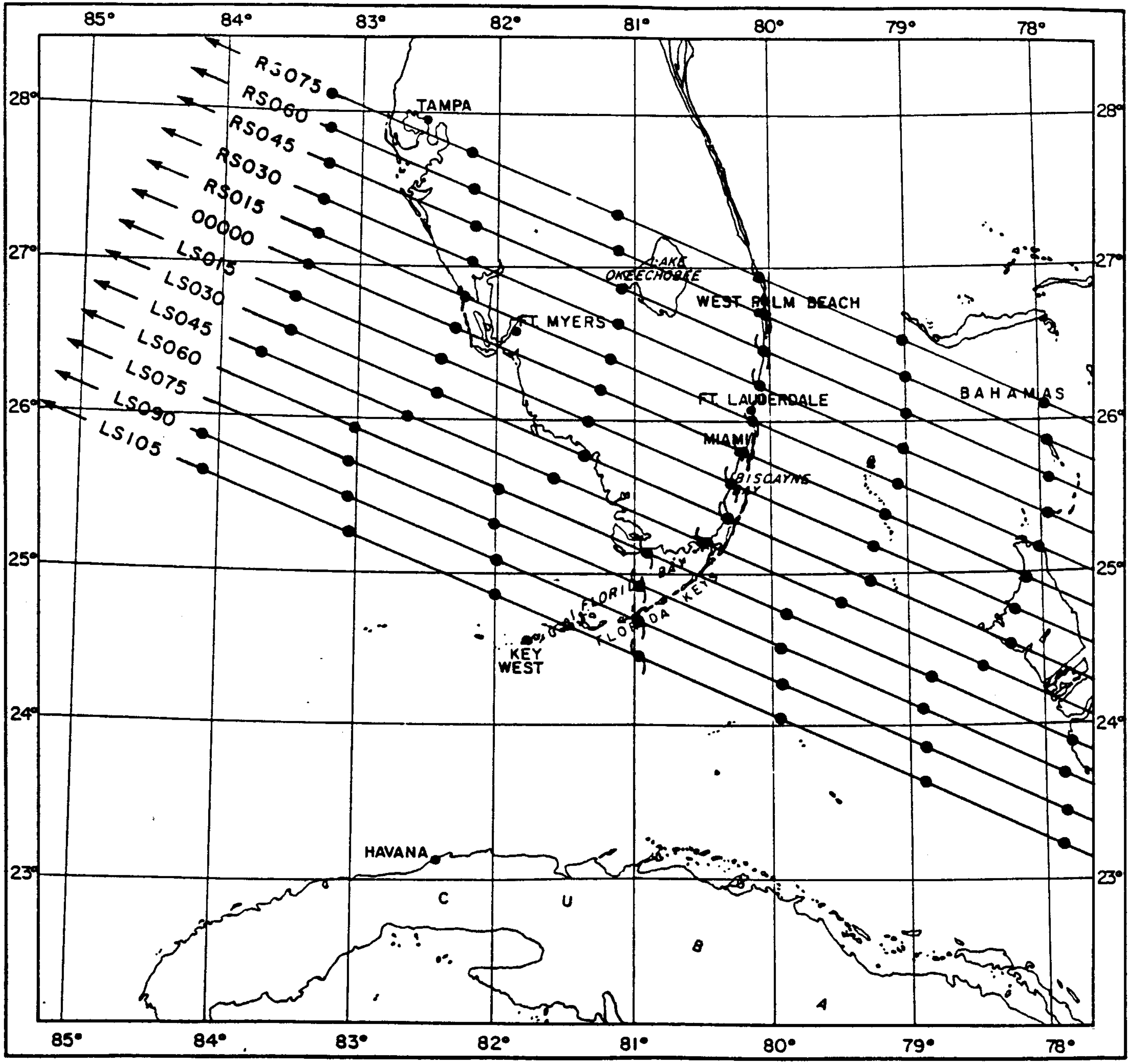


FIGURE 13.

Selected Headings and Tracks
from SLOSH Analysis

FIGURE 2-2

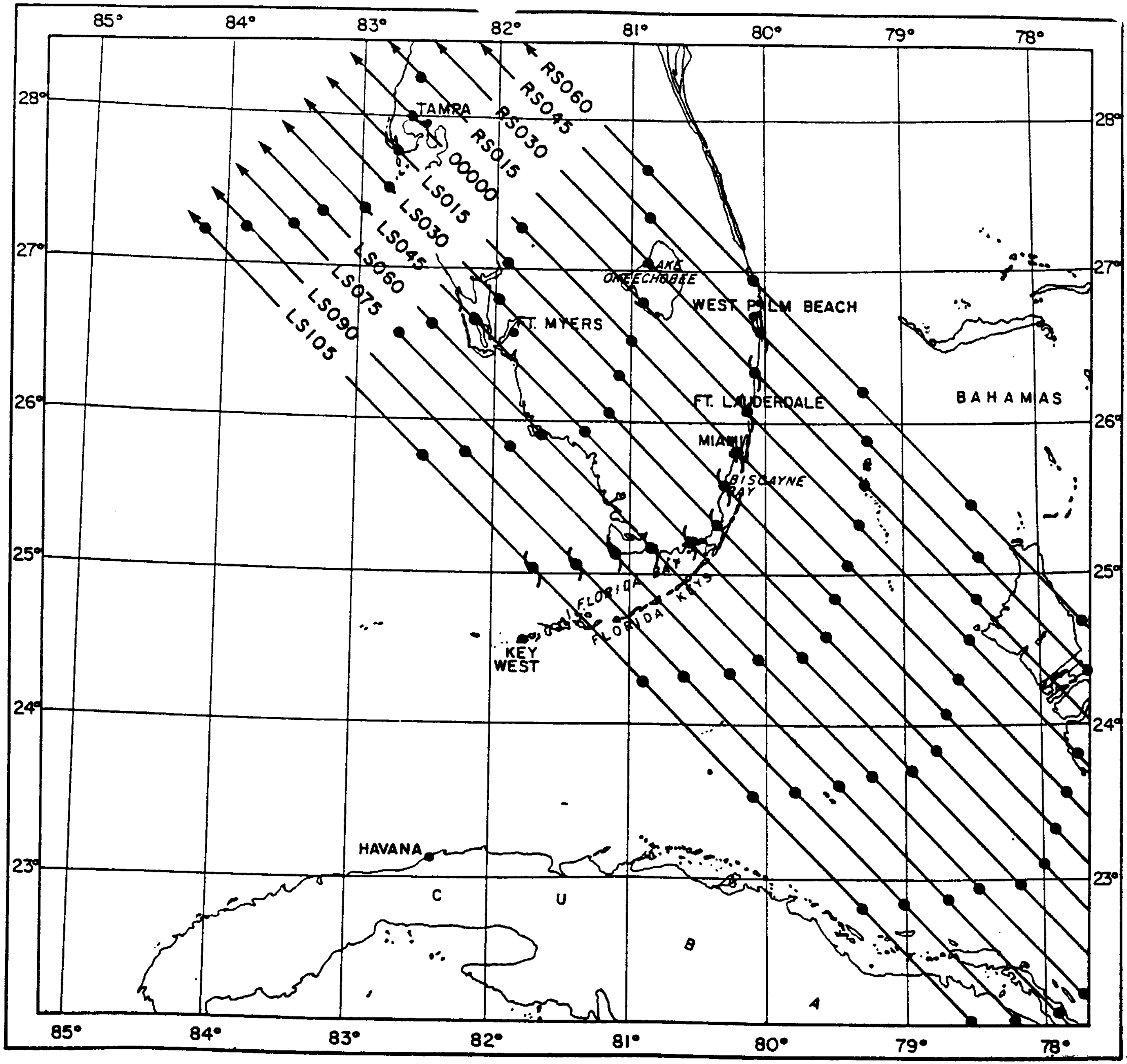


FIGURE 14.

Selected Headings and Tracks
from SLOSH Analysis

FIGURE 2-2

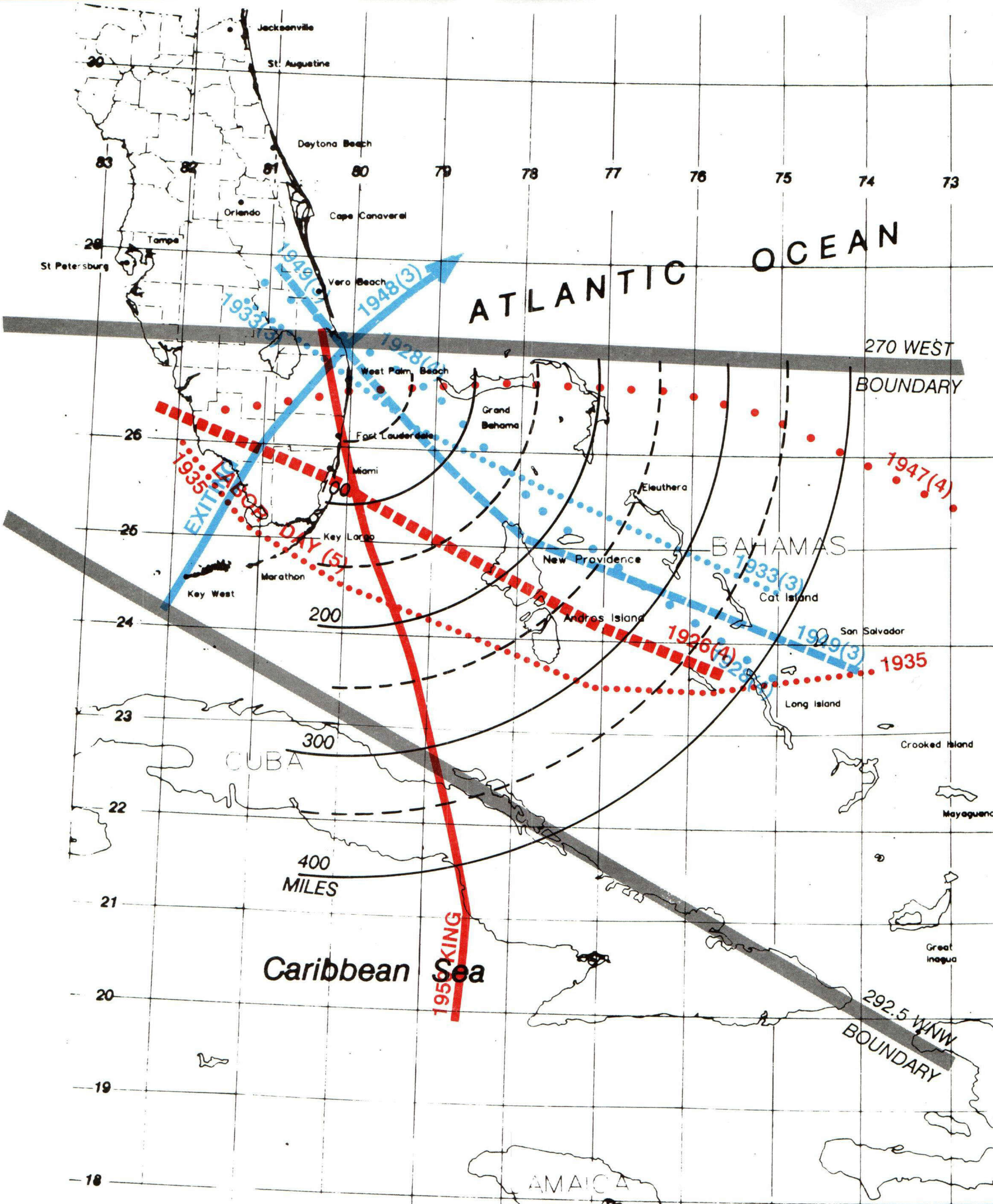
In addition to the typical storm approaching through the Bahamas on the mostly west-northwest heading, Palm Beach County has been threatened and blitzed by some storms approaching from very different directions. Although the 1928 and 1949 storms approached in generally the same pattern, they shifted from a west-northwest heading to a northwest heading prior to attacking the Palm Beach area. Much unlike the typical approach, the 1947 storm moved directly west then slightly west-southwest prior to hitting the coast. Because of its location farther up the coast the area appears to be more vulnerable to typical exiting storms that originate in the lower Gulf/Caribbean. The 1948 storms, one of which is shown on Figure 2-3, are examples of this threat.

The Palm Beach area may be a good example (and there are others) of where the likelihood of occurrence may be more important than the "worst case" conditions. The Palm Beach area has not been directly threatened by a large storm since 1965 (some 25 years) although David provided a real test in 1979 before becoming a paralleling storm. Although a threat, Hurricane Betsy in 1965 was considerably south of Palm Beach.

One other piece of historical evidence is worthy of mention here. Emergency planning has to emphasize the primary threats. All exiting hurricanes have been either Category 1 or 2 intensity storms. Although a Category 4 or 5 crossing (and exiting) storm is a possibility, it has not occurred in the 20th century. There were, however, two smaller exiting storms which occurred in the same year (1948) and both threatened Palm Beach County.

The SLOSH model generates maximum wind values which agree well with the Saffir/Simpson Hurricane Scale range. Sustained winds for Category 3-5 could be expected to be in the 110-150 mile per hour range with gusts in the 140-200 mile per hour range. Evidence exists that a tremendous increase in damage and forces occur when winds move from the 90-100 mile per hour level to the 140-150 mile per hour level. Storm tide heights (elevations above MSL) consistent with the SLOSH Atlas are presented at various locations on Figure 2-4.

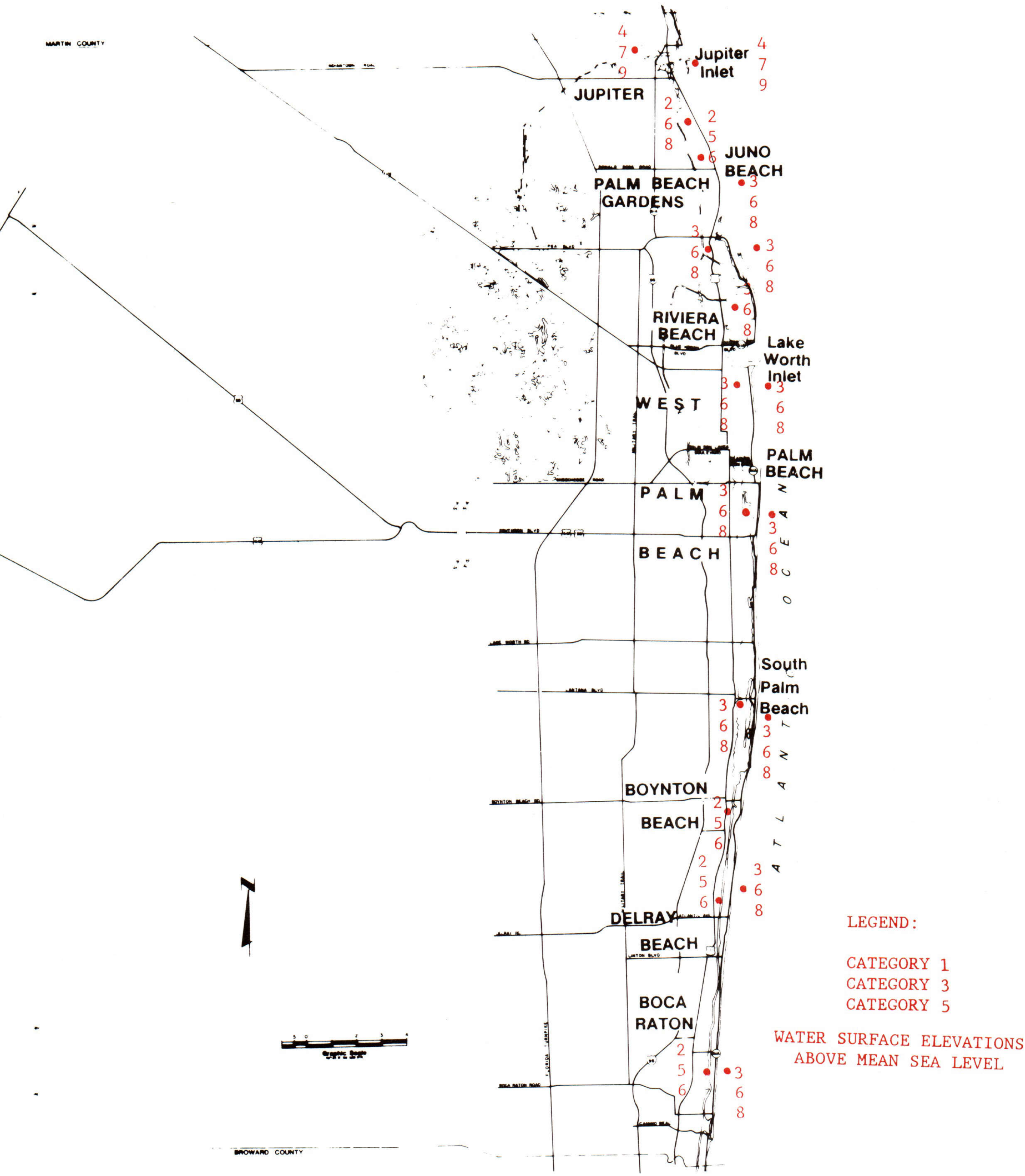
The foregoing risks are real and one cannot ignore the scope of those risks. The problems come in assuring the safety of residents of all areas. One thing that must be kept in mind is that the hazard data is for worst case situations. When a storm strikes it may only severely affect a part of Palm Beach County. However, this is little consolation since there is no assurance whatsoever where that part will be. Palm Beach County has an extensive coastline from north to south. Western Palm Beach County was analyzed only from the stand point of wind effects and the evacuation of residents in mobile homes. In addition, Lake Okeechobee, a major concern during hurricanes was not analyzed as part of this effort.



(4) = HURRICANE CATEGORY

CATASTROPHIC STORMS AFFECTING PALM BEACH COUNTY

FIGURE 2-3



PALM BEACH COUNTY

STORM TIDE HEIGHTS

FIGURE 2-4

CHAPTER THREE
VULNERABILITY ANALYSIS

PURPOSE

The purpose of this Vulnerability Analysis is to identify the areas, populations, and facilities which are vulnerable to flooding associated with hurricanes. The storm surge data from the Hazards Analysis were used to develop inundation maps (see Hurricane Storm Tide Atlas for Palm Beach County), evacuation zones, and evacuation scenarios; to quantify the population at risk under a range of hurricane intensities; and to identify major medical/ institutional and other facilities (especially shelters) that are potentially vulnerable to storm surge.

HURRICANE EVACUATION ZONES

a. General. Evacuation zones have been developed for Palm Beach County. Each of the evacuation zones are delineated as much as possible using major natural or manmade geographic features and conform to existing political or demographic boundaries (i.e., census tracts or traffic analysis zones) within the county. The purpose of this delineation is to aid in the development of population data to be used in traffic modeling; to determine sheltering requirements; and to facilitate future updating.

b. Zone Descriptions. Descriptions of the evacuation zones established for Palm Beach County are contained in the appendices. Zone delineations are shown on Figure 3-1. This generally defines the areas at risk or the vulnerability.

HURRICANE EVACUATION SCENARIOS

a. County Scenarios. Figure 3-1 and Table 3-1 and Chapter 6 contain the hurricane evacuation scenarios developed for Palm Beach County and the Transportation Appendix lists the evacuation zones comprising each scenario. Maps illustrating each hurricane evacuation scenario are also contained in the Transportation Appendix. The analyses were performed on a county by county basis since evacuation decisions are made independently by each county.

b. Vulnerable Population. The vulnerable population within Palm Beach County is comprised of those persons residing within the evacuation zones subject to storm surge, as well as the residents of mobile homes located in non-vulnerable zones. Due to their greater vulnerability to the strong winds associated with hurricanes, all mobile home residents are included in any evacuation. The total potential tourist population, based on the number of existing tourist units, is also included in the population of each evacuation zone. The total number of persons identified for evacuation in the transportation modeling is shown in Table 3-1. This is the vulnerable population.

c. Institutional/Medical Facilities. Inventories of institutional/medical facilities have been compiled for Palm Beach County. One of the purposes of the Vulnerability Analysis is to determine which of these institutions may require evacuation under various hurricane threats. The first floor elevation of each medical facility in or near areas vulnerable to storm surge has been established where appropriate. The data on inventories, capacities, surge analysis, and flood hazard evaluation for the institutional/medical facilities are maintained by Palm Beach County emergency officials. A complete listing is in the Appendices along with the vulnerability assessment for the facilities. The following facilities have been identified as near the ocean or water and probably risky:

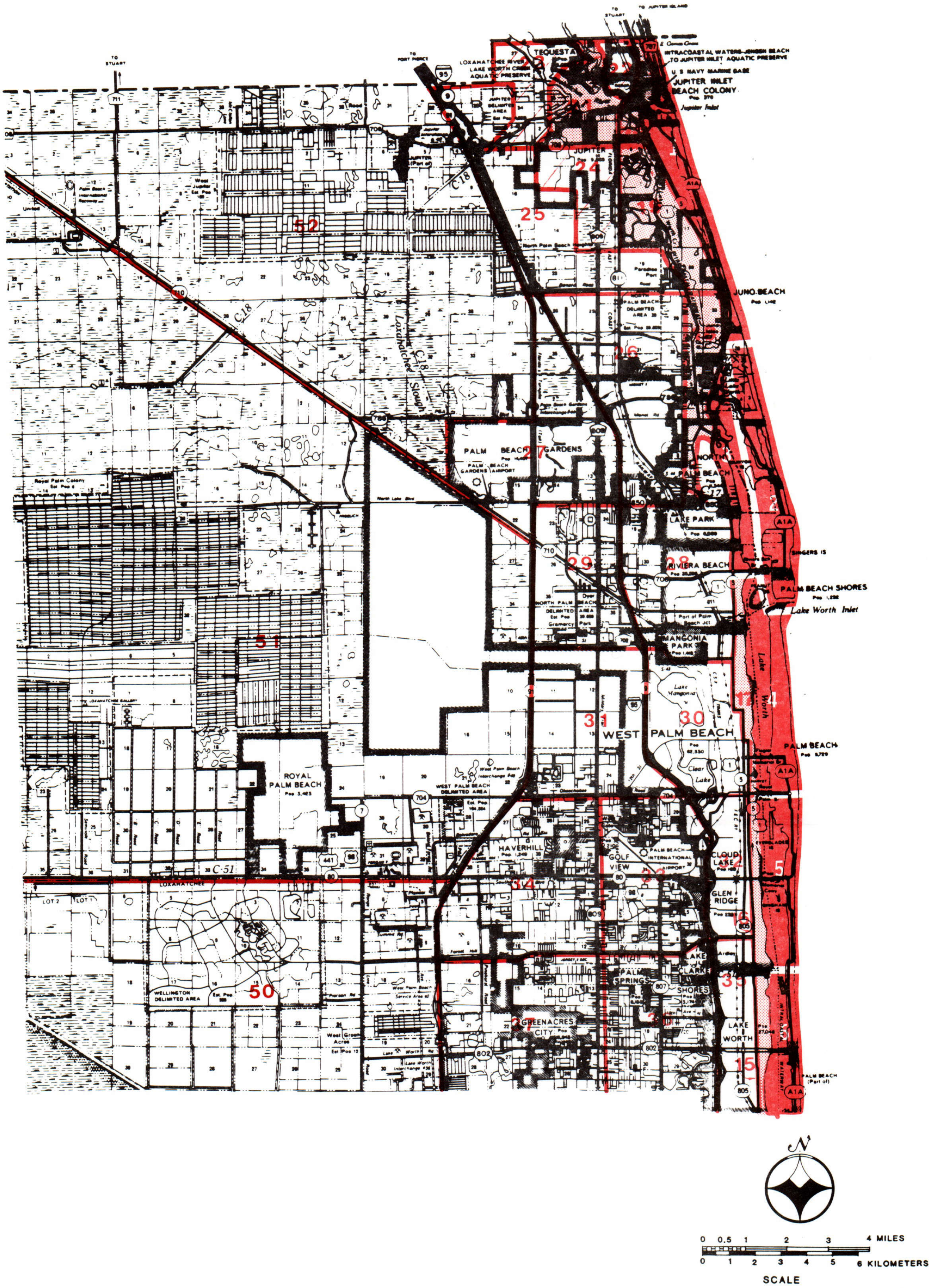
The Waterford in Juno Beach
Lourdes - Noreen Gen. Care in West Palm Beach
Harbor House ACLF in Riviera Beach
Broadway Home Care in West Palm Beach
Williams Home Care Center in West Palm Beach
Rustic Retreat in Boynton Beach
Harbours Edge in Delray Beach
CHE Home in Jupiter
Jupiter Convalescent in Jupiter
Jupiter Care Center in Jupiter

The numbers relate to the appendix listing. Because of the water and wind threats, movement of the residents of the foregoing facilities is recommended especially for a large (Cat 3-5) incoming storm.

d. Shelters. Shelter inventories have been compiled and are listed in the Appendices along with their vulnerabilities. The following shelters are a bit border line for a very large storm (Cat 4-5) and care should be exercised in their use:

Jupiter High School	Jupiter
Jerry Thomas Elementary	Jupiter
Jupiter Middle School	Jupiter

It is suggested that the three shelters not be used because, even for a very large storm and "high seasonal occupancy", there is ample shelter space even if these are eliminated. Although the lowest floors were not surveyed, it is recommended that they not be used because of the flooding uncertainties, the general vulnerability of the Jupiter area and the fact that ample shelter capacity would still be available elsewhere.



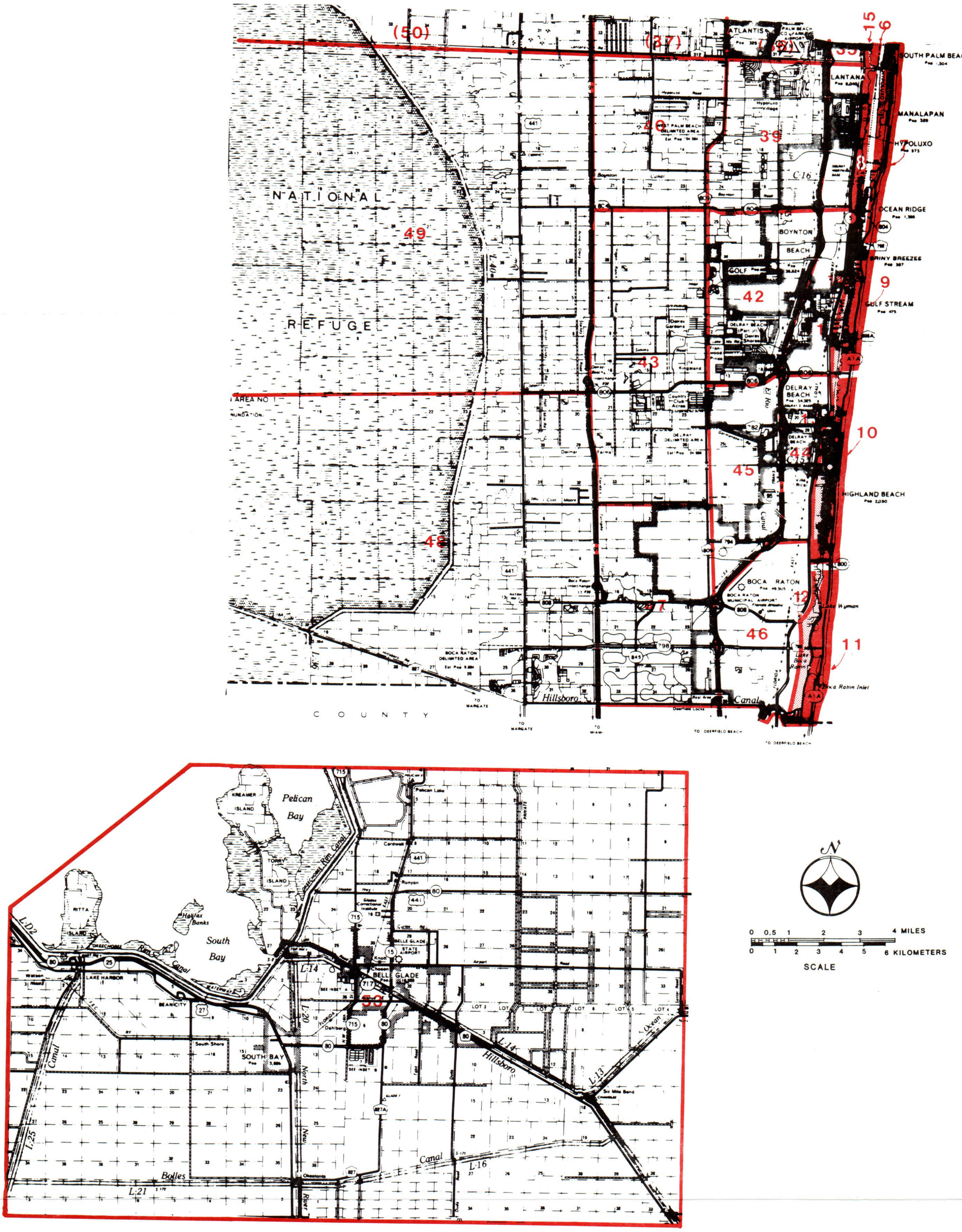
Legend

- CATEGORY 1-2 SURGE AREA
- CATEGORY 3 ADDITIONAL SURGE AREA
- CATEGORY 4-5 ADDITIONAL SURGE AREA

NORTH PALM BEACH COUNTY

VULNERABLE AREAS AND EVACUATION ZONES

FIGURE 3-1



2 OF 2

Legend

- CATEGORY 1-2 SURGE AREA
- CATEGORY 3 ADDITIONAL SURGE AREA

FIGURE 3-1

SOUTH PALM BEACH COUNTY AND BELLE GLADE

VULNERABLE AREAS AND EVACUATION ZONES

Table 3-1

EVACUATING PEOPLE STATISTICS

Storm Scenario	People Evacuating Dwelling Units
Category 1-2 Hurricane Low seasonal occupancy	133,000 (129,100 from surge zones & mobile homes) (3,900 from "non-vulnerable" units)
Category 1-2 Hurricane High seasonal occupancy	137,800 (133,750 from surge zones & mobile homes) (4,050 from "non-vulnerable" units)
Category 3 Hurricane Low seasonal occupancy	207,200 (199,900 from surge zones & mobile homes) (7,300 from "non-vulnerable" units)
Category 3 Hurricane High seasonal occupancy	214,900 (207,450 from surge zones & mobile homes) (7,450 from "non-vulnerable" units)
Category 4-5 Hurricane Low seasonal occupancy	227,000 (212,700 from surge zones & mobile homes) (14,300 from "non-vulnerable" units)
Category 4-5 Hurricane High seasonal occupancy	234,850 (220,200 from surge zones & mobile homes) (14,650 from "non-vulnerable" units)

KEY ASSUMPTIONS:

1991 assumed base year population - 900,000

Occupancy of tourist/seasonal units - two levels (45% and 90%)

For all the scenarios the figures include 100% of permanent and seasonal residents in surge zones and a small portion (1/2% - 1-1/2%) of the theoretically non-vulnerable population.

CHAPTER FOUR
BEHAVIORAL ANALYSIS

PURPOSE

The purpose of the Behavioral Analysis is to provide public evacuee response data for use in the Shelter Analysis, Transportation Analysis, and for guidance in emergency decision-making and public awareness efforts. The study included representation from the residential population residing in high-risk(barrier islands), medium-risk (mainland evacuation zones), and low-risk (wind affected only) areas. The study determined evacuation rates, timing, vehicle use, destinations, and types of refuges sought.

OBJECTIVES

The specific objectives of the Behavioral Analysis were to determine the following:

a. Evacuation rates: The percentages of the resident and tourist population in both low-risk, medium-risk, and high-risk areas that would evacuate under various hurricane conditions.

b. Evacuation timing: The response times of the threatened population in low-risk, medium-risk, and high-risk areas to an evacuation advisory or order.

c. Vehicle use: The numbers and types of vehicles that would be used in the Palm Beach County area in a hurricane evacuation.

d. Destinations of the Palm Beach County population in low-risk, medium-risk, and high-risk areas.

e. Types of refuge such as public shelters, homes of friends or relatives, motels, etc. preferred by Palm Beach County evacuees under a hurricane threat.

DATA ANALYSIS

The primary analytical tool used to obtain the behavioral information was a General Response Model, which is discussed in detail in the Behavioral Appendix. The General Response Model indicates how selected behaviors vary as a function of specific situations and circumstances in a study area.

Data gathered on actual responses to hurricanes David and Floyd in Dade, Broward and Palm Beach Counties and to hurricane David in the Treasure Coast region, just north of the study area, were used to test the predictive ability of the General Response Model and as a basis for calibrating the model to the study area.

A second model, an Intended Response Model, was also developed for the study. The Intended Response Model was similar to the General Response Model, but was based on intended responses obtained from households in the study area.

The results of the General Response Model which were based on actual behavior patterns were compared with Intended Response Model results which were based on hypothetical behavior responses to yield the final projections for the selected behaviors in the study area.

COLLECTION OF INTENDED RESPONSE DATA

Data for the Intended Response Model were obtained by means of a stratified random sample of households in Palm Beach County. Residents were telephoned and interviewed concerning hurricane evacuation intentions, past experience, and demographic information which could predict response. In Palm Beach County, 200 respondents were interviewed with phone numbers selected from cross-reference directories. Half the interviews were conducted with people living in beach areas and half with mainland residents within areas which would probably need to evacuate in major hurricanes.

ANALYSIS RESULTS

The following paragraphs present the results of the study in terms of each of the specific objectives established Behavioral Analysis.

a. Evacuation Timing. Regardless of the proficiency of emergency management officials, circumstances will arise in which very prompt evacuation is necessary, and residents will respond accordingly. In other cases, the notice will be issued earlier, and evacuation can and will proceed more leisurely. For planning purposes, the three different timing response curves shown in the Transportation Appendix should be considered, because eventually Southeast Florida will experience all three. In each threat scenario, occupants of lower risk areas will tend to wait longer to evacuate than those lining in more hazardous location.

b. Vehicle Use. For each locations available, vehicle use will be between 65% and 75%. For mainland locations, it will vary from 60% to 70%. The variation in intention to pull trailers and take motorhomes probably reflects variation in ownership from place to place, but with samples of just 100 in each location, not too much should be made of the variations. Overall only 3 to 5 percent of evacuees will pull trailers or take motorhomes.

c. Evacuation Rates. Table 4-1 summarizes the evacuation rates which should be used for planning. Recommendations are stratified on four dimensions: risk area, action by public officials, and strength of storm, and type of house.

TABLE 4-1

EVACUATION RATES TO BE USED FOR PLANNING

Severe Storm Evacuation Ordered in High and Moderate Risk Areas and Mobile Homes			Weak Storm Evacuation Ordered in High Risk Areas Only But All Mobile Homes		
Risk Area					
High	Mod	Low	HIGH	MOD	LOW
Housing Other Than Mobile Homes					
90%+	80%	30%	85%	40%	20%
Mobile Homes					
95%	90%	80%+	90%	75%	65%

d. Destinations. Table 4-2 indicates the percentage of evacuees who say they will leave their own county from each of three risk areas and in each of two threat scenarios. The first threat is a very severe hurricane (Category 3 or greater) in which people are told in plenty of time to evacuate, say 24 hours before expected arrival of tropical force winds. More people say they will leave their own county in that sort of circumstance. Planning assumptions derived from the Behavioral Survey for people going to shelters are contained on Table 4-3.

TABLE 4-2

PLANNING ASSUMPTIONS
PERCENT OF EVACUEES LEAVING COUNTY

Very Strong Storm Early Evacuation			Weak Storm Typical Timing		
Risk Area			Risk Area		
High	Mod	Low	High	Mod	Low
50%	35%	20%	35%	20%	15%

Low income evacuees seldom evacuate very far, and the rates in Table 4-2 should be at least 20 points lower for those groups. For last minute evacuations in which evacuees do not have the luxury of driving very far, particularly late at night, the figures will also be lower than those in Table 4-2.

TABLE 4-3

PLANNING ASSUMPTIONS
EVACUEES GOING TO PUBLIC SHELTERS

	RISK AREA		
	HIGH	MOD	LOW
INCOME			
High	10%	10%	5%
Medium	20%	15%	10%
Low	35%	30%	25%

These were the planning guides. However, specific percentages that were used in the transportation modeling process are contained in the Transportation Appendix to this report.

CHAPTER FIVE
TRANSPORTATION ANALYSIS

GENERAL

During a hurricane evacuation effort, it is widely recognized that a large number of vehicles have to be moved across a road network in a relatively short period of time. The number of vehicles and evacuees becomes particularly significant for an area such as Palm Beach County, Florida where causeways connect many urban areas and seasonal communities. The magnitude of evacuating vehicles varies depending upon the intensity of the hurricane, presence of tourists, and certain behavioral response and participation characteristics of the vulnerable population.

Vehicles enter the road network at different times depending on the evacuee's response relative to an evacuation order or 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 friends' or relatives' homes in non-flooded areas. Vehicles move across the road network from trip origin to destination at a speed dependent on the traffic loadings on various roadway segments and the ability of the segments to handle a certain volume of vehicles each hour.

The overall goals of the transportation analysis performed for the Palm Beach County portion of the Lower Southeast Florida Hurricane Evacuation Study were to estimate clearance times (the time it takes to clear the county's roadways of all evacuating vehicles), to define the evacuation road network, and to look at general traffic control measures that could improve traffic flow along critical roadway segments. Clearance time is a value resulting from transportation engineering analysis performed under a specific set of assumptions. It must be coupled with marine advisory data to determine when a strong evacuation advisory must be issued to allow all evacuees time to reach safe shelter before the arrival of sustained tropical storm winds. Factors that influence clearance time must be studied intensively to determine which factors have the strongest influence. Therefore, a sensitivity analysis was performed and approximately 100 clearance times calculated by varying key input parameters.

The transportation analysis task initially identified the kinds of traffic movements associated with a hurricane evacuation that must be considered in the development of clearance times. Basic assumptions for the transportation analysis were then developed related to storm scenarios, population-at-risk, behavioral and socioeconomic characteristics, the roadway system and traffic control. A transportation modeling methodology and a roadway system representation were developed for the study area to facilitate model application and development of clearance times. General information and data related to the transportation analysis are presented in summary form in the Transportation Appendix. A Transportation Model Support Document is available through the Jacksonville District Corps of Engineers and includes a detailed account of all transportation modeling activities and zone by zone data listings for Palm Beach County. Evacuating people statistics for general information are included as Table 5-1.

Table 5-1

EVACUATING PEOPLE STATISTICS

Storm Scenario	People Evacuating Dwelling Units	People Going to Public Shelter
Category 1-2 Hurricane Low seasonal occupancy	133,000 129,100 (1) 3,900 (2)	17,500
Category 1-2 Hurricane High seasonal occupancy	137,800 133,750 (1) 4,050 (2)	18,000
Category 3 Hurricane Low seasonal occupancy	207,200 199,900 (1) 7,300 (2)	27,400
Category 3 Hurricane High seasonal occupancy	214,900 207,450 (1) 7,450 (2)	28,200
Category 4-5 Hurricane Low seasonal occupancy	227,000 212,700 (1) 14,300 (2)	31,700
Category 4-5 Hurricane High seasonal occupancy	234,850 220,200 (1) 14,650 (2)	32,500

LEGEND:
(1) From surge zones and mobile homes
(2) From "non-vulnerable" units

KEY ASSUMPTIONS:

1. 1991 assumed base year population - 900,000

2. Occupancy of tourist/seasonal units - two levels (45% and 90%)
3. Figures include 100% of permanent and seasonal residents in surge zones and a small portion (1/2% - 1-1/2%) of the theoretically non-vulnerable population was also included in each scenario.
4. Assumed percent of evacuees to public shelter was varied by evacuation zone and storm scenario, depending on a zone's distance from the coastline and general income level - for example, high income barrier island zone's figures were 5 to 10 percent while "mobile home only" zones were 30 to 35 percent in this regard.

TRANSPORTATION MODELING

CLEARANCE TIMES

The transportation modeling for Palm Beach County is not affected dramatically by additional tourists in the area during the hurricane season. One hour seems to be the maximum effect. It is affected dramatically when significant areas are additionally inundated as the result of higher storm tide values for the Category 4 and 5 storms. Reference is made to the storm tide values shown on Figure 2-4 in the Hazards Analysis chapter.

One key consideration is that the numbers of persons (or evacuees) loaded on the travel network is based on "worst case" conditions for each scenario, i.e., Cat 1-2, Cat 3, and Cat 4-5. Depending on the movement of the storm and other specific factors the decision to evacuate may not be made for certain lesser storms (category 1 and 2). Even though risky, the closer the Emergency Manager can allow the storm to come before making the decision to evacuate, the more accurate the decision on the scope of the evacuation. This is important and the Decision Arcs (in the following chapter) and the HURREVAC computer model are important aids in making the decision.

Results of the transportation modeling for Palm Beach County are shown on Tables 5-2 and 5-3. These are the times that should be used when managers utilize the decision arcs and/or the HURREVAC computer model to arrive at decision times for Palm Beach County.

The fact that the table presents clearance times for a Category 1 hurricane scenario, does not mean that an evacuation order is necessary. While evacuation, at best, is very expensive and chaotic(e.g. Hurricane David in 1979), it may well be too risky not to evacuate.

Of course, the Category 4-5 scenario is most critical because it involves the most people and presents the storm scenario that we all fear. The manager must ascertain those steps which will dramatically affect or reduce the clearance time. Then the response strategies that will give the best response under the given situations must be determined. Suggestions for these strategies and stages of evacuation are outlined in Chapter Seven, "Response and Strategies".

From Tables 5-2 and 5-3, the following are critical determinations:

a. Requiring vulnerable tourists to leave Palm Beach County early-on could reduce "external" clearance times some but does not appear to be a critical factor in "internal" evacuations.

b. The immediate or rapid (as opposed to slow) response could give a 3 1/2 to 4 1/2 hour edge. (Probably directly dependent on the urgency of the appeal from public officials).

The foregoing steps are considerations for reducing clearance times and in no way reflect the reality that it will (or will not) happen this way. For planning purposes, it is important that a close match-up of theoretical and actual movements be obtained.

Table 5-2 portrays the clearance times for local evacuation movements ("internal") and Table 5-3 for Florida Turnpike/ I-95 movements ("external"). The "external" numbers are for worst case situations but, the numbers could be even worse depending on movements north in the Treasure Coast area. It may be that certain storms necessitating evacuation for Palm Beach County will not necessitate evacuation in the Florida Keys or Dade County. It is entirely conceivable, in certain storms, that evacuation in north Dade (and particularly Broward County) might move in the other direction (south towards Homestead and the Keys). Nevertheless, the times must be reckoned with. What it means is that those people going out of the county (or, at least, traffic apart from the internal evacuation) must leave much earlier or some 24-30 hours ahead of the storm. This is discussed in the next section and it means that they would have to leave when tropical force winds extend out from the storm center to a point some 360 to 450 miles for a storm moving 15 mph and some 480 to 600 miles for a storm moving 20 mph. Is this too early to start any kind of evacuation movement? Maybe, but it does indicate which movements should be made early.

TABLE 5-2

CLEARANCE TIMES
(Local Evacuation Movements Not
Involving Florida Turnpike or I-95)

Category 1-2 Hurricane	Summer Seasonal Occupancy	Late Fall/November Seasonal Occupancy
Rapid Response	6	6 1/2
Medium Response	7 1/4	7 3/4
Slow Response	9 1/2	10
Category 3 Hurricane		
Rapid Response	9 1/4	9 3/4
Medium Response	11	11 3/4
Slow Response	13 1/2	14 1/2
Category 4-5 Hurricane		
Rapid Response	11	11 3/4
Medium Response	12 3/4	13 3/4
Slow Response	15 1/4	16 1/2

TABLE 5-3

CLEARANCE TIMES*
(Florida Turnpike/I-95 Evacuation Movements)

Category 1-2 Hurricane	Summer Seasonal Occupancy	Late Fall/November Seasonal Occupancy
Rapid Response	15 1/4	19 1/4
Medium Response	15 1/2	19 3/4
Slow Response	16 1/4	20 1/4
Category 3 Hurricane		
Rapid Response	24 1/4	29
Medium Response	24 3/4	29 1/4
Slow Response	25 1/4	30
Category 4-5 Hurricane		
Rapid Response	36 1/2	41 1/4
Medium Response	37	41 3/4
Slow Response	37 1/2	42 1/4

* Clearance times reflect accumulation of Monroe, Dade, Broward and Palm Beach County out of county movements on the Florida Turnpike and I-95. Times could be worse than these "north" as Treasure Coast evacuees attempt to evacuate out of county.

CHAPTER SIX
DECISION CONCEPTS AND ARCS

GENERAL

Decision making information for Palm Beach County was developed with heavy consideration to historical information relating to the most damaging modern day storms to hit the County. Without question, the greatest risks for Palm Beach County are from intense storms coming from the east (generally, called "Cape Verde" storms) through the Bahamas, that have not been impeded by significant land masses such as Cuba and the Dominican Republic. These storms have the following common characteristics (especially, the 1919, 1926, 1928, 1935, 1947, 1949, 1960, and 1965 storms):

a. Most occurred very early (or sometime) in September.
b. They stayed north of Cuba and the Dominican Republic. Most passed north of Puerto Rico.
c. All came through the mid or lower Bahamas.
d. All were on west or west-northwest headings
e. None passed over large bodies of land (or mountains) that may have caused some loss of energy.

The storm paths are included in Figure 2-3. Hurricane King in 1950, approaching from the south, and the 1947 storm approaching from the east, were exceptions.

Previously developed data included "pre-landfall hazards times" generated from the old SPLASH model to define tropical force wind arrivals relative to storm landfall. The new SLOSH models for the area also provide this information. However, it has been determined more appropriate to obtain the tropical force wind information from NOAA marine advisories where it is provided in terms of distances in miles from the center of the storm. Thus, if one knows the precise location of the storm, arcs defining the extent of the tropical force winds can be developed using the location of the storm as the center. The point where the tropical force wind arc intersects an arc defining a specific evacuation (or clearance) time (converted to distance), would determine when, or at what storm location, the evacuation should begin.

To facilitate the foregoing determinations, a set of tables were developed for a number of storm speeds matching clearance times and distances. These were then converted to a set of lines relating evacuation time and distances. The relationships are included in Figure 6-1. If one knows the approximate time needed for evacuation (from the transportation modeling), the point where the evacuation needs to begin can be determined. This can be called the decision maker's "arc of interest". The figure is set up for knots and nautical miles but MPH can be used and statue miles determined also.

The only thing that the decision makers then need to determine is where the storm center will be when the tropical force winds arrive at the "arc of interest". They can readily determine the current position and location in miles from their place of interest from the advisories and through plotting on the decision chart. From the advisories they then obtain the extent of the tropical force winds in miles and subtract that from the center of storm location in miles to see where the tropical force winds are now. They then determine the difference in miles between this point and their "arc of interest" thus determining the distance the hurricane must move. Knowing the storm speed, they then know how many hours are available before the tropical force winds reach their arc of interest. An example is provided on Figures 6-2 and 6-3 for determination of the critical values. The example uses statute miles and mph. In reality, the information from the NOAA marine advisories is in nautical miles and knots.

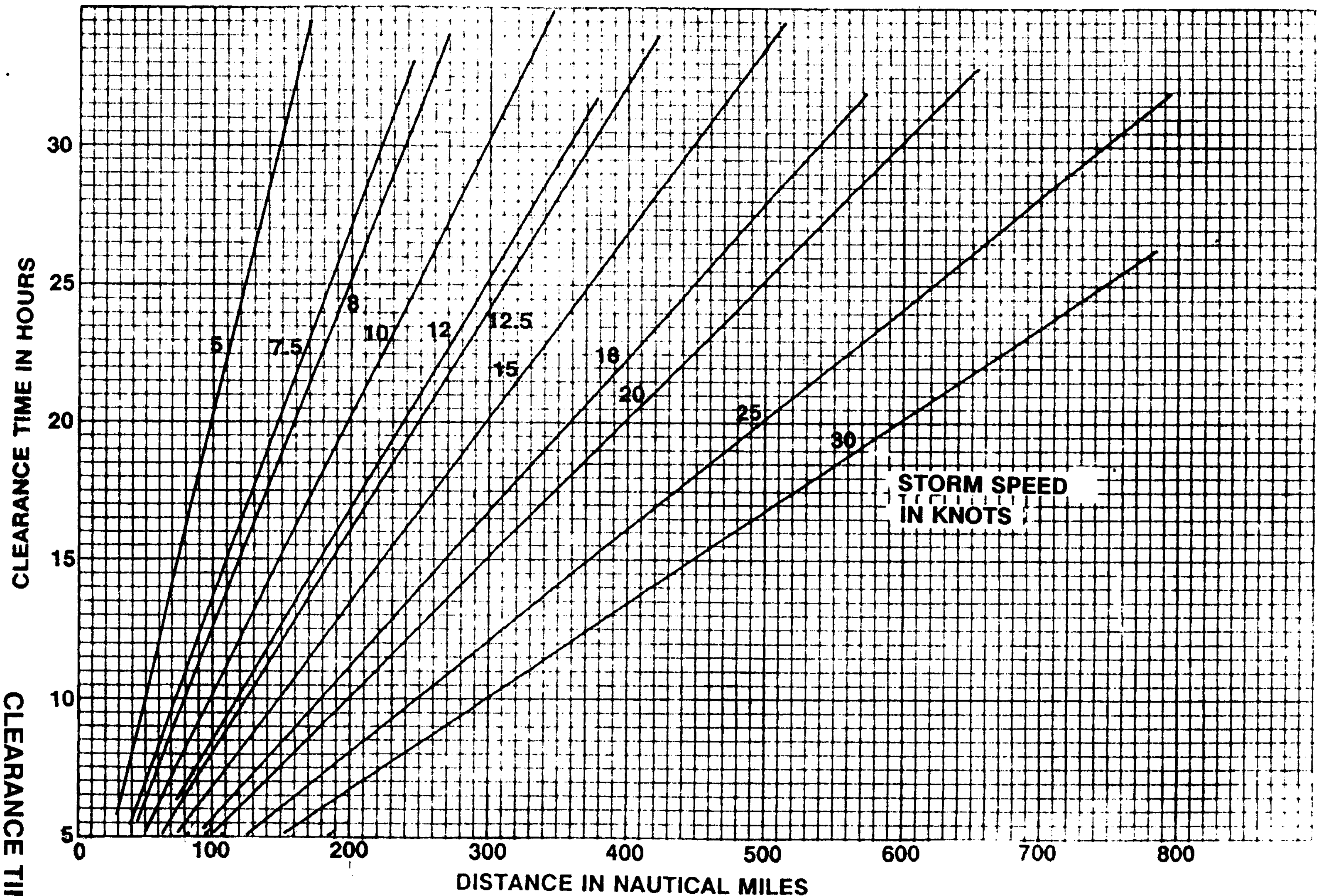
Tables 6-1 and 6-2 portray clearance times for three response levels and two tourist occupancy levels. They are also presented for internal(6-1) and external(6-2) evacuations. The external considers the heavy evacuating traffic effects from Broward and Dade Counties and the Florida Keys. Clearance times were then converted to distances for various storm speeds and matched with a lettered decision arc on Figure 6-4. Distances were rounded to match the next highest arc (or the next one away from the center). This decision arc then becomes the "arc of decision" for the emergency manager. A storm plot overlay also is included in Figure 6-5 to aid in determination of a specific storm and storm center where certain tropical force wind arcs intersect the clearance arc of interest.

If emergency managers examine the tables and the decision arcs they become acutely aware that "internal" evacuation times provide a relatively reasonable "arc of interest" for Palm Beach County, giving the decision makers a fairly good match-up with probabilities from the advisories. However, one must conclude, that the opposite is true when considering the "external" evacuation times. The clearance times for an "external" evacuation for a Category 1-2 scenario exceed the "internal" times for a Category 4-5 situation. Thus, for large storms, the "arcs of interest" go to unreasonable distances.

Based on the foregoing, and the uncertainties of traffic on the Florida Turnpike and I-95 (and evacuations in the other counties), one must conclude that certain early-on steps would be needed for those who anticipate going out of the county.

DETAIL

A Hurricane Evacuation Decision worksheet and a discussion of the HURREVAC computer model are provided for guidance at the end of this report in Annex I.



CLEARANCE TIMES
STORM SPEEDS
AND DISTANCES
FIGURE 6-1

DECISION ARC INFORMATION

EXAMPLE

1. Determine Arc of Interest from curves Figure 6-1.
   Example: 10 hours clearance time needed.
   Storm moving 20 mph = 200 miles.

2. Determine location of storm center from advisory.
   Example: Longitude 75.7
   Latitude 23.2 @ 400 miles

3. Determine Extent of tropical force winds from advisory.
   Example: gale force winds extend 150 miles
   400 - 150 = 250 miles location

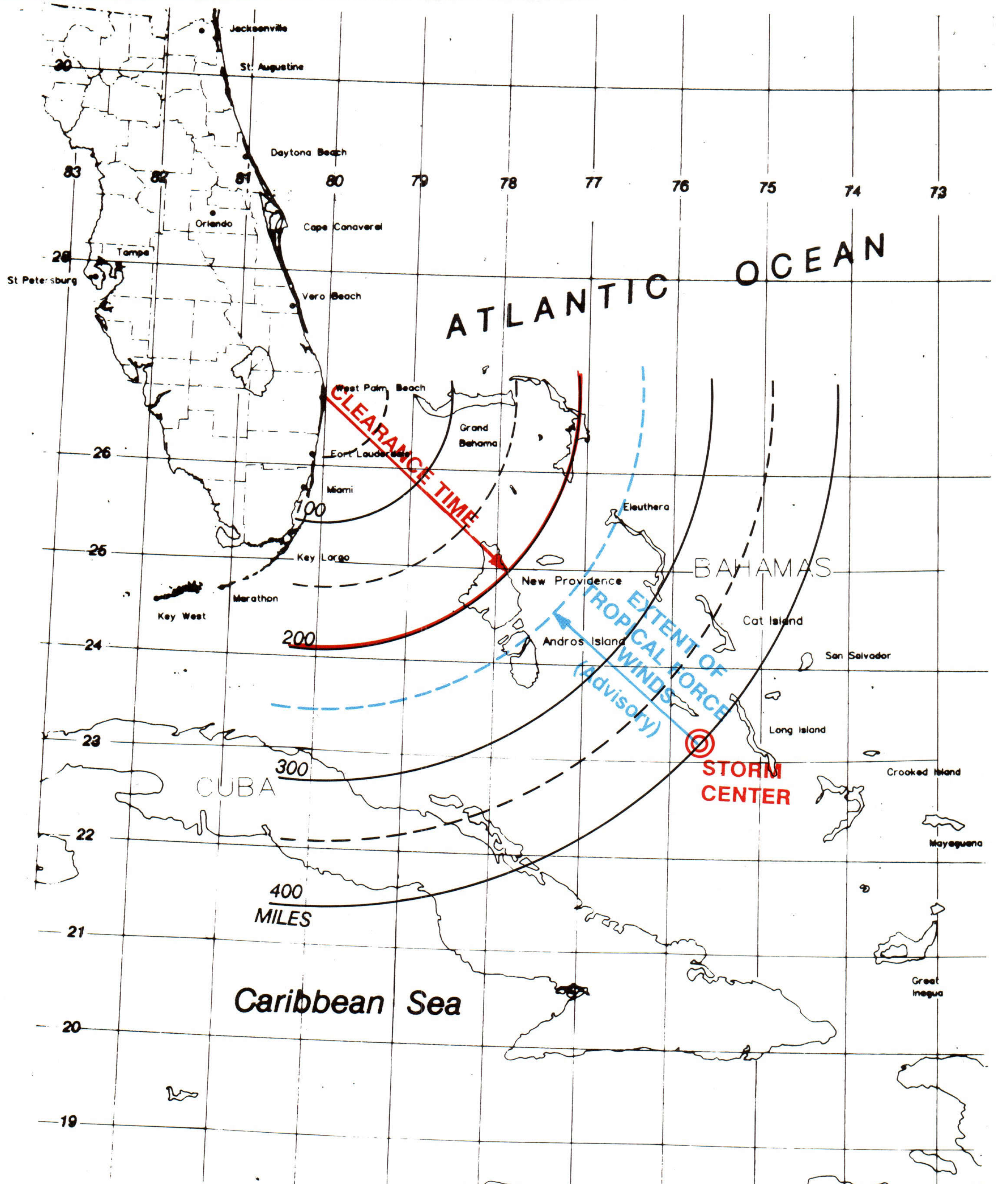
4. Determine how much time is available before tropical force winds reach the "Arc of interest".
   Example: 250 - 200 = 50 miles
   Storm moving 15 mph
   Answer: 2 1/2 hours available (before evacuation order is given)

5. From advisory determine 12 hour forecast position of storm. Subtract from current storm center position in miles (in this example 400 miles) to determine how far storm is expected to move in 12 hours. Divide by 12 to determine new forecasted storm speed.

6. Utilizing forecasted storm speed go back and re-determine arc of interest. Continue process, if needed.

NOTE: Numbers in this example are in MPH and statue miles.

Figure 6-2



EXAMPLE:

STORM MOVING 20 MPH
CLEARANCE TIME 10 HOURS

PALM BEACH COUNTY

DETERMINATION OF TIME FRAMES AND CRITICAL DISTANCES

FIGURE 6-3

TABLE 6-1

DECISION ARC SET-UP
WITH NEWLY COMPUTED
CLEARANCE TIMES FROM
CURRENT STUDY
Cat 1-2
(Internal)

Cat 1-2 Evacuee Response		Clearance times in hours for 2 tourist occupancy levels: L Low	H High
R	Rapid	6	6 1/2
M	Medium	7 1/4	7 3/4
S	Slow	9 1/2	10

Storm* Speed Response	Decision Arc L	Decision Arc H	Storm* Speed Response	Decision Arc L	Decision Arc H
10-R	C	D	15-R	E	E
10-M	D	D	15-M	F	F
10-S	E	E	15-S	H	F
	L	H		L	H
20-R	F	G	25-R	H	I
20-M	H	H	25-M	J	J
20-S	J	J	25-S	L	M

*Storm speed in knots

TABLE 6-1 (con't)

DECISION ARC SET-UP
WITH NEWLY COMPUTED
CLEARANCE TIMES FROM
CURRENT STUDY
Cat 4-5
(Internal)

Cat 4-5 Evacuee Response		Clearance times in hours for 2 tourist occupancy levels	
		L Low	H High
R	Rapid	11	11 3/4
M	Medium	12 3/4	13 3/4
S	Slow	15 1/4	16 1/2

Storm* Speed Response	Decision Arc		Storm* Speed Response	Decision Arc	
	L	H		L	H
10-R	F	F	15-R	H	H
10-M	G	G	15-M	J	K
10-S	H	I	15-S	L	M
	L	H		L	H
20-R	K	L	25-R	N	O
20-M	M	N	25-M	P	R
20-S	P	Q	25-S	T	U

*Storm speed in knot

TABLE 6-2

DECISION ARC SET-UP
WITH NEWLY COMPUTED
CLEARANCE TIMES FROM
CURRENT STUDY
Cat 4-5
(External)

Cat 4-5

Evacuee Response		Clearance times in hours for 2 tourist occupancy levels: L Low	H High
R	Rapid	36 1/2	41 1/4
M	Medium	37	41 3/4
S	Slow	37 1/2	42 1/4

Storm* Speed Response	Decision Arc L	Decision Arc H	Storm* Speed Response	Decision Arc L	Decision Arc H
10-R	S	U	15-R	BB	EE
10-M	S	U	15-M	BB	FF
10-S	S	V	15-S	CC	FF

Storm* Speed Response	L	H	Storm* Speed Response	L	H
20-R			25-R		
20-M			25-M		
20-S			25-S		

*Storm speed in knots

TABLE 6-2 (con't)

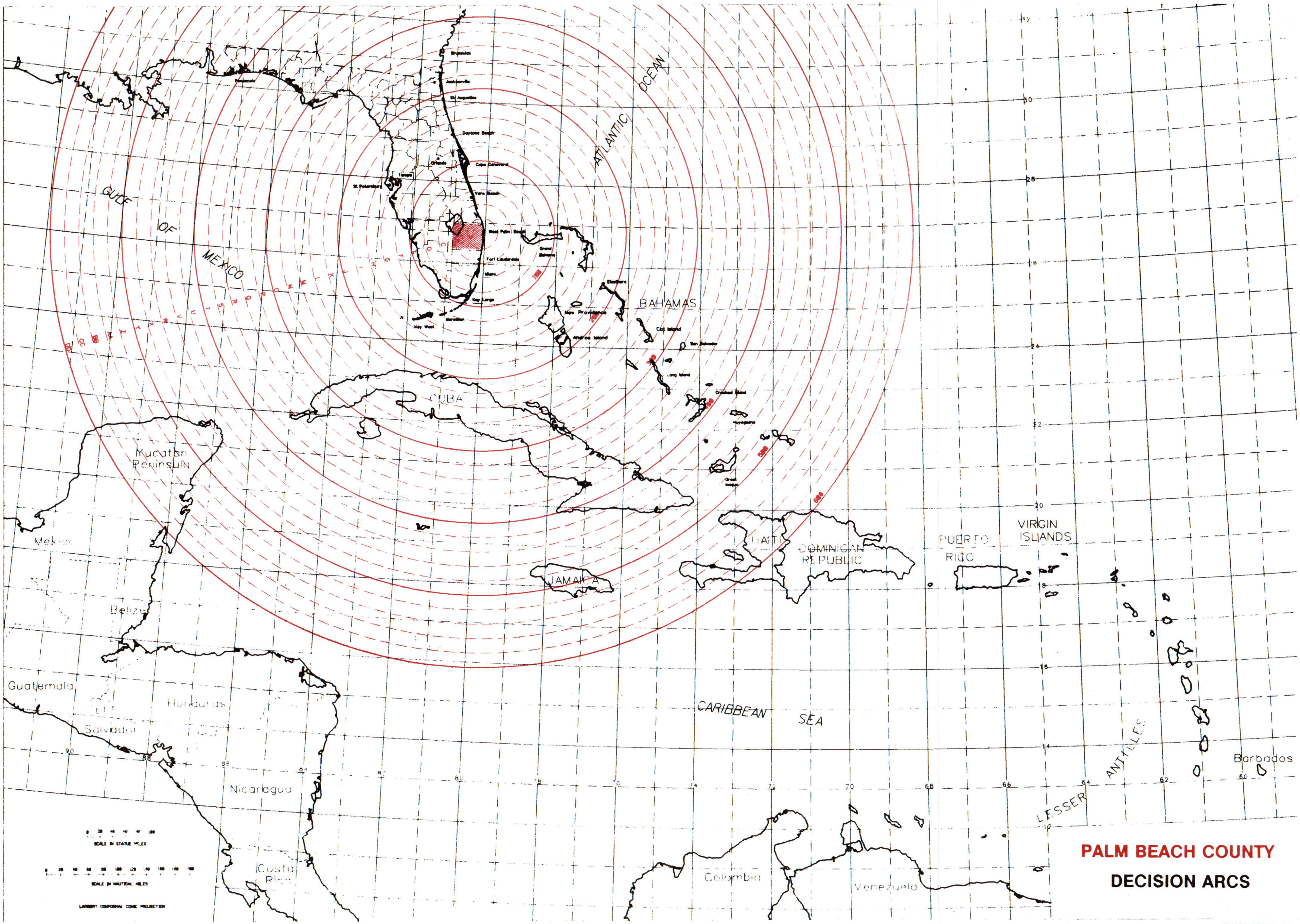
DECISION ARC SET-UP
WITH NEWLY COMPUTED
CLEARANCE TIMES FROM
CURRENT STUDY
Cat 1-2
(External)

Cat 1-2

Evacuee Response		Clearance times in hours for 2 tourist occupancy levels: L Low	H High
R	Rapid	15 1/4	19 1/4
M	Medium	15 1/2	19 3/4
S	Slow	16 1/4	20 1/4

Storm* Speed Response	Decision Arc L	Decision Arc H	Storm* Speed Response	Decision Arc L	Decision Arc H
10-R	H	J	15-R	L	O
10-M	H	J	15-M	L	O
10-S	I	K	15-S	M	P
	L	H		L	H
20-R	P	T	25-R	T	Y
20-M	P	T	25-M	T	Y
20-S	Q	U	25-S	U	Z

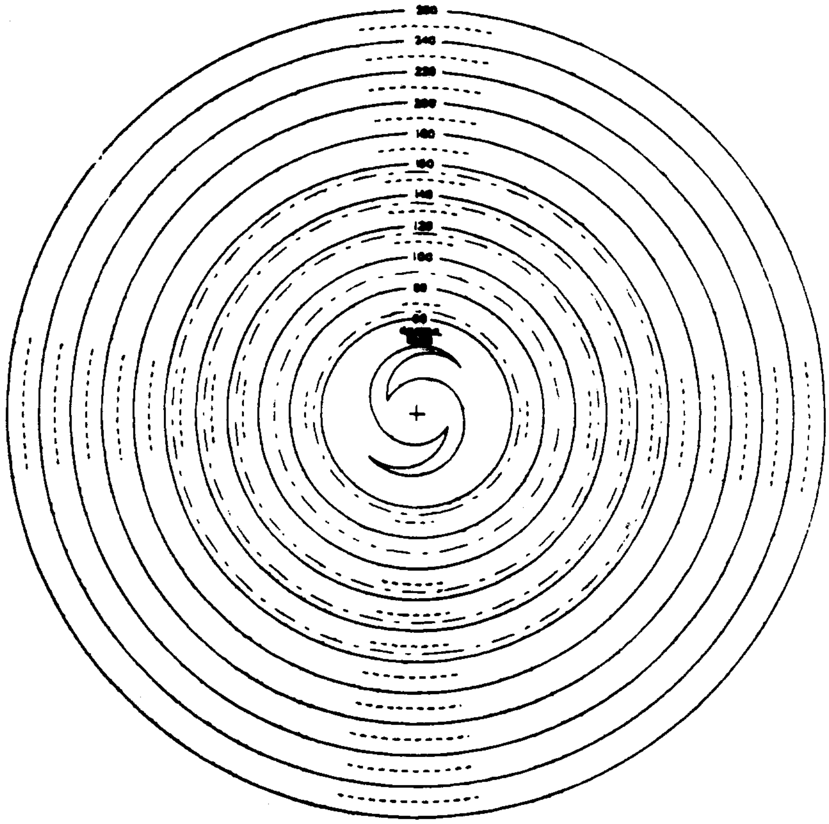
*Storm speed in knots



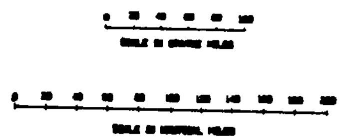
PALM BEACH COUNTY

DECISION ARCS

FIGURE 6-4



STORM PLOT OVERLAY



PALM BEACH COUNTY

FIGURE 6-5

CHAPTER SEVEN
RESPONSE AND STRATEGIES

GENERAL

Palm Beach County's clearance times for "internal" evacuations are not excessive. Even with the large number of evacuees (see transportation chapter) the roadways allow a fairly reasonable "internal" evacuation response even for the very worst scenario. Because of the fairly reasonable times and a more normal storm approach, a fairly straight forward approach to the evacuation decision can be made. Maximum evacuation times in the 12-16 hour range would translate to an arc of interest in the 180 - 320 mile range for storms with forward speeds ranging between 15 and 20 mph (which is the normal speed in this area).

The "internal" evacuation decision thresholds for Palm Beach County, then, relate fairly well to better defined probabilities from the NOAA marine advisories. Any large storm approaching through the "Bahama Boundary" that is still on target when the tropical force winds approach the 200 - 300 mile arc range becomes a serious concern at that point. Considering the impact of the "external" evacuation on times and maybe even on the "internal" evacuation times themselves, there should be considerable early-on movement in advance of the 200-300 mile range. Every conceivable strategy should be used to minimize the time needed to start and finish an evacuation. The evacuation should be staged such that, at a minimum, the following might occur:

a. Tourists and/or those evacuating externally should leave the barrier islands as early as possible. All motels, hotels, campsites and RV parks should be closed.

b. Residents between the ocean and the intracoastal waterway should leave as early as possible.

c. An urgent appeal to evacuate must be made through the media and by public officials.

d. Residents adjacent to or near the intracoastal waterway and particularly near the Jupiter and Jupiter Inlet areas should leave as early as possible.

e. Crucial that Navy and Coast Guard personnel commit to the evacuation (or to the decision to stay, if that be the case) as early as possible.

f. Traffic control and vehicle assistance provisions must be available well in advance or when the storm is 300 miles out.

The foregoing basically would result in two evacuations for a large storm, one as early as possible and another somewhat later. Meanwhile, the storm should be monitored to insure that selective movements of the remaining people further inland or on the northern and/or southern county perimeters can be made depending on 1) what the storm is doing and 2) on the strike probabilities. All of this assumes, of course, that the minimum strategies outlined above are implemented (and agreed upon before hand). If during or near the end of the initial stage, the storm is still a large-intense storm and the probability of landfall in Palm Beach County has not diminished appreciably, then, full scale mass evacuation of major portions of the county should be ordered.

For a larger storm threatening Palm Beach County it is imperative that those on the barrier islands, and those who anticipate evacuating out of the County leave as early as possible.

ANNEX 1

HURRICANE EVACUATION DECISION WORKSHEET

HURREVAC COMPUTER MODEL

HURRICANE EVACUATION DECISION WORKSHEET

There are four (4) basic "tools" you will need in your evacuation decision process: (1) county Decision Arc Map; (2) county Decision Arc tables; (3) transparent STORM disk; (4) the NOAA National Weather Service (NWS) marine advisory.

1. From the NWS marine advisory, plot the last reported position of the hurricane eye on the county Decision Arc Map. Notate 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 notate the four forecast positions of the hurricane from the advisory.

2. From the marine advisory, note the largest radius of 34-knot winds, the forecast maximum sustained wind speed at landfall (to determine hurricane category), and the current forward speed.

3. Using the forecast maximum sustained wind speed in knots at landfall and the Saffir/Simpson Hurricane Scale, determine the category of the approaching hurricane. The Saffir/Simpson scale with maximum sustained wind speeds in knots is in a table at the end of this worksheet. Because of potential forecast and SLOSH model inaccuracies, it may be advisable to add one category to the forecast landfall intensity. With the category and the current forward speed, enter the county Decision Arc table and select the appropriate clearance time and corresponding Decision Arc. Mark this arc on the county Decision Arc Map.

4. Plot the largest radius of 34-knot winds onto the transparent STORM.

5. Using the center of the STORM as the hurricane eye, locate the STORM on the Decision Arc Map at the last reported hurricane position. Note if the radius of 34-knot winds falls within the Decision Arc. If so, the hurricane has passed the Decision Point (the point at which the radius of 34-knot winds crosses into the selected Decision Arc). In this case, measures should be taken to ensure a rapid public response in order for the evacuation to be completed prior to the arrival of sustained 34-knot winds (or consider advising no evacuation).

6. Determine the forecast forward speed of the hurricane by measuring the distance between the first and second forecast positions and dividing by 12. A speed faster than the current forward speed will indicate that the hurricane is forecast to accelerate, and, therefore, that less time will be available to the decision-maker. If forecast forward speed is greater than current, reenter the Decision Arc table and select the appropriate Decision Arc.

7. Move the STORM to the first forecast position. Again, note if the radius of 34-knot winds falls within the Decision Arc. If so, the recommendation to evacuate should be given before the hurricane eye reaches the first forecast position.

8. Determine as closely as possible how many hours remain before a decision must be made. Determine if sufficient time remains to evacuate after the next NWS marine advisory will be received. Use the probabilities table in the marine

advisory to determine where an evacuation is likely to take place. Determine how

other counties would be affected by an evacuation of your county, and when they should be notified. Check inundation maps to determine where flooding may occur, and evacuation zone maps for zones that should evacuate.

9. At the Decision Point, check the probability table for your location. If probability is greater than 30 percent, strongly consider recommending evacuation. If the probability is less than 30 percent, you are encouraged to contact your Area Coordinator or State emergency operations center for recommendations.

10. Steps 1 through 9 should be repeated after each NWS advisory until a decision is made by the county.

Because information given in the marine advisory is in nautical miles and knots, the Decision Arc Maps and STORM have a nautical miles scale. 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.

SAFFIR/SIMPSON HURRICANE SCALE RANGES

Scale Number Category	Central Pressure Millibars	Central Pressure Inches	Winds (Mph)	Winds (Kts)	Damage
1	$\geq$ 980	28.94	74-95	64-83	Minimal
2	965-979	28.50-28.91	96-110	84-96	Moderate
3	945-964	27.91-28.47	111-130	97-113	Extensive
4	920-944	27.17-27.88	131-155	114-135	Extreme
5	< 920	< 27.17	> 155	> 135	Catastrophic

HURREVAC

Some of the most important products developed as a part of the FEMA/Corps of Engineers hurricane studies and delivered to local state officials have been evacuation decision making tools. These tools have been decision arc maps and tables such as contained in this report, as well as computer software. Products such as these graphically tie together real-time storm characteristics with clearance time data. Their purpose is to give directors a means of retrieving technical information without having to dig through a report during an emergency. Evacuation decision tools suggest when an evacuation should begin relative to a specific hurricane, its associated wind field, forward speed, probabilities, forecast track, and intensity.

A computerized informational model has been developed which utilizes technical data contained in the study along with information contained in the marine and public advisories from the National Hurricane Center. The model, called HURREVAC, is a tool to assist local officials in making hurricane evacuation decisions. HURREVAC was adapted to Georgia and its data base and delivered to county officials just days before Hugo threatened the area.

After entry of Hurricane Center Marine Advisory data into the HURREVAC program the emergency manager can know within a few seconds, the implications of the latest Advisory for his community..such things as Gale Arrival time, Evacuation Decision time, Eye Arrival time, Evacuation Clearance time, extent of flooding from the Zone Map graphics, etc., all based on official data and Federal studies, and a quick idea of the Evacuation Scenario that could develop, based on historical evacuation patterns.

Using HURREVAC, a new Emergency Management official can quickly get "up to speed" on the complexities of the situation...a process which might have taken many months (or years) of experience to develop. HURREVAC can be used to run hypothetical hurricanes into the area as valuable training.

Following are the main features of the HURREVAC program:

QUICK DATA ENTRY - The Data Entry screen is designed to allow quick and easy entry to data from the NHC Marine Advisory. The program automatically handles non-standard Advisories such as Special and Intermediate Advisories, allowing you to update every 2 or 3 hours when the storm gets close.

RUN "WHAT IF" SCENARIOS - The program allows you to adjust the Storm intensity and track to quickly see the effect of unanticipated changes in those parameters on your area.

EVACUATION ZONES MAPS - Quickly bring up computer graphics showing the SLOSH generated flooding maps for your area, for this storm or any other Category of storm. Evacuation Zones and Flooding scenarios are highlighted. One can cycle through the maps using just the arrow keys on the keyboard...Up/Down arrows to access the next higher or lower Category map, Right/Left arrows to access maps for an adjacent area or county.

SHELTER DISPLAYS - See which shelters are available, their capacity and their vulnerability to storm surge, for each storm Category.

RESEARCH/TRAINING CAPABILITY - Run old Advisories or make up new storms to test Emergency Management actions and procedures. Computer will set the Date/Time for you and restore your original time upon exit.

The HURREVAC model is being provided all four counties in the Lower Southeast Florida study area.