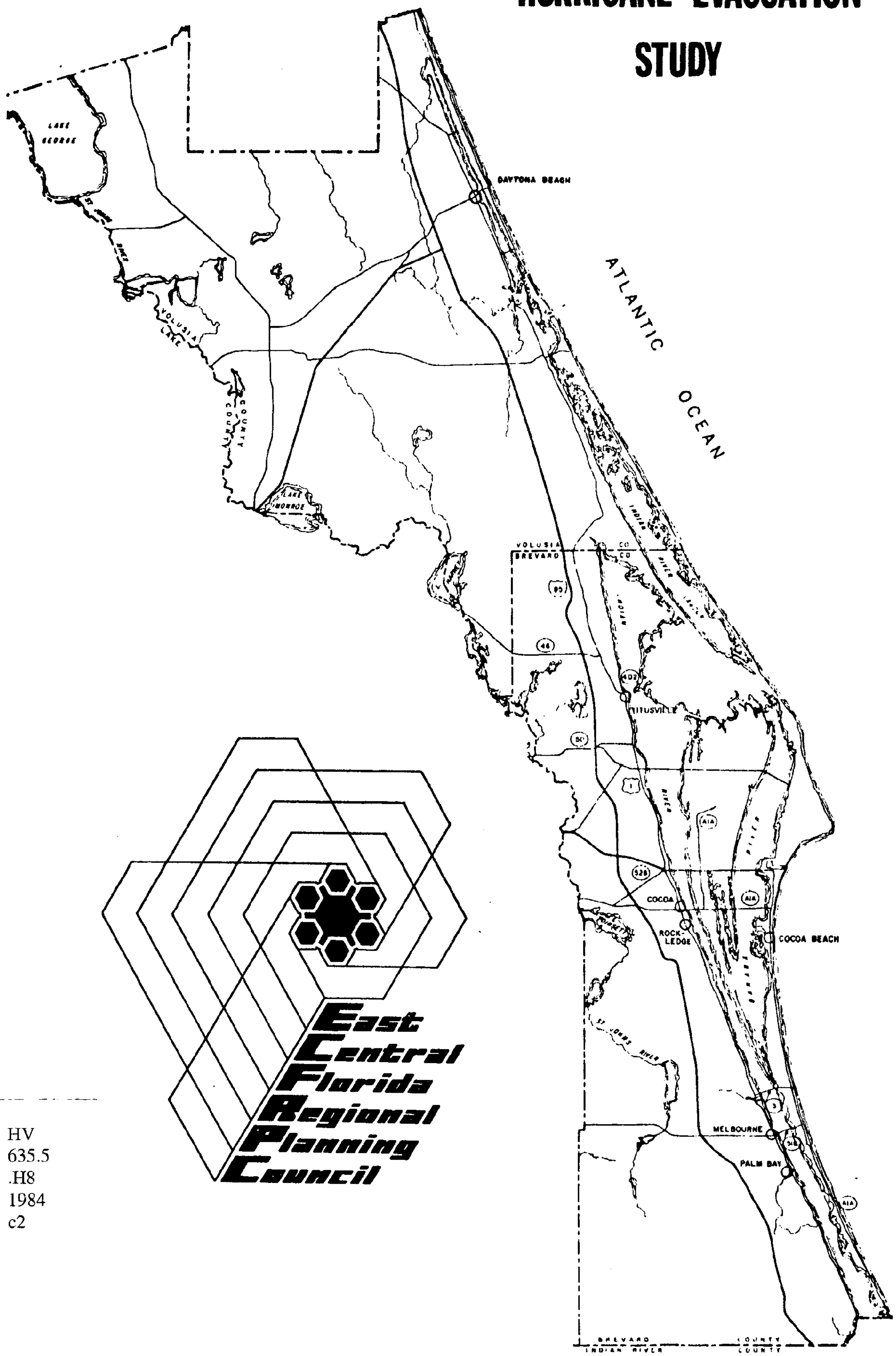
# HURRICANE EVACUATION STUDY




East
Central
Florida
Regional
Planning
Council

# HURRICANE EVACUATION STUDY

# FOR

# EAST CENTRAL FLORIDA

FINAL REPORT

JUNE 1984

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# INTRODUCTION

The State of Florida is recognized as an area highly vulnerable to the destructive effects of a hurricane. The great length of the State's shoreline, characterized by low-lying coastal topography and numerous tidal inlets, offers little protection from the hazards produced by a major storm. This vulnerability is enhanced by the historically high probability of the State being subjected to a hurricane each year.

As rapid development continues to occur along Florida's coast, the potential for a major disaster as a result of this vulnerability increases each year. Those areas most susceptible to the destructive forces of a hurricane--barrier islands--are also the areas most attractive to development and resulting population growth. It is estimated that over seven million persons reside in the coastal areas of Florida, the majority of whom have never experienced the effects of a hurricane.

To reduce the potential for a major disaster along the State's coastal areas, the Florida Department of Community Affairs has undertaken a program to develop a series of coordinated hurricane evacuation studies throughout the State. These studies are regional in nature--in that they recognize that the destructive forces of a hurricane are not limited to one community or county, but extend regionwide. As such, regional planning councils encompassing coastal counties within their boundaries have been selected to prepare individual studies for their areas.

The central issue to be addressed by each of these studies is the timing of issuing an evacuation order. There is a point in time relative to hurricane landfall when state and local authorities must order an evacuation of vulnerable areas if there is to be sufficient time available for residents to move to safety. In the past, when coastal areas were less developed and many areas still retained rural development characteristics, consideration of when an evacuation should begin was not a major concern. Most areas could complete their evacuation within the 12 hours of warning time provided by the National Hurricane Center. This may no longer be the case, however, for many of the rapidly development coastal communities in Florida. As the population along these areas continues to expand, the length of time needed for evacuation also expands, and the importance of quantifying and incorporating this variable into evacuation decisions increases.

There are two major conditions influencing the parameter of time required for the evacuation of any given area. These are:

1. The volume of traffic that may be expected to utilize the evacuation routes and the capacity of these routes to accommodate the traffic within a certain time period.

2. The time in which the arrival of the storm surge and/or high winds may adversely affect the ability of residents to safely evacuate vulnerable areas.

Consideration of these two factors forms the basis for development of the hurricane evacuation studies. These studies should assist local governments in determining the probable impacts of a hurricane approaching their area and serve as a decision-making tool for local response to these conditions. They are meant to guide local disaster preparedness officials in determining when and to what extent evacuation must take place based upon information released by the National Weather Service as the hurricane approaches. The development of these studies is not intended to describe how an evacuation should be carried out or develop procedures for implementing the evacuation. That is a function of the local Civil Defense offices and, as such, is beyond the scope of these work efforts.

The Hurricane Evacuation Study for East Central Florida includes 13 work elements. These work elements provide a basis from which evacuation times may be measured by identifying and quantifying the major factors contributing to the hurricane vulnerability of the region. The major tasks accomplished as part of the program are as follows:

<u>Hazard Analysis</u>

A comprehensive analysis of the potential hurricane hazards to the East Central Florida coastal areas.

<u>Vulnerability Analysis</u>

An identification of the areas of Volusia and Brevard counties vulnerable to specific hurricane hazards.

<u>Population Data</u>

A systematic enumeration of the dwelling units and population within the identified vulnerable areas.

<u>Behavioral Data</u>

A statistically significant investigation of the probable tendencies of potential evacuees.

Surge Roadway Inundation Analysis

An identification of low-lying roadways within vulnerable areas and an analysis of their susceptibility to storm surge inundation.

Shelter Data

An inventory of existing public shelter characteristics and shelter capacity analysis.

Freshwater Roadway Inundation Analysis

An identification of historically inundated roadways from rainfall flooding.

Shelter/Medical Facility Surge Analysis

An analysis of the geographic storm surge vulnerability of existing public shelter structures and hospital/nursing home structures.

Evacuation Zones

A delineation of the vulnerable areas into evacuation zones with common hazard vulnerability and common evacuation routes.

Evacuation Routes

The assignment of evacuation vehicle volumes from specific zones to specific routes to develop optimum intra- and inter-county routing strategies.

Shelter Assignment

The assignment of specific evacuation zones to specific shelters based on evacuation routing strategies and shelter capacities.

Clearance Time

The calculation of vehicle volume traveling times associated with the movement of the enumerated vulnerable population from specific vulnerable evacuation zones to specific evacuation destinations.

Evacuation Time

The formulation of recommendations for the timing of issuing evacuation orders based on all components of evacuation time analyzed.

## HAZARD ELEMENT

### INTRODUCTION

The first step in the development of the Hurricane Evacuation Study is to examine the expected hazards that would require the actual evacuation of residents in Brevard and Volusia counties. This section will identify and analyze the predicted hazards that may be expected to occur based on a number of hypothetical hurricanes which have been simulated by the National Hurricane Center for this Study. Included as part of this analysis are the following: a history of hurricane activity for the coastal areas of East Central Florida; hazards to be considered in the analysis; the methodology used to predict the hazards of probable hurricane events; concepts and assumptions to be utilized in quantifying the hazards; and results of the analysis.

### HISTORY OF HURRICANE ACTIVITY

The basis upon which this Study is to be developed is to plan for the worst probable hurricane events that may impact the East Central Florida coast. As such, it is neither necessary nor appropriate to assign quantitative probabilities to the hypothetical hurricanes considered for analysis. However, the general probability considered in the selection of the hypothetical hurricanes by the National Hurricane Center was based on past historical hurricane activity in this region, in addition to what was found to be meteorologically probable. Such historical activity can be summarized in Table 1 which identifies 16 hurricanes as having passed within 60 nautical miles of the City of Titusville, the center point of the region's coast.

The National Hurricane Center has officially designated the months between June through November as "hurricane season," when the ocean temperatures are at their warmest. Hurricanes will form only over tropical oceans where the water temperature exceeds 79°F. In examining periods of hurricane activity, it should be noted that there are important seasonal changes in the areas of hurricane formation, due to large-scale atmospheric circulation patterns. These patterns include the Bermuda High and the circulation features at upper levels over the western Atlantic and Caribbean regions. Hurricane track charts compiled by NOAA indicate that the majority of the hurricanes formed in June and July develop in the Gulf of Mexico. During August and September, hurricane activity shifts to the Atlantic where most of the storms affecting Florida form east of the Caribbean and approach the State from the southeast. By September and October, weather patterns have shifted again--hurricane formation is focused in the western Caribbean and storms approaching Florida will do so from the southwest. As can be noted in Table 1, the period of greatest

TABLE 1

HURRICANES PASSING WITHIN 60 NAUTICAL MILES OF 28.37 N. 80.41 W.

TITUSVILLE, FL., 1886-1981

| Starting Date | Name* | Closest Point** of Approach (C.P.A.) (Lat.) | Closest Point** of Approach (C.P.A.) (Long.) | Date at C.P.A. | Distance to C.P.A. | Wind Speed*** (Knots per hr.) | Saffir Simpson Scale |
|---|---|---|---|---|---|---|---|
| 8/15/1887 | Not Named | 28.6N | 79.6W | 08/20 | 49.NM | 105 | 3 |
| 08/15/1893 | Not Named | 28.6N | 80.1W | 08/27 | 29.NM | 105 | 3 |
| 09/25/1893 | Not Named | 28.5N | 79.9W | 10/12 | 34.NM | 96 | 2 |
| 09/18/1894 | Not Named | 28.6N | 81.5W | 09/26 | 54.NM | 84 | 2 |
| 10/07/1896 | Not Named | 27.8N | 80.0W | 10/09 | 44.NM | 74 | 1 |
| 08/03/1899 | Not Named | 28.4N | 80.0W | 08/14 | 27.NM | 105 | 3 |
| 10/20/1921 | Not Named | 29.1N | 80.7W | 10/26 | 42.NM | 82 | 1 |
| 11/29/1925 | Not Named | 28.7N | 81.2W | 12/01 | 41.NM | 64 | 1 |
| 07/22/1926 | Not Named | 28.3N | 80.6W | 07/28 | 6.NM | 82 | 1 |
| 08/03/1928 | Not Named | 28.0N | 80.9W | 08/08 | 32.NM | 80 | 1 |
| 07/25/1933 | Not Named | 27.4N | 80.5W | 07/31 | 58.NM | 67 | 1 |
| 08/07/1939 | Not Named | 27.7N | 81.0W | 08/12 | 48.NM | 68 | 1 |
| 08/23/1949 | Not Named | 27.6N | 81.2W | 08/27 | 59.NM | 100 | 3 |
| 10/13/1950 | KING | 28.1N | 81.3W | 10/18 | 44.NM | 71 | 1 |
| 08/20/1964 | CLEO | 28.3N | 80.9W | 08/28 | 19.NM | 70 | 1 |
| 08/25/1979 | DAVID | 28.4N | 80.6W | 09/04 | 5.NM | 85 | 2 |

*Storms were not formally named prior to 1950.
**These columns give location and time of closest approach and distance of storm center to site.
***Maximum sustained wind speed near storm center while storm center is within specified distance from site. This is not necessarily the wind recorded at given site.

frequency of hurricane activity for East Central Florida is the three-month period of August to October. Of the hurricanes passing through this region, 81% have historically occurred during this period.

## HURRICANE HAZARDS

The major characteristic associated with hurricanes is the exceptional amount of energy associated with this type of storm. This energy is capable of generating immense destructive forces that may threaten thousands of coastal residents and hundreds of miles of coastline as it approaches land. This study is primarily concerned with the three major hazards associated with hurricanes: storm surge; high winds; freshwater flooding. Each of these hazards constitutes a major destructive force which may require the evacuation of residents, as well as impede the ability of these residents to safely evacuate. Of these, storm surge has proven to be the most destructive in terms of loss of life. It is estimated that since 1900, 90% of all fatalities in major storms have occurred as a result of saltwater drowning. High winds are also a potentially devastating force, particularly to persons caught outside and to structures such as mobile homes that are not built to specific hurricane resistance codes. To a lesser extent, freshwater flooding from rainfall may also prove dangerous to residents and destructive to property. Heavy rainfall advancing with the hurricane may inundate poorly drained areas and effectively block evacuation routes.

### Storm Surge

For coastal areas, an increase in the ocean's surface level resulting in the inundation of beach areas and low-lying inland areas is the main source of destruction during a hurricane. Storm surges have been recorded as high as 24 feet above MSL (Hurricane Camille, 1969) and extending over 50 miles along the coast. Combined with its breaking waves and the normal astronomical tide which is superimposed onto it, the storm surge acts like a giant bulldozer sweeping everything away in its path. The higher the surge grows over the sea, the more land will be inundated by the propagation of its waters over low-lying land.

The storm surge is the creation of a number of factors occurring within and around the hurricane. Primarily, it is the result of the barometric pressure drop at the eye of the hurricane. The higher pressure exerted on the water surface outside the hurricane center forces water down and into the low pressure area, creating a dome of water. This dome of water is contained by the high winds on the forward side of the hurricane, producing a "damming effect" against the strong winds from the opposite side of the storm. The dome of water is carried with the hurricane as it moves toward land.

The storm surge in any given area is proportional to the pressure drop of the hurricane center. The greater the pressure drop, the higher the storm surge that can be expected. A number of other factors, however, contribute to the propagation of the surge and may reduce it or increase it from what could be expected with the single consideration of pressure. These include: the size and intensity of the storm; its forward speed; angle and position of the storm as it moves toward land; the offshore bottom conditions (depth and slope); the physical configuration of the coastline.

Generally, shallow water off the coast where the hurricane comes ashore increases the surge height. Also, the closer to perpendicular the storm is to the coastline, the higher the expected surge height. Finally, increases in the size of the storm or its forward speed will increase the surge.

As mentioned earlier, the wave setup and astronomical tide are superimposed on the surge and increase its flooding potential. "Wave setup" is a technical term used to refer to the ocean waves generated by the storm. The height of the wave setup is a function of the relative height of the ocean, which is, in turn, a function of the storm surge and astronomical tide. The maximum invasion of the coast will depend not only on the surge heights, but on the daily and monthly tide cycle as well as any tide enhancement (tidal anomaly) resulting from the general disturbance caused by a hurricane. This relationship of the wave invasion to the tide cycle means that a greater threat would be posed by a hurricane which arrived during those portions of the month and the time of day when the gravitational tide is high.

The sand dunes along the coast constitute the primary bulwark against tidal flooding. These dunes are highest in northern Volusia County and southern Brevard County and decrease to the south and north, respectively. Other mitigating factors include onshore vegetation and man-made alterations which contribute to "friction factors" that serve to decrease the areas affected by the flooding.

The value in predicting expected storm surge heights in this Study is twofold. First, the extent of land inundation is primarily determined for the coastal area by the surge height. The movement of a significant surge into the nearshore areas will not only devastate low-lying terrain, but provide a base on which its high waters can be driven further inland by hurricane winds. Second, storm surges may inundate coastal roadways before the eye of the hurricane actually makes landfall. This would render such potential evacuation routes useless to vehicles attempting to leave vulnerable areas.

## High Winds

Wind is the most commonly thought-of hazard associated with a hurricane. Wind speeds may exceed 200 mph, although there are relatively few measurements of sustained wind speeds above 150 mph since most equipment is destroyed or becomes inoperative at extreme wind speeds. The highest wind speeds which have been reliably measured in Florida were those during the hurricane of September 1947. The maximum wind speed averaged over one minute was approximately 155 mph, and the highest five-minute average was 121 mph.

Hurricane force winds are defined as those reaching or exceeding a sustained wind velocity of 74 mph. It should be noted, however, that an increase in force exerted by these winds is not proportional to an increase in the speed. While the wind speed may double, the force of the wind increases fourfold. As an example, Hurricane David had a recorded maximum wind speed of 55 mph over the region. Should a hurricane the strength of Camille impact the region with 220 mph winds, the force would be sixteen times that experienced with Hurricane David.

A hurricane usually weakens very rapidly after moving inland. This weakening is due primarily to the removal of the energy source provided by the warm tropical oceans and the friction exerted by the land surface. With the weakening of the storm, winds are also reduced to the extent that a few miles inland from the coast, windspeeds may only be 60-70% of their speed at the open coast.

Any time wind velocity exceeds 50 mph, damaging effects can be expected. In a high wind, severe damage can result not only from the wind itself, but also from flying debris. While the effects of these winds present a hazard to all residents, mobile home structures are the most vulnerable. A mobile home is necessarily of light-weight construction, with flat roof and sides. Because of these characteristics, high winds can easily destroy it or flying debris severely damage it and cause injury to persons inside. Consequently, the National Weather Service recommends that mobile home residents move to more sound structures prior to the onset of hurricane force winds.

The hazard associated with high wind is not limited to its potential for destruction, but it must also be considered for its ability to interrupt evacuation efforts. Evacuation efforts cannot be safely carried out after the arrival of sustained gale force winds (40 mph). These winds generally arrive several hours before hurricane eye landfall and generally before the arrival of the storm surge.

## Freshwater Flooding

Based on past history, it can be expected that approximately 6-12 inches of rainfall will accompany a hurricane, although no predictive tools are available for determining the rate and geographic distribution of such a phenomenon. While the event of rainfall itself may not necessitate an emergency evacuation of coastal residents, it is significant in two aspects. First, the amount of rainfall largely governs the water level in the Indian, Banana, and Halifax rivers. Extensive rainfall in the weeks preceding a hurricane will result in a high water level in the river basins, requiring less water to overload them and resulting in flooding of lower elevated land areas. Second, in poorly drained areas such rainfall may cause the early inundation of evacuation routes. Intersections or points of major roadways in Brevard and Volusia counties which may experience significant freshwater roadway inundation are listed in Table 2 and illustrated in Figure 1.

## METHODOLOGY

The major device utilized in this study in order to evaluate the potential hazards of a hurricane striking the coast of Volusia or Brevard County is the Special Program to List the Amplitudes of Surges from Hurricanes (SPLASH II). The SPLASH II numerical storm surge prediction model was developed at the Techniques Development Lab of the National Oceanic and Atmospheric Administration (NOAA). SPLASH II is a dynamic computer model which estimates the potential amplitude, extent, and duration of hurricane-produced surges for an entire coastline, resulting from a series of hypothetical hurricane scenarios.

A total of 74 hypothetical hurricane scenarios were developed and simulated by the SPLASH II model. The various storm characteristics, or parameters, which compose the scenarios were selected by surge forecasters and analysts at the National Hurricane Center. The selected parameters were based on actual past history of hurricane activity and are considered to be reasonable and probable predictions of future hurricane activity in Brevard and Volusia counties. The combination of the 74 scenarios which were modeled covers the full spectrum of any hurricane activity which could reasonably be expected to affect the coastline being studied. The parameters which comprise the scenarios include the location of direction of the hurricane track, the size of the hurricane (radius of maximum wind), the speed it is traveling, and the intensity of the hurricane measured by pressure drop and wind velocity. A listing of the 74 hypothetical hurricanes analyzed by SPLASH II appears in Table 3.

To ensure that all probable hurricane events were considered, three different hurricane movements were modeled: landfalling, exiting/crossing; and paralleling. These movements--as well as a representation of point of landfall, closest approach, and angle of approach--are graphically presented in Figures 2, 3, and 4.

The output of the SPLASH II model provides three major types of data on the effects of the simulated hurricanes on East Central Florida. They are as follows:

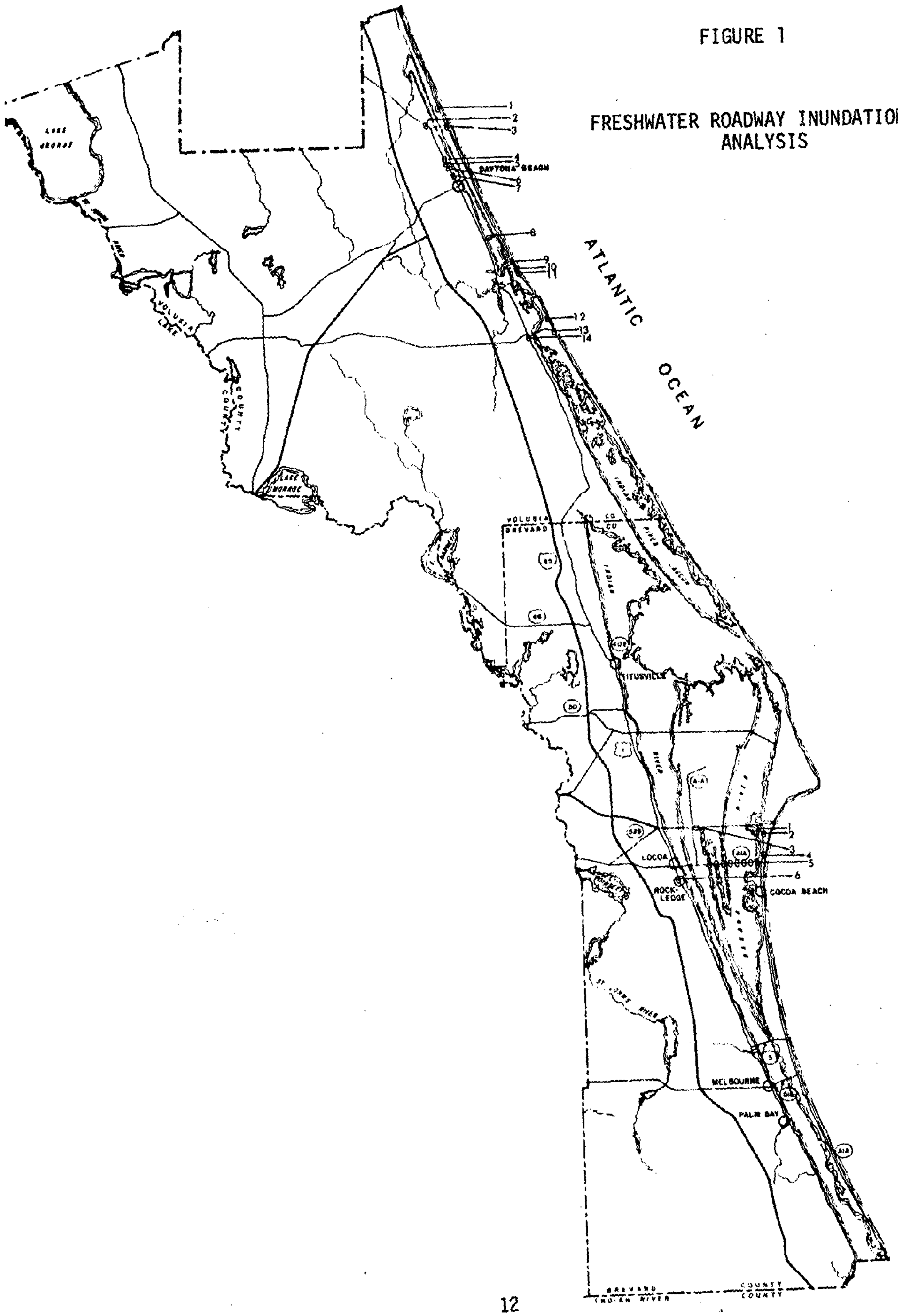
TABLE 2.

FRESHWATER ROADWAY INUNDATION ANALYSIS - SUMMARY

| Site Number | Jurisdiction | Vulnerable Roadway Description |
|---|---|---|
| BREVARD COUNTY | | |
| 1 | Cape Canaveral | A1A at the intersection of Central Blvd. |
| 2 | Cape Canaveral | A1A at the intersection of No. Atlantic Ave. |
| 3 | Brevard County (unincorporated) | Bennett Causeway (SR 528) on Merritt Island along Sykes Creek |
| 4 | Cocoa Beach | A1A at the intersection of Meade Ave. |
| 5 | Brevard County (unincorporated)/ Cocoa Beach | Merritt Island Causeway (SR 520) between A1A and Sykes Creek Pkwy. |
| 6 | Rockledge | US 1 at the intersection of Bougainvillea Dr. |
| VOLUSIA COUNTY | | |
| 1 | Ormond Beach | A1A at the intersection of Neptune Ave. |
| 2 | Ormond Beach | US 1 at the intersection of Hernandez Ave./Yonge St. |
| 3 | Ormond Beach | A1A at the intersection of Bovard Ave. |
| 4 | Holly Hill | US 1 at the intersection of 8th St. |
| 5 | Holly Hill | US 1 at the intersection of 6th St. |
| 6 | Holly Hill | US 1 at the intersection of 2nd St. |
| 7 | Daytona Beach | US 1 at the intersection of Mason Ave. |
| 8 | Port Orange | Western approach of Port Orange Bridge |
| 9 | Ponce Inlet | A1A - 700' north of East Winds condominium |
| 10 | Ponce Inlet | A1A between Katherine Ave. and Oceanview |
| 11 | Ponce Inlet | A1A at the intersection of Inlet Harbor Rd. |
| 12 | New Smyrna Beach | A1A between Lincoln Ave. and Florida St. |
| 13 | New Smyrna Beach | A1A between 4th Ave. and 5th Ave. |
| 14 | New Smyrna Beach | US 1 at the intersection of Lytle Ave. |

FIGURE 1

FRESHWATER ROADWAY INUNDATION ANALYSIS



# TABLE 3

HURRICANES SIMULATED BY SPLASH II
(Special Program to List the Amplitudes of Surges from Hurricanes)

| Type* | Number | Cat. | Landfall/Exiting Pt. or Closest Approach | Area Receiving Max. Surge/Winds | Pressure Drop (Millibars) | Radius of Max. Winds (Statute Mi.) | Forward Speed (in mph) | Direction of Storm** |
|---|---|---|---|---|---|---|---|---|
| L | RS 80 | 1 | Daytona Beach | Ormond-by-the-Sea | 30 | 20 | 12 | 250 |
| L | RS 60 | 1 | Mosquito Lagoon | Daytona Beach | 30 | 20 | 12 | 246 |
| L | RS 40 | 1 | Canaveral Natl.Seashore | New Smyrna Beach | 30 | 20 | 12 | 241 |
| L | RS 20 | 1 | Kennedy Space Ctr. | Mosquito Lagoon | 30 | 20 | 12 | 237 |
| L | LS 00 | 1 | Melbourne | Cape Canaveral | 30 | 20 | 12 | 234 |
| L | LS 20 | 1 | Sebastian Inlet | Melbourne | 30 | 20 | 12 | 230 |
| L | LS 40 | 1 | Vero Beach | Sebastian Inlet | 30 | 20 | 12 | 225 |
| L | RS 80 | 2 | Daytona Beach | Ormond-by-the-Sea | 40 | 20 | 12 | 250 |
| L | RS 60 | 2 | Mosquito Lagoon | Daytona Beach | 40 | 20 | 12 | 246 |
| L | RS 40 | 2 | Canaveral Natl.Seashore | New Smyrna Beach | 40 | 20 | 12 | 241 |
| L | RS 20 | 2 | Kennedy Space Ctr. | Mosquito Lagoon | 40 | 20 | 12 | 237 |
| L | LS 00 | 2 | Melbourne | Cape Canaveral | 40 | 20 | 12 | 234 |
| L | LS 20 | 2 | Sebastian Inlet | Melbourne | 40 | 20 | 12 | 230 |
| L | LS 40 | 2 | Vero Beach | Sebastian Inlet | 40 | 20 | 12 | 225 |
| L | RS 80 | 3 | Daytona Beach | Ormond-by-the-Sea | 60 | 20 | 12 | 250 |
| L | RS 60 | 3 | Mosquito Lagoon | Daytona Beach | 60 | 20 | 12 | 246 |
| L | RS 40 | 3 | Canaveral Natl.Seashore | New Smyrna Beach | 60 | 20 | 12 | 241 |
| L | RS 20 | 3 | Kennedy Space Ctr. | Mosquito Lagoon | 60 | 20 | 12 | 237 |
| L | LS 00 | 3 | Melbourne | Cape Canaveral | 60 | 20 | 12 | 234 |
| L | LS 20 | 3 | Sebastian Inlet | Melbourne | 60 | 20 | 12 | 230 |
| L | LS 40 | 3 | Vero Beach | Sebastian Inlet | 60 | 20 | 12 | 225 |
| L | RS 80 | 4 | Daytona Beach | Ormond-by-the-Sea | 80 | 20 | 12 | 250 |
| L | RS 60 | 4 | Mosquito Lagoon | Daytona Beach | 80 | 20 | 12 | 246 |
| L | RS 40 | 4 | Canaveral Natl.Seashore | New Smyrna Beach | 80 | 20 | 12 | 241 |
| L | RS 20 | 4 | Kennedy Space Ctr. | Mosquito Lagoon | 80 | 20 | 12 | 237 |
| L | LS 00 | 4 | Melbourne | Cape Canaveral | 80 | 20 | 12 | 234 |
| L | LS 20 | 4 | Sebastian Inlet | Melbourne | 80 | 20 | 12 | 230 |
| L | LS 40 | 4 | Vero Beach | Sebastian Inlet | 80 | 20 | 12 | 225 |
| L | RS 80 | 5 | Daytona Beach | Ormond Beach | 100 | 12 | 12 | 250 |
| L | RS 60 | 5 | Mosquito Lagoon | Ponce Inlet | 100 | 12 | 12 | 246 |
| L | RS 40 | 5 | Canaveral Natl.Seashore | Mosquito Lagoon | 100 | 12 | 12 | 241 |
| L | RS 20 | 5 | Kennedy Space Ctr. | Canaveral Natl.Seashore | 100 | 12 | 12 | 237 |
| L | LS 00 | 5 | Melbourne | Cocoa Beach | 100 | 12 | 12 | 234 |
| L | LS 20 | 5 | Sebastian Inlet | Melbourne | 100 | 12 | 12 | 230 |
| L | LS 40 | 5 | Vero Beach | Sebastian Inlet | 100 | 12 | 12 | 225 |
| E | RS 80 | 1 | Daytona Beach | Flagler Beach | 30 | 20 | 12 | 52 |
| E | RS 60 | 1 | Mosquito Lagoon | Daytona Beach | 30 | 20 | 12 | 52 |
| E | RS 40 | 1 | Canaveral Natl.Seashore | New Smyrna Beach | 30 | 20 | 12 | 52 |
| E | RS 20 | 1 | Cape Canaveral | Mosquito Lagoon | 30 | 20 | 12 | 52 |
| E | LS 00 | 1 | Melbourne | Cocoa Beach | 30 | 20 | 12 | 52 |
| E | LS 20 | 1 | Sebastian Inlet | Melbourne | 30 | 20 | 12 | 52 |
| E | LS 40 | 1 | Vero Beach | Sebastian Inlet | 30 | 20 | 12 | 52 |
| E | RS 80 | 2 | Daytona Beach | Flagler Beach | 40 | 20 | 12 | 52 |
| E | RS 60 | 2 | Mosquito Lagoon | Daytona Beach | 40 | 20 | 12 | 52 |
| E | RS 40 | 2 | Canaveral Natl.Seashore | New Smyrna Beach | 40 | 20 | 12 | 52 |
| E | RS 20 | 2 | Cape Canaveral | Mosquito Lagoon | 40 | 20 | 12 | 52 |
| E | LS 00 | 2 | Melbourne | Cocoa Beach | 40 | 20 | 12 | 52 |
| E | LS 20 | 2 | Sebastian Inlet | Melbourne | 40 | 20 | 12 | 52 |
| E | LS 40 | 2 | Vero Beach | Sebastian Inlet | 40 | 20 | 12 | 52 |
| E | RS 80 | 3 | Daytona Beach | Flagler Beach | 60 | 20 | 12 | 52 |
| E | RS 60 | 3 | Mosquito Lagoon | Daytona Beach | 60 | 20 | 12 | 52 |
| E | RS 40 | 3 | Canaveral Natl.Seashore | New Smyrna Beach | 60 | 20 | 12 | 52 |
| E | RS 20 | 3 | Cape Canaveral | Mosquito Lagoon | 60 | 20 | 12 | 52 |
| E | LS 00 | 3 | Melbourne | Cocoa Beach | 60 | 20 | 12 | 52 |
| E | LS 20 | 3 | Sebastian Inlet | Melbourne | 60 | 20 | 12 | 52 |
| E | LS 40 | 3 | Vero Beach | Sebastian Inlet | 60 | 20 | 12 | 52 |

*Key: L = Landfalling Hurricane; E = Exiting/Crossing Hurricane

**Degree Clockwise from North

## TABLE 3 (cont.)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| P | 1 | 20 Mi. West of KSC | Cocoa Beach | 30 | 20 | 12 | 160 to 1 |
| P | 1 | Kennedy Space Ctr. | Daytona Bch/Cocoa Bch | 30 | 20 | 12 | 155 to 5 |
| P | 1 | 20 Mi. East of KSC | Canaveral Natl.Seashore | 30 | 20 | 12 | 150 to 10 |
| P | 1 | 40 Mi. East of KSC | Canaveral Natl.Seashore | 30 | 20 | 12 | 147 to 15 |
| P | 1 | 60 Mi. East of KSC | Canaveral Natl.Seashore | 30 | 20 | 12 | 142 to 25 |
| P | 2 | 20 Mi. West of KSC | Cocoa Beach | 40 | 20 | 12 | 160 to 1 |
| P | 2 | Kennedy Space Ctr. | Daytona Bch/Cocoa Bch | 40 | 20 | 12 | 155 to 5 |
| P | 2 | 20 Mi. East of KSC | Canaveral Natl.Seashore | 40 | 20 | 12 | 150 to 10 |
| P | 2 | 40 Mi. East of KSC | Canaveral Natl.Seashore | 40 | 20 | 12 | 147 to 15 |
| P | 2 | 60 Mi. East of KSC | Canaveral Ntl.Seashore | 40 | 20 | 12 | 142 to 25 |
| P | 3 | 20 Mi. West of KSC | Cocoa Beach | 60 | 20 | 12 | 160 to 1 |
| P | 3 | Kennedy Space Ctr. | Daytona Bch/Cocoa Bch | 60 | 20 | 12 | 155 to 5 |
| P | 3 | 20 Mi. East of KSC | Canaveral Natl.Seashore | 60 | 20 | 12 | 150 to 10 |
| P | 3 | 40 Mi. East of KSC | Canaveral Natl.Seashore | 60 | 20 | 12 | 147 to 15 |
| P | 3 | 60 Mi. East of KSC | Canaveral Natl.Seashore | 60 | 20 | 12 | 142 to 25 |
| P | 4 | 40 Mi. E. of KSC | Canaveral Natl.Seashore | 80 | 20 | 12 | 147 to 15 |
| P | 4 | 60 Mi. E. of KSC | Canaveral Natl.Seashore | 80 | 20 | 12 | 142 to 25 |
| P | 5 | 60 Mi. E. of KSC | Canaveral Natl.Seashore | 100 | 12 | 12 | 142 to 25 |

*Key: P = Paralleling Hurricane

**Degree Clockwise from North

FIGURE 2

LANDFALLING HURRICANES

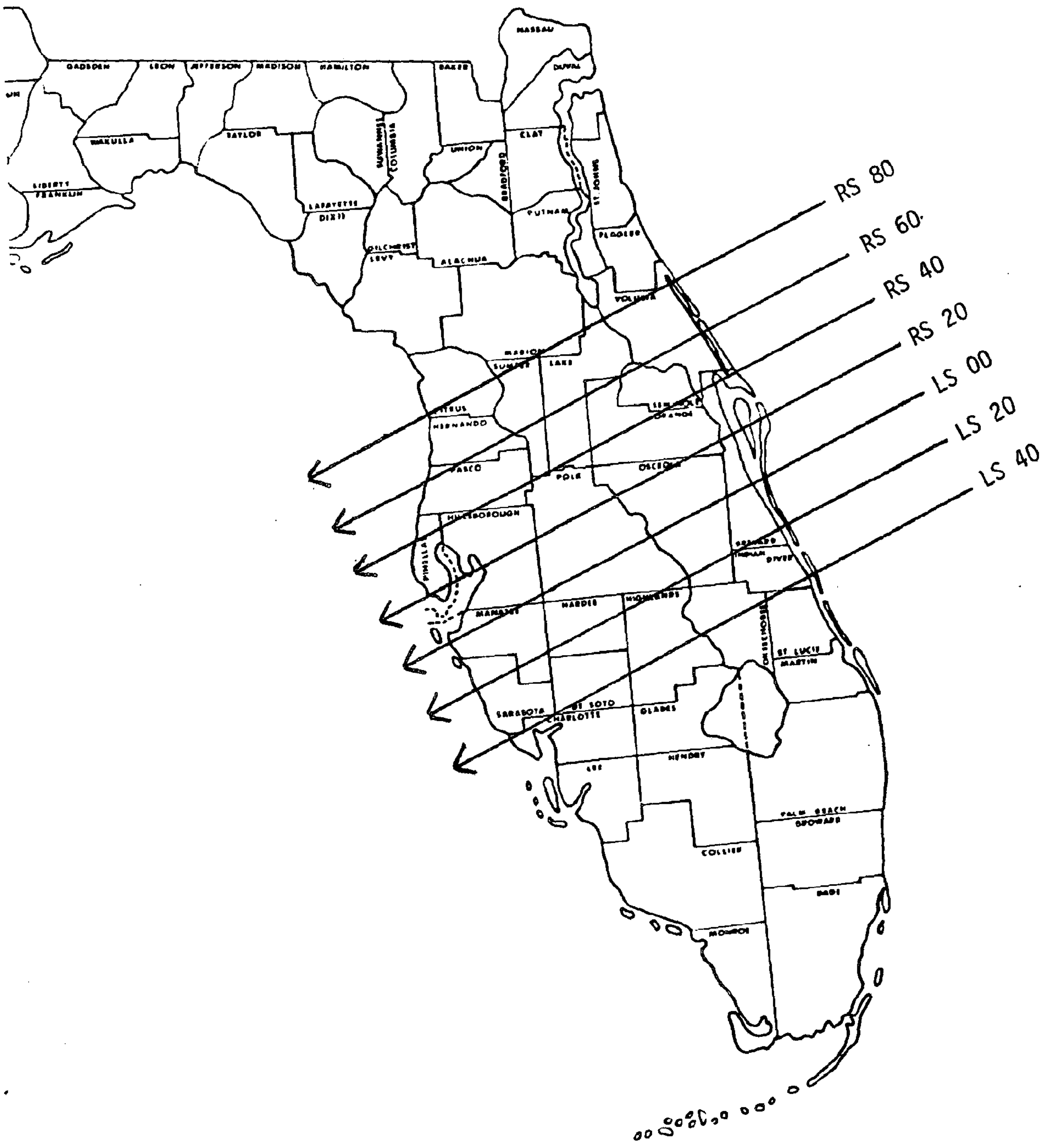


FIGURE 3

CROSSING/EXITING HURRICANES

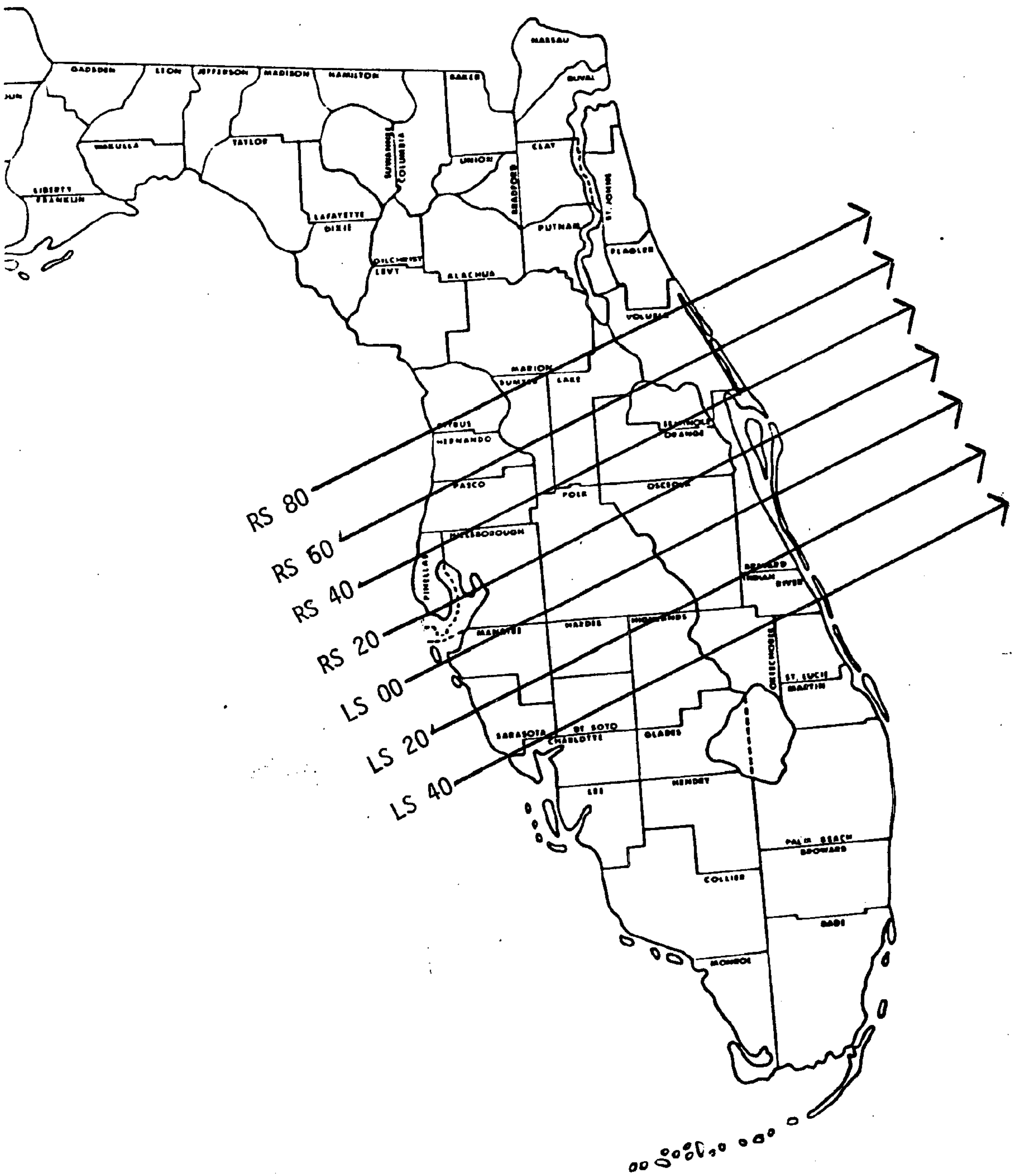
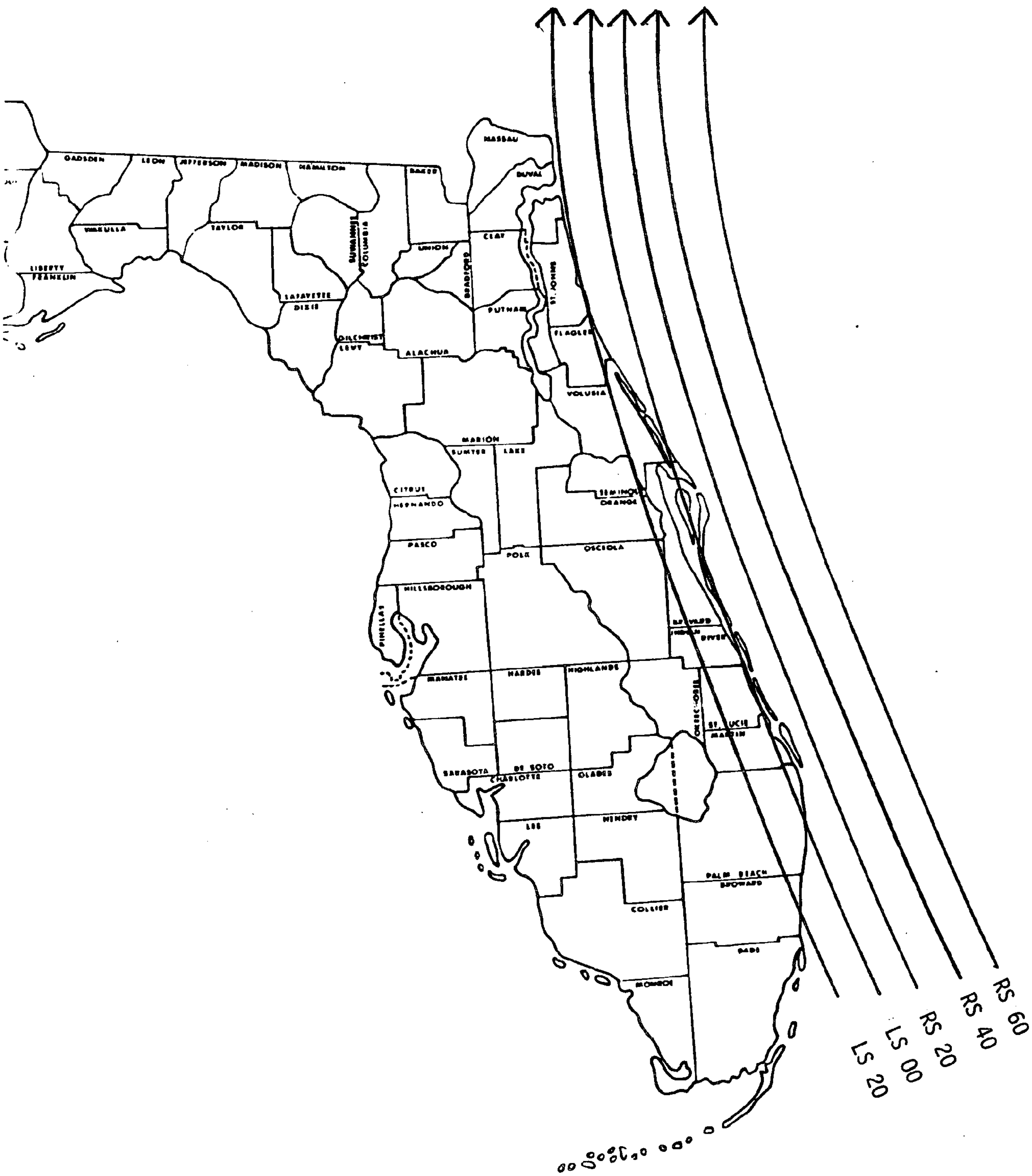


FIGURE 4

PARALLELING HURRICANES



- a surface envelope of expected highest surges for the entire storm duration;
- a space-time plot of surge heights along the coast; and
- a space-time plot of coastal wind speeds.

The results of the SPLASH II model will be used to analyze various factors pertinent to determining evacuation times. First, the envelope of expected surges will be used to determine the extent of probable flooding along the coast for each of the simulated hurricanes. Second, the space-time plot of surge heights (which depicts how high the surge is expected to be at specific locations and when the surge will occur relative to hurricane eye landfall) will be used to determine potential flooding of roadways. Third, the space-time plot of coastal wind speeds will indicate when specific locations can expect the onset of gale-force and hurricane-force winds and the duration of dangerously high winds.

## Concepts and Assumptions

As with any evacuation planning effort that is concerned with the prevention of loss of life, this Study is based on identifying the potential effects resulting from the worst probable hurricane events that may be reasonably expected to impact the region's coast. The hypothetical hurricanes selected and simulated through the SPLASH II model are those which, in addition to being meteorologically probable, are of such an intensity and an angle of approach as to maximize the hazards considered by this Study. By analyzing the worst probable cases, hazards of any potential magnitude will be considered in the planning efforts at both the local and regional levels.

The outputs resulting from the simulation of the worst probable storms provide a means of quantifying the effects of hurricane hazards. The use of these predictive tools begins to address the two primary concerns of this Study, which are: the extent of the areas threatened by a hurricane and requiring evacuation; and the time required for residents in a threatened area to safely evacuate before the life-threatening effects of the hurricane hazards arrive.

In addition to the predictive tools of the SPLASH II model, two general assumptions must also be made to completely address these concerns. As mentioned previously, SPLASH II does not offer any information on the amount of rainfall expected to accompany a hurricane. In addition, the effects of the frictional drag on the velocity of winds as the hurricane moves inland cannot be determined from this model. Therefore, two assumptions to be used in this Study are as follows:

- all mobile home residents should evacuate from the direct approach of a hurricane; and

- o the arrival of rainfall sufficient to flood evacuation routes will generally parallel the arrival of sustained gale force winds.

To illustrate the concepts and assumptions of this Study, Table 4 has been provided which describes the effects of each hazard considered in this Study. It then lists the predictive tool or assumption used to address the effect, the action required to evacuate residents from the effect, and the contribution of each effect to evacuation time. This table is a general illustration of the hazard analysis concept used in the development of regional evacuation studies throughout the State. It has been modified to reflect the use of the SPLASH II computer model.

Input Parameters

As previously discussed, a number of meteorological parameters were selected by the National Hurricane Center staff for inputs into the SPLASH II model. These parameters were directly accessible and amenable to measurement and represent the major variables associated with a hurricane for predicting the storm surge amplitude. As can be noted in Table 3, the input parameters used to compose each hypothetical hurricane included:

- o barometric pressure drop (millibars)
- o storm size (radius of maximum winds)
- o forward speed (miles per hour)
- o direction and landfall/approach angle of track
- o Saffir/Simpson Scale category

The principal parameter concentrated on by the National Hurricane Center in programming the SPLASH II model is the pressure drop of the storm. The peak surge value varies almost linearly with the pressure drop, so that the greater the pressure drop, the higher the expected surge value. As shown on Table 3 for each category of storm modeled, the pressure drop increased--ranging from 20 millibars for a Category 1 storm to 100 millibars for a Category 5 storm. Based solely on this consideration, with other parameters held constant, an increase in the intensity of the storm would be expected to generate a corresponding increase in the storm surge amplitude.

An additional indicator of storm surge amplitude is the radius of maximum winds. This is a secondary consideration to pressure drop in predicting storm surge values, but is, nonetheless, an important factor. From Table 3 it can be noted that most of the hypothetical hurricanes simulated had a storm size of 20 statute miles representing what the National Hurricane Center forecasters considered to be probable for this area. However, the Saffir/Simpson Category 5 hurricanes were all simulated through SPLASH II as having a radius of maximum winds of 12 statute miles. The radius was reduced for this category of hurricane because, in general, Category 5

## TABLE 4

## HAZARD ANALYSIS CONCEPT

| HAZARD | RESPONSE CHARACTERISTIC (objectives) | EFFECT | TOOL OR ASSUMPTION | EVACUATION ACTION | CONTRIBUTION TO EVACUATION TIME |
|---|---|---|---|---|---|
| STORM SURGE | Extent of evacuation | Inundation of land and devastation of structures | SPLASH II and Inland Flooding model: surface envelope of highest surges above MSL | Evacuate all residents within predicted path of storm surge | Clearance time |
| | Timing of evacuation order | Inundation of evacuation routes before eye landfall | SPLASH II and Inland Flooding model: time histories of surges | Evacuate vulnerable residents before predicted inundation of evacuation routes | Pre-landfall hazards time |
| HIGH WINDS | Extent of evacuation | Devastation of structures | Assumption: All mobile home residents should evacuate from hurricane | Evacuate all mobile home residents | Clearance time |
| | Timing of evacuation order | Arrival of sustained gale force winds before eye landfall | SPLASH II: Time histories of computed wind speeds | Evacuate vulnerable residents before predicted arrival of sustained gale force winds | Pre-landfall hazards time |
| RAINFALL | Extent of evacuation | - - - | - - - | - - - | - - - |
| | Timing of evacuation order | Inundation of evacuation routes before eye landfall | Assumption: Torrential rainfall sufficient to inundate evacuation routes will generally parallel the arrival of sustained gale force winds | Evacuate vulnerable residents before predicted arrival of sustained gale force winds | Pre-landfall hazards time |

storms are smaller in size with a more compact storm center. As can be seen in the discussion of the results of the SPLASH II analysis later in this chapter, this reduced storm size was a mitigating factor in the peak surge amplitude of a Category 5 storm.

Forward speed of the storm was also considered in developing the parameters for the model. There exists a critical motion relative to the coast that generates the highest possible surge under any given set of conditions. The critical speed is generally greater than 30 mph. It will be less only with exceptionally small storms or in exceptionally shallow or wide basins. However, storms reaching land rarely attain a critical speed; thus, in order to simplify the model, the National Hurricane Center staff selected a constant speed for all of the hypothetical hurricanes. As shown on Table 3, a forward speed of 12 mph was used in each case, which represented a mean speed for all the hypothetical storms modeled.

Another selection of input parameters focused on the angle of the track on which the hurricane is approaching the coast. Table 3 and Figure 2 show that the hypothetical landfalling hurricanes were simulated as approaching at an $80^{o}$ angle clockwise from the north. While storm surge values would be maximized by a perpendicular ($90^{o}$) landfall angle, this track was determined not to be meteorologically possible for this region.

The final parameter used in producing the hypothetical hurricanes was the intensity of the storm according to the Saffir/Simpson Scale. This scale defines storms according to the sustained speed of hurricane force winds and also describes the expected surge heights associated with each category of storm. Also from Table 3, a description of the categories of storms modeled for each storm movement is available. Briefly, landfalling storms were modeled for category 1-5 storms, exiting storms for category 1-3, and paralleling storms for different categories depending on the location of the storm in relation to the coast.

The height of the storm surge is determined not only by the parameters of the hurricane itself, but also by the local topographic conditions of the area. As mentioned previously, factors involved in that determination include offshore bathymetry, coastline configurations, and astronomical tides.

The offshore bathymetry, or ocean bottom topography, can have either a positive or negative effect on the expected storm surge height. Wide continental shelves with shallow depths of water, as found on the Gulf coast of Florida, will produce higher storm surges than those found on the east coast of Florida with its narrower shelf widths and deeper water. Storm surge heights for different locations will vary somewhat with the surge values described by the Saffir/Simpson Scale due to these unique offshore characteristics. The surge height ranges listed in the Saffir/Simpson Scale are those expected for a "standard basin" which is considered a hypothetical mean for all basins on the Atlantic and Gulf coasts.

Coastline configurations also have a determining effect on expected surge heights, but the effects are less well known. The impact of the two inlets along the East Central Florida coast cannot be determined by the SPLASH II model, although, due to their small size, it is not expected to be substantial. The land configuration of Cape Canaveral does produce a noticeable effect on the storm surge height, which is discussed later in this chapter.

Lastly, astronomical tides can increase an already dangerous situation when both the peak meteorological and astronomical tides occur at nearly the same time. This situation generates larger total surges. As it is impossible to tell if these tides will occur simultaneously, for planning purposes, it is assumed that they will. These tides were superimposed onto expected surge heights in assisting to determine vulnerable areas.

## HAZARD ANALYSIS OUTPUT

As noted earlier, the major outputs produced by SPLASH II include storm surge heights and time histories for surge and winds. For the purposes of this Study, the time histories have been grouped under pre-landfall hazard times which offer quantitative means of determining the amounts of time needed for evacuating threatened areas prior to hurricane eye landfall.

The results of the SPLASH II model are provided for each movement modeled: landfalling, exiting, and paralleling. The surge heights and pre-landfall hazard times associated with each of these movements are presented in the discussion which follows.

### Landfalling Hurricanes

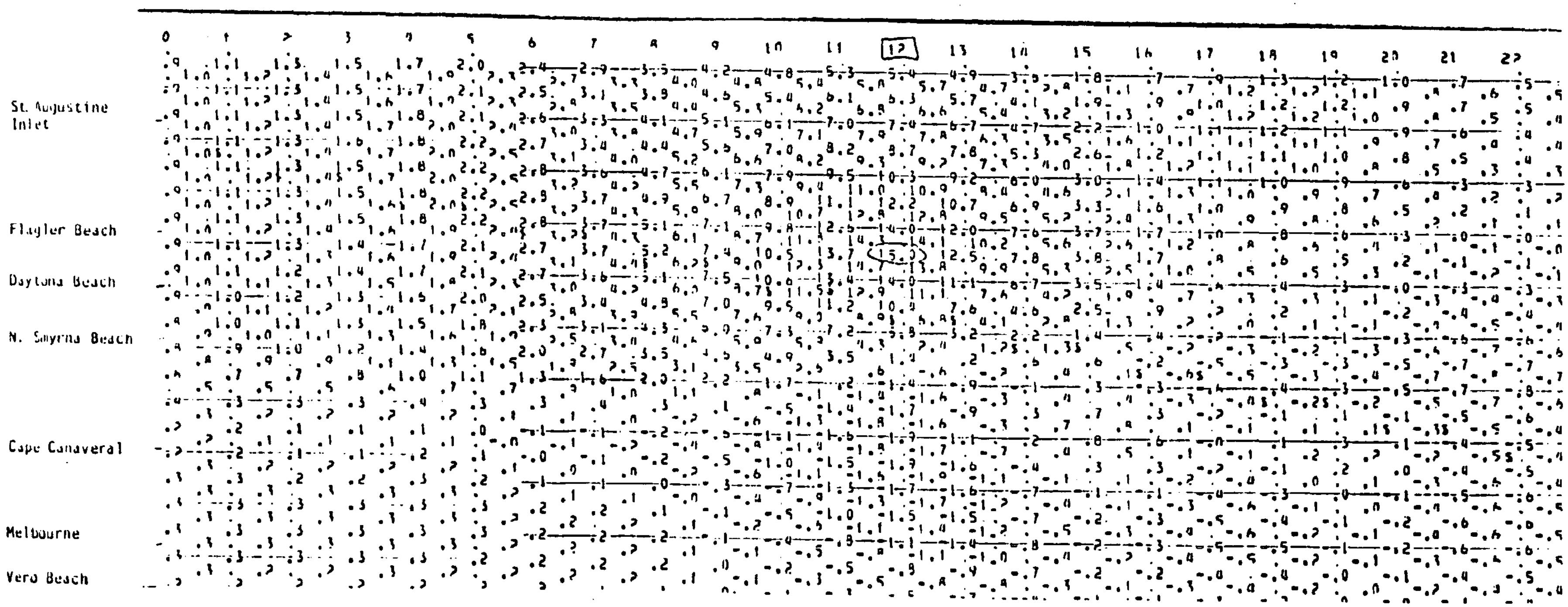
#### Storm Surge

Storms reaching land, traveling near normal to the coast, generate surge profiles that grow with time. The position of the highest surge on the profile remains stationary, eventually reaching its peak surge amplitude at approximately the time of landfall. The surge, however, builds and abates with time, with locations along the coast experiencing their highest surge at different periods. In addition, there are negative surges to the south of where the storm makes landfall. These characteristics are illustrated in Figure 5 which presents a space-time plot of coastal surges for a Category 4 hurricane landfalling 60 miles north of Melbourne (RS 60 on Figure 2). The space-time plot provides a snapshot of tide heights along the coast at half-hour intervals before and after landfall.

To initially assess the inland flooding potential for a hurricane, it is necessary to quantify the peak surge value for each location along the coast, irrespective of time. The curve made up of the highest surges at each point over the entire duration of the storm is provided by the SPLASH

# FIGURE 5

SPACE-TIME PLOT OF COASTAL SURGES



II model as a storm surge envelope. The example of this envelope for the hurricane displayed in Figure 5 is provided in Figure 6.

In examining the storm surge envelope, several points are worth noting that are characteristic of all the landfalling hurricanes modeled. First, the highest surge value always occurs to the north of the point of landfall, due to the counter-clockwise motion of the storm. In the example used above, the storm L4RS60 landfalls just south of New Smyrna Beach but produces the highest surge at Daytona Beach. Second, storm surge values increase rapidly to the south of eye landfall and fall off gradually to the north once again. This is the result of the counter-clockwise motion of the storm aided by the "damming effect" of the high winds within the hurricane. Third, as evident from the surge envelope, a hurricane will produce various peak surge values along the coastline. While a 15.1-foot surge can be expected at Daytona Beach for the particular storm mentioned above, the peak surge experienced at Cape Canaveral is less than 1 foot.

The different surge values produced by a storm have a particular relevance to this Study. As a storm approaches land, it is necessary for disaster preparedness officials to be able to assess the impacts from a hurricane that may pass close by, but not directly over, their county. In the case of Brevard and Volusia counties, with their long coastlines, it is also necessary to determine what the effect of a storm striking one part of the county will have on the other part. Table 5 provides information on the expected surge levels that may be expected along the coastline for each of the landfalling hurricanes modeled. This table illustrates which storm tracks will create tidal flooding problems for particular sections along the region's coastal areas.

As can be noted from Table 5, landfalling hurricanes simulated as approaching at an $80^{o}$ angle (worst possible) resulted in a peak surge height of 15.5 feet at the worst single point for the worst probable storm event, a Category 5 storm. The more likely flooding, however, results from a Category 1 or 2 storm, producing a peak surge amplitude of less than 8 feet. A storm surge profile graphically illustrating the peak surge values predicted for each category of storm is provided in Figure 7.

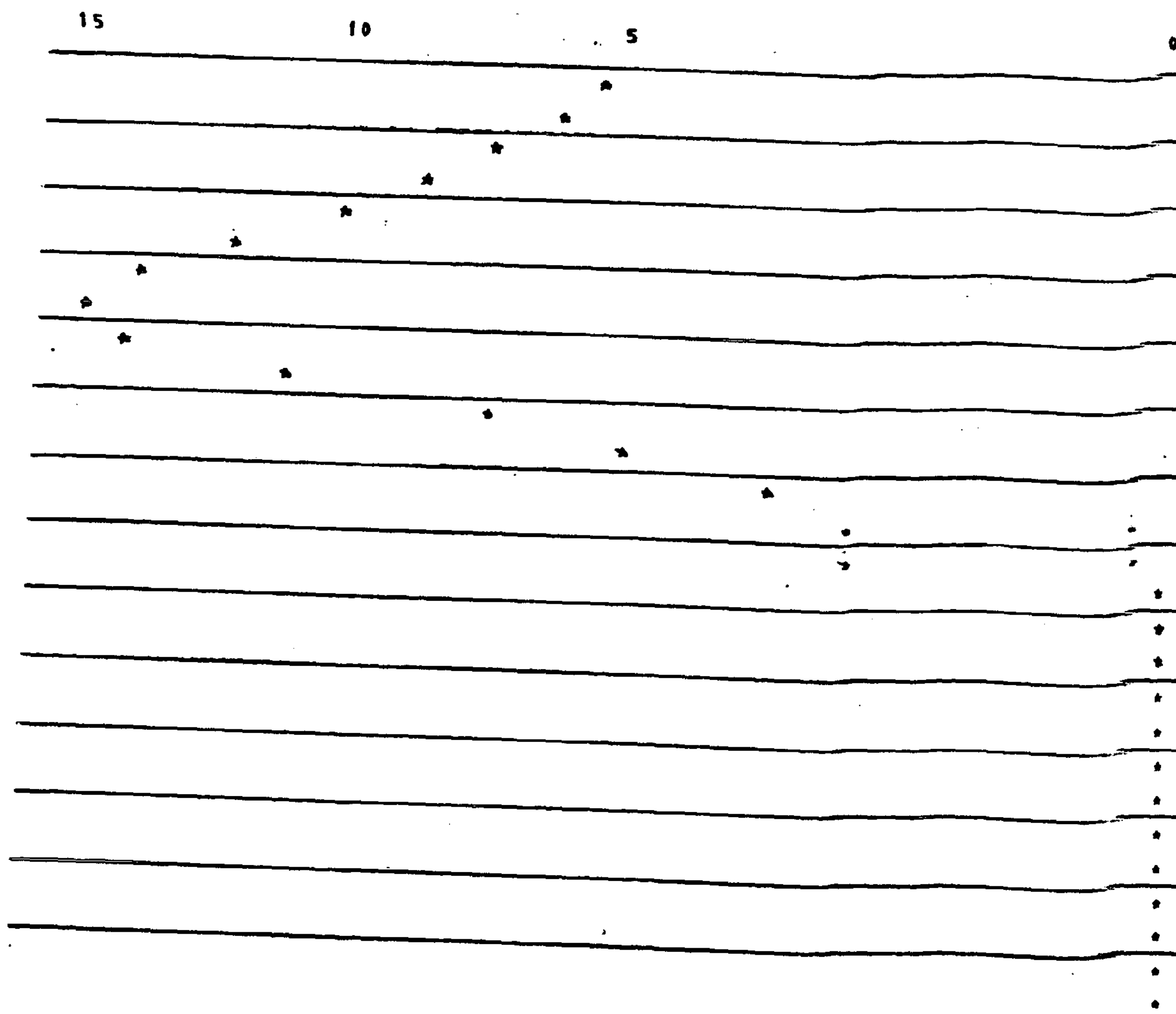
When compared to typical tidal flooding heights expected by the Saffir/Simpson Scale, values for storm surges in the region are similar, although they usually fall within the lower end of the Scale. This is particularly true for Brevard County. The lower values are explained by the relatively low shoaling factor along the East Central Florida coast, which ranges from 0.67 in south Brevard County to 0.85 in north Volusia County. The shoaling factor is a measurement of the slope of the offshore bathymetry and is a function of the width of the continental shelf. This shelf is relatively narrow along the region's coast when compared to the rest of the coastline along the Atlantic and Gulf coasts.

The shoaling factor also explains the noticeable rise in storm surge values the further north a hurricane makes landfall. The continental shelf width

FIGURE 6
STORM SURGE ENVELOPE FOR HURRICANE DISPLAYED IN FIGURE 5

Nearest approach of storm to basin center is-----------111 miles, on Thur., 9/2/82, at 12 hours
The basin's center is located-------------------------- 0 miles to the left of Vero Beach
Initial, closest approach & final pressure drops are--- 60.0 60.0 41 mbs, respectively
Initial, closest approach & final storm sizes are------ 20.0 20.0 25 statute miles, respectively

Storm
Storm Surge Heights (feet)




| | | | |
|---|---|---|---|
| 5.4 | 160. | ST AUG INL | 1200LST |
| 6.3 | | | 1200LST |
| 7.4 | | | 1200LST |
| 8.7 | | | 1200LST |
| 10.3 | | FLGLR BCH | 1200LST |
| 12.2 | 120. | | 1200LST |
| 14.0 | | OTONA BCH | 1200LST |
| 15.1 | | | 1200LST |
| 14.2 | | N SMYRNA B | 1200LST |
| 11.3 | | | 1100LST |
| 7.4 | 80. | | 1000LST |
| 5.0 | | | 1000LST |
| 2.2 | | | 0900LST |
| 0.7 | | CP CANAVRL | 1500LST |
| 0.8 | | | 1500LST |
| 0.3 | 40. | | 1600LST |
| 0.3 | | MELBOURNE | 0000LST |
| 0.3 | | | 0000LST |
| 0.3 | | | 0000LST |
| 0.3 | | | 0000LST |
| 0.3 | 0. | VERO BEACH | 0000LST |
| 0.2 | | ~~FT PRC INL~~ | 0000LST |
| 0.2 | | | 0000LST |
| 0.2 | | | 2000LST |
| 0.3 | | | 1600LST |
| 0.3 | -40. | HOBE SOUND | 1600LST |
| 0.3 | | | 1600LST |
| 0.3 | | | 1600LST |

# TABLE 5

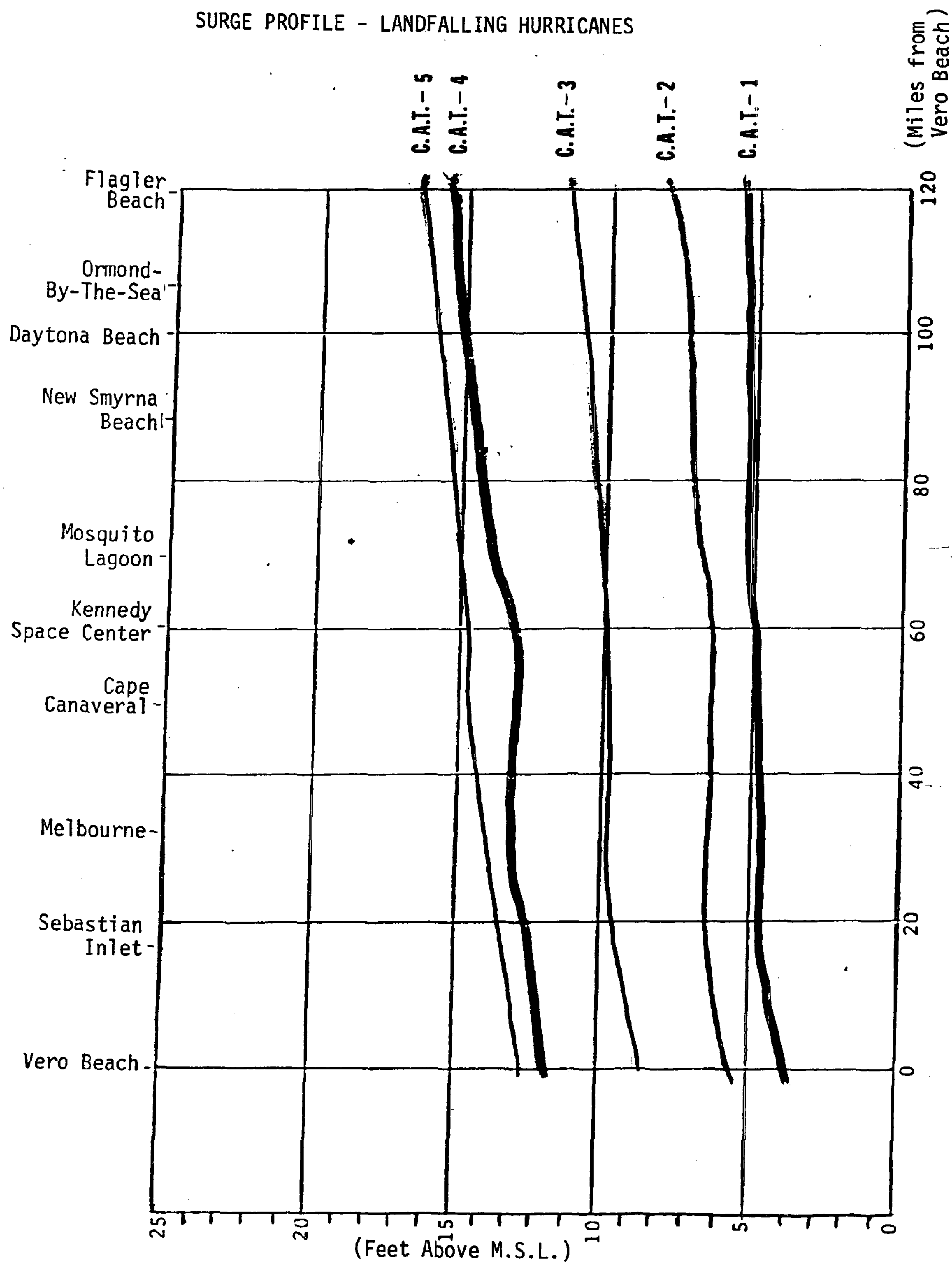
STORM SURGE HEIGHTS AT SELECTED POINTS

Normal Landfalling Hurricanes

| HURRICANE | Sebastian Inlet | Melbourne | Cape Canaveral | Mosquito Logoon | New Smyrna Beach | Daytona Beach | Ormond By The Sea |
|---|---|---|---|---|---|---|---|
| L1RS80 | .2 | .1 | .5 | 1.3 | 2.7 | 4.8 | 5.5 |
| L1RS60 | .2 | .2 | 1.0 | 2.8 | 5.1 | 5.4 | 5.0 |
| L1RS40 | .3 | .3 | 2.2 | 5.1 | 5.3 | 4.8 | 4.1 |
| L1RS20 | .5 | .6 | 4.8 | 5.0 | 3.7 | 2.5 | 1.8 |
| L1LS00 | 1.1 | 2.6 | 4.5 | 2.7 | 1.9 | 1.4 | 1.2 |
| L1LS20 | 3.6 | 4.7 | 3.2 | 1.6 | 1.2 | .9 | .9 |
| L1LS40 | 4.5 | 3.3 | 1.5 | 1.0 | .8 | .7 | .7 |
| L2RS80 | .2 | .2 | .6 | 1.7 | 3.5 | 6.5 | 7.4 |
| L2RS60 | .2 | .2 | 1.2 | 3.7 | 6.9 | 7.3 | 6.8 |
| L2RS40 | .4 | .3 | 3.0 | 6.9 | 7.1 | 5.5 | 4.6 |
| L2RS20 | .6 | .8 | 4.0 | 6.7 | 4.9 | 3.4 | 2.5 |
| L2LS00 | 1.4 | 3.5 | 6.1 | 3.6 | 2.6 | 1.9 | 1.7 |
| L2LS20 | 4.9 | 6.3 | 4.2 | 2.1 | 1.6 | 1.3 | 1.1 |
| L2LS40 | 6.1 | 4.4 | 2.6 | 1.4 | 1.1 | .9 | .9 |
| L3RS80 | .2 | .2 | .8 | 2.5 | 5.3 | 9.9 | 11.3 |
| L3RS60 | .3 | .3 | 1.7 | 5.6 | 10.6 | 11.2 | 10.4 |
| L3RS40 | .4 | .4 | 4.4 | 10.5 | 10.9 | 8.4 | 5.9 |
| L3RS20 | .9 | 1.0 | 9.9 | 10.4 | 6.3 | 4.4 | 3.8 |
| L3LS00 | 2.1 | 5.3 | 9.4 | 6.9 | 4.6 | 3.3 | 2.5 |
| L3LS20 | 7.5 | 9.6 | 5.1 | 3.3 | 2.5 | 1.9 | 1.7 |
| L3LS40 | 9.3 | 6.8 | 3.1 | 2.1 | 1.7 | 1.4 | 1.3 |
| L4RS80 | .3 | .2 | .9 | 3.2 | 7.0 | 13.3 | 15.2 |
| L4RS60 | .3 | .3 | 2.2 | 7.4 | 14.2 | 15.1 | 14.0 |
| L4RS40 | .5 | .5 | 5.9 | 14.2 | 14.7 | 11.4 | 8.0 |
| L4RS20 | 1.0 | 1.4 | 8.2 | 13.9 | 10.2 | 7.0 | 5.0 |
| L4LS00 | 2.7 | 7.2 | 12.6 | 9.3 | 6.2 | 4.5 | 3.4 |
| L4LS20 | 10.1 | 13.0 | 8.7 | 5.3 | 3.8 | 2.9 | 2.3 |
| L4LS40 | 12.5 | 9.1 | 5.3 | 3.4 | 2.6 | 2.1 | 1.8 |
| L5RS80 | .3 | .5 | .5 | 1.3 | 4.9 | 15.5 | 15.5 |
| L5RS60 | .3 | .3 | .5 | 3.1 | 15.0 | 14.5 | 10.4 |
| L5RS40 | .4 | .5 | 1.7 | 15.1 | 13.1 | 7.9 | 4.9 |
| L5RS20 | .7 | 1.0 | 14.4 | 11.8 | 6.7 | 4.3 | 2.9 |
| L5LS00 | 1.5 | 8.5 | 13.1 | 5.7 | 3.5 | 2.4 | 1.7 |
| L5LS20 | 11.6 | 13.6 | 8.1 | 2.9 | 1.9 | 1.4 | 1.2 |
| L5LS40 | 13.0 | 7.8 | 4.3 | 1.7 | 1.3 | 1.1 | .9 |

FIGURE 7

SURGE PROFILE - LANDFALLING HURRICANES



increases toward the north and is responsible for increasing the storm surge height almost 3 feet for a Category 4 hurricane. The effect of the shoaling factor is also evident in the values produced by storms landfalling near Cape Canaveral. The extension of the Cape into open water decreases the availability of shelf space, resulting in deeper water and less of a slope. This tends to decrease the surge amplitude in the Cape's vicinity.

As discussed earlier, a small storm size (12 statute miles radius of maximum winds instead of 20 statute miles) was selected for the simulation of all Category 5 hurricanes. As shown on Figure 7, the step increase in surge heights from a Category 1, 2, 3, and 4 storm did not take place with a Category 5 storm. This resulted in a Category 5 storm producing a surge less than one foot higher than a comparable Category 4 storm. The divergence from the expected step increase is due to the existence of a critical storm size, for a given storm speed, that generates an upper maximum surge. The size is generally thought to be a radius of maximum winds of 30 miles. With all other storm parameters remaining constant, any storm size greater or less than this results in a decreased surge value. This explains why--when the storm speed is held constant--the surge values for a Category 4 storm with a radius of maximum winds of 20 statute miles were similar to the surge heights of a Category 5 storm having a radius of maximum winds of 12 statute miles.

## Pre-Landfall Hazard Times

In general, the build-up of the storm surge heights along the East Central Florida coastline occurs gradually, followed by a rapid increase immediately preceding eye landfall. Peak surge heights are reached approximately at the time of landfall and then decrease rapidly. Categories 1-5 hurricanes analyzed by the SPLASH II model showed the arrival of significant surge heights to occur as follows:

| | Hours before Landfall |
|---|---|
| Category 1 | 1-2 hours |
| Category 2 | 2-3 hours |
| Category 3 | 3-4 hours |
| Category 4 | 4-5 hours |
| Category 5 | 3-4 hours |

These times were based on the rise of the ocean surface to 4 feet above MSL. It is assumed, due to the elevation of the coastline, that no significant flooding would occur prior to the increase in these heights.

The other major output for the SPLASH II model consists of time histories of wind speed for selected points along the coast. As with the time histories of surges, the output affords a quantitative means of assessing pre-eye landfall hazard times. Figure 8 graphically illustrates the

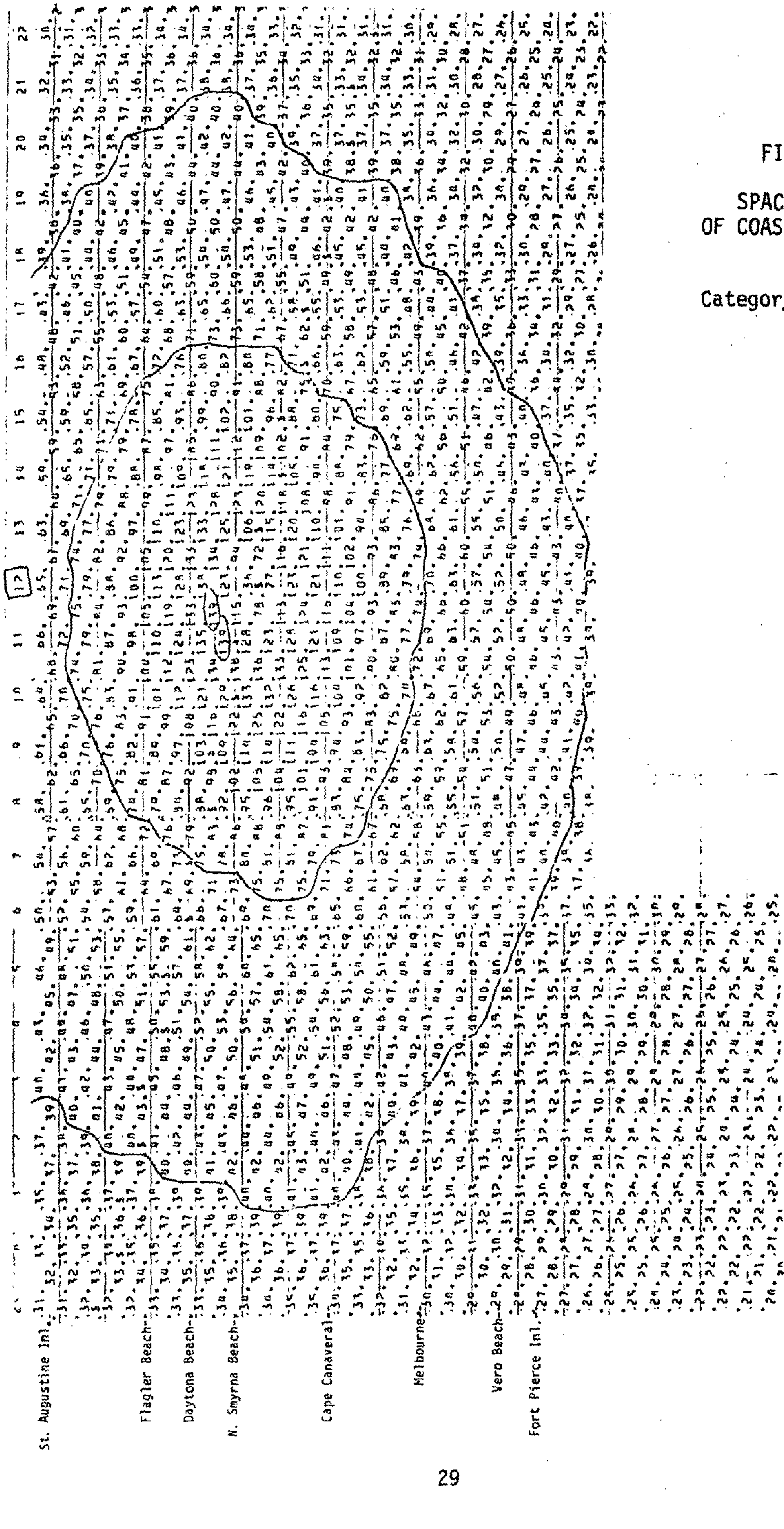



FIGURE 8

SPACE-TIME PLOT
OF COASTAL WIND SPEED

Category 4 - Normal
Landfalling

relation of hurricane force winds and gale force winds to the hurricane eye.

The analysis of the SPLASH II histories for landfalling hurricanes revealed that sustained gale force winds could be expected to arrive at certain points along the coast up to 11.5 hours before eye landfall. This is well in advance of expected surge heights. For all storms modeled, the average arrival time for gale force winds was 8 to 10 hours prior to landfall. A Category 4 hurricane, because of its size, produces the earliest arrival of these winds. A full description of the pre-eye landfall wind times for each category of storm is provided in Table 6.

## Exiting Hurricanes

### Storm Surge

Like landfalling hurricanes, exiting storms generate surge profiles that grow with time. However, as the storm is initially passing over land, there is only limited time to form the storm surge in the vicinity of the coast and, consequently, there is a lower potential to develop significant surges at the coast.

The storm profile developed for exiting storms is provided in Figure 9. In referring to the profile it can be noted that the peak surges are substantially less than those produced by a landfalling storm. The maximum surge height generated by a Category 3 exiting storm is only 5.8 feet. Storms for categories 4 and 5 were not modeled, based on the assumption that storms of this magnitude striking the west coast of Florida would be of reduced intensity when reaching the east coast.

### Pre-Landfall Hazard Time

With the smaller storm surge values associated with exiting storms, it is expected that the arrival of significant storm surge heights would occur almost simultaneously with the arrival of the storm center. The time histories of surge heights provided by the SPLASH II model seem to bear this out. These times are shown as follows:

| | Hours Before Arrival of Storm Center |
|---|---|
| Category 1 | 0 |
| Category 2 | 0 |
| Category 3 | 1-1.5 |

The analysis of the time histories of wind speeds for exiting storms revealed that the arrival of sustained gale force winds for exiting storms is similar to that of landfalling hurricanes. One importance difference, however, is that a Category 3 exiting storm produces gale force winds at the same time as a Category 4 landfalling storm--approximately 11.5 hours

TABLE 6

HURRICANE HAZARDS FOR MODELED STORMS



| DESCRIPTION OF HURRICANE | MAXIMUM SURGE HEIGHT | GALE FORCE WINDS Extent | GALE FORCE WINDS Arrival Time* | HURRICANE FORCE WINDS Extent | HURRICANE FORCE WINDS Arrival Time* |
|---|---|---|---|---|---|
| NORC1RS080 | 5.4 | 120 miles | 6 | 40 miles | 2.5 |
| NORC1RS060 | 5.4 | 140 miles | 6 | 40 miles | 2.5 |
| NORC1RS040 | 5.3 | 120 miles | 6 | 60 miles | 2.5 |
| NORC1RS020 | 5.0 | 120 miles | 6.5 | 40 miles | 3 |
| NORC1LS000 | 4.5 | 120 miles | 7 | 40 miles | 2.5 |
| NORC1LS020 | 4.7 | 120 miles | 6 | 40 miles | 2.5 |
| NORC1LS040 | 4.5 | 140 miles | 6.5 | 40 miles | 2.5 |
| NORC1LS060 | 4.2 | 140 miles | 6 | --- | --- |
| NORC1LS080 | 3.6 | 160 miles | 6 | --- | --- |
| NORC2RS080 | 7.3 | 120 miles | 7.5 | 60 miles | 3 |
| NORC2RS060 | 7.3 | 140 miles | 7.5 | 60 miles | 3 |
| NORC2RS040 | 7.1 | 160 miles | 7.5 | 60 miles | 3.5 |
| NORC2RS020 | 6.7 | 160 miles | 8 | 60 miles | 3.5 |
| NORC2LS000 | 6.0 | 160 miles | 8 | 60 miles | 3.5 |
| NORC2LS020 | 6.3 | 160 miles | 7.5 | 60 miles | 3.5 |
| NORC2LS040 | 6.1 | 160 miles | 7.5 | 80 miles | 3.5 |
| NORC2LS060 | 5.6 | 160 miles | 7.5 | --- | --- |
| NORC2LS080 | 4.8 | 160 miles | 7.5 | --- | --- |
| NORC2LS100 | 3.6 | 160 miles | 7.5 | --- | --- |
| NORC3RS080 | 11.2 | 160 miles | 9.5 | 100 miles | 4.5 |
| NORC3RS060 | 11.2 | 160 miles | 9.5 | 100 miles | 4.5 |
| NORC3RS040 | 10.9 | 180 miles | 9.5 | 140 miles | 4.5 |
| NORC3RS020 | 10.4 | 200 miles | 10 | 100 miles | 5 |
| NORC3LS000 | 9.2 | 200 miles | 10 | 100 miles | 5 |
| NORC3LS020 | 9.6 | 200 miles | 9.5 | 100 miles | 4.5 |
| NORC3LS040 | 9.4 | 200 miles | 9.5 | 100 miles | 4.5 |
| NORC3LS060 | 8.6 | 220 miles | 9.5 | 100 miles | 4.5 |
| NORC3LS080 | 7.4 | 240 miles | 9.5 | --- | --- |
| NORC3LS100 | 5.5 | 220 miles | 9.5 | --- | --- |
| NORC4RS080 | 15.1 | 180 miles | 11 | 120 miles | 5.5 |
| NORC4RS060 | 15.0 | 180 miles | 11 | 120 miles | 5.5 |
| NORC4RS040 | 14.7 | 200 miles | 11 | 140 miles | 5.5 |
| NORC4RS020 | 13.9 | 220 miles | 11.5 | 120 miles | 6 |
| NORC4LS000 | 12.4 | 240 miles | 11.5 | 120 miles | 6 |
| NORC4LS020 | 12.9 | 240 miles | 11 | 120 miles | 5.5 |
| NORC4LS040 | 12.6 | 240 miles | 11 | 120 miles | 5.5 |
| NORC4LS060 | 11.5 | 260 miles | 11 | 120 miles | 5.5 |
| NORC4LS080 | 10.0 | 240 miles | 11 | 120 miles | 5.5 |
| NORC4LS100 | 7.2 | 240 miles | 11.5 | --- | --- |
| NORC5RS080 | 14.3 | 140 miles | 8.5 | 100 miles | 4 |
| NORC5RS060 | 15.0 | 160 miles | 8.5 | 80 miles | 4 |
| NORC5RS040 | 15.1 | 180 miles | 8.5 | 100 miles | 4 |
| NORC5RS020 | 13.8 | 180 miles | 8.5 | 80 miles | 4.5 |
| NORC5LS000 | 13.1 | 180 miles | 9 | 100 miles | 4.5 |
| NORC5LS020 | 13.6 | 180 miles | 8.5 | 80 miles | 4 |
| NORC5LS040 | 13.0 | 180 miles | 8.5 | 80 miles | 4.5 |
| NORC5LS060 | 12.4 | 200 miles | 8 | 100 miles | 4 |
| NORC5LS080 | 9.1 | 200 miles | 8 | --- | --- |
| NORC5LS100 | 6.9 | 200 miles | 8.5 | --- | --- |
| CRSC1RS080 | 2.7 | 140 miles | 6.5 | 40 miles | 2.5 |
| CRSC1RS060 | 2.6 | 140 miles | 7 | 40 miles | 2.5 |
| CRSC1RS040 | 2.6 | 140 miles | 7.5 | 40 miles | 3.5 |
| CRSC1RS020 | 2.4 | 140 miles | 7.5 | 40 miles | 3.5 |
| CRSC1LS000 | 2.4 | 140 miles | 6.5 | 60 miles | 2.5 |
| CRSC1LS020 | 2.4 | 140 miles | 6.5 | 40 miles | 2.5 |
| CRSC1LS040 | 2.2 | 160 miles | 7 | --- | --- |
| CRSC1LS060 | 2.1 | 160 miles | 7.5 | --- | --- |

*number of hours before eye landfall

## TABLE 6 (cont.)

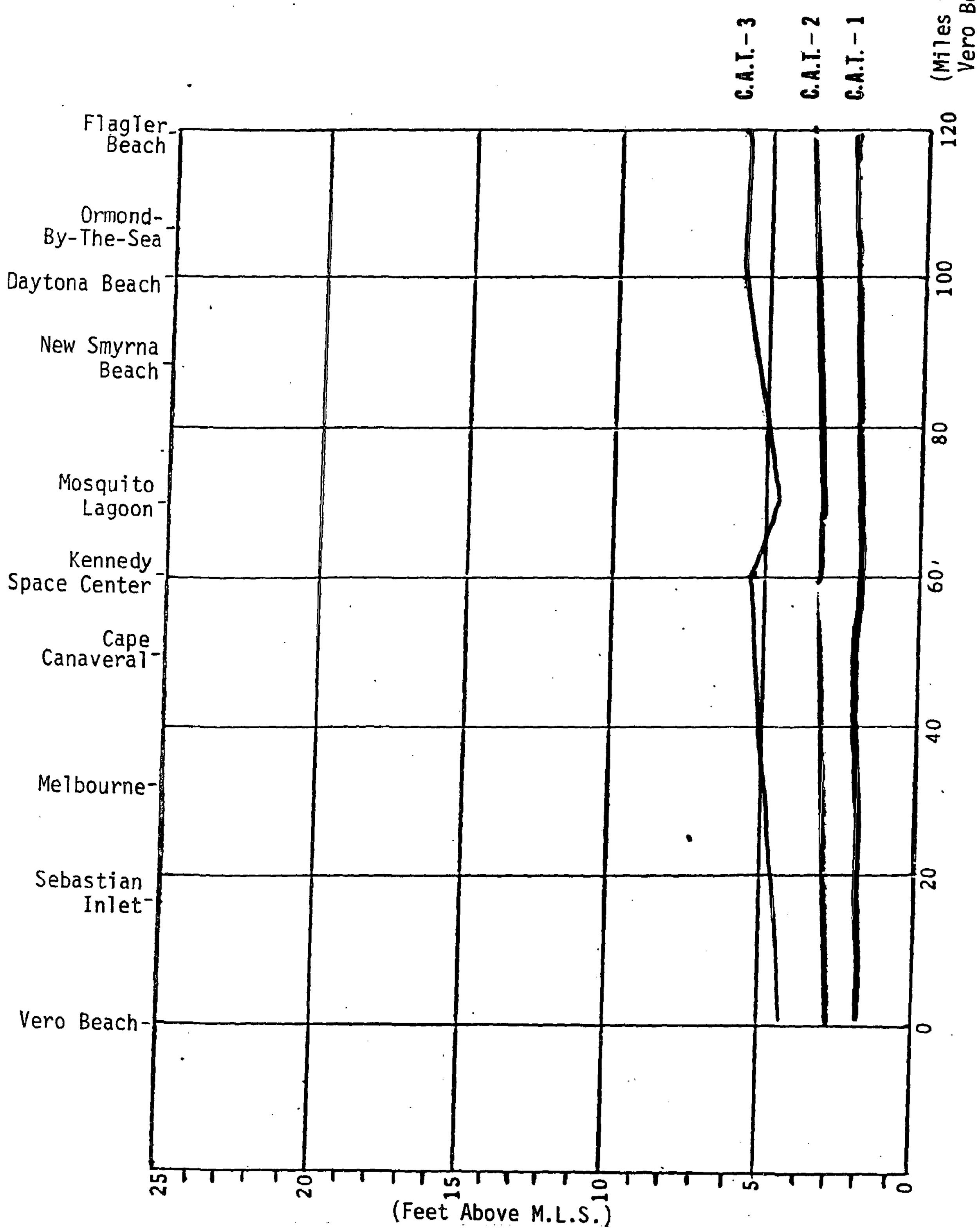


| DESCRIPTION OF HURRICANE | MAXIMUM SURGE HEIGHT | GALE FORCE WINDS Extent | GALE FORCE WINDS Arrival Time* | HURRICANE FORCE WINDS Extent | HURRICANE FORCE WINDS Arrival Time* |
|---|---|---|---|---|---|
| CRSC2RS080 | 3.7 | 160 miles | 7.5 | 60 miles | 3.5 |
| CRSC2RS060 | 3.7 | 180 miles | 8.5 | 60 miles | 3.5 |
| CRSC2RS040 | 3.6 | 160 miles | 9 | 80 miles | 4.5 |
| CRSC2RS020 | 3.4 | 160 miles | 8.5 | 80 miles | 4.5 |
| CRSC2LS000 | 3.3 | 160 miles | 8 | 60 miles | 3.5 |
| CRSC2LS020 | 3.3 | 160 miles | 8 | 60 miles | 3.5 |
| CRSC2LS040 | 3.1 | 200 miles | 8.5 | 60 miles | 3.5 |
| CRSC2LS060 | 2.9 | 200 miles | 9.5 | --- | --- |
| CRSC2LS080 | 2.7 | 200 miles | 11 | --- | --- |
| CRSC3RS080 | 6.0 | 180 miles | 10 | 100 miles | 4.5 |
| CRSC3RS060 | 5.9 | 200 miles | 10.5 | 100 miles | 5 |
| CRSC3RS040 | 5.8 | 220 miles | 11 | 100 miles | 5.5 |
| CRSC3RS020 | 5.4 | 240 miles | 10.5 | 100 miles | 5.5 |
| CRSC3LS000 | 5.3 | 220 miles | 10 | 100 miles | 5 |
| CRSC3LS020 | 5.2 | 240 miles | 10 | 100 miles | 5 |
| CRSC3LS040 | 4.9 | 240 miles | 11.5 | 100 miles | 5 |
| CRSC3LS060 | 4.6 | 240 miles | 13 | 100 miles | 5 |
| CRSC3LS080 | 4.2 | 220 miles | 14 | --- | --- |
| CRSC3LS100 | 3.1 | 200 miles | 14 | --- | --- |
| | / Max. Wind Speed | | | | |
| PARC1RS060 | 1.2 / 49 mph | 60 miles | 1 | --- | --- |
| PARC1RS040 | 2.0 / 65 mph | 100 miles | 3 | --- | --- |
| PARC1RS020 | 3.1 / 79 mph | 120 miles | 4.5 | --- | --- |
| PARC1LS000 | 3.0 / 85 mph | 140 miles | 5.5 | 20 miles | 2 |
| PARC1LS020 | 2.4 / 85 mph | 140 miles | 5.5 | 60 miles | 2 |
| PARC2RS060 | 1.5 / 59 mph | 100 miles | 2.5 | --- | --- |
| PARC2RS040 | 2.8 / 77 mph | 120 miles | 4 | --- | --- |
| PARC2RS020 | 4.2 / 92 mph | 140 miles | 5.5 | 40 miles | 1 |
| PARC2LS000 | 4.3 / 98 mph | 160 miles | 6 | 80 miles | 2 |
| PARC2LS020 | 3.3 / 98 mph | 160 miles | 7 | 80 miles | 3 |
| PARC3RS060 | 2.5 / 74 mph | 160 miles | 5 | --- | --- |
| PARC3RS040 | 4.4 / 97 mph | 120 miles | 6 | 60 miles | 1.5 |
| PARC3RS020 | 6.7 / 108 mph | 200 miles | 7.5 | 80 miles | 2.5 |
| PARC3LS000 | 6.9 / 120 mph | 220 miles | 8 | 100 miles | 3.5 |
| PARC3LS020 | 5.1 / 120 mph | 220 miles | 9 | 100 miles | 4 |
| PARC4RS040 | 6.0 / 115 mph | 200 miles | 8 | 80 miles | 2 |
| PARC4RS060 | 3.4 / 87 mph | 200 miles | 7 | 40 miles | with storm center arrival |
| PARC5RS060 | 1.9 / 73 mph | 120 miles | 4 | --- | --- |

*number of hours before eye landfall

FIGURE 9

SURGE PROFILE - CROSSING/EXITING HURRICANES



prior to the arrival of the storm's eye. This step increase in the times also holds true for Category 1 and 2 exiting storms. The arrival of gale force winds will occur at approximately the same time as Category 2 and 3 landfalling storms. This may be explained by the decrease in the storms' intensity as they cross land. It is assumed that a Category 3 exiting storm began as a Category 4 storm on the west coast. While the intensity of the hurricane was reduced by crossing land, the size of the storm--or, more specifically, the maximum extent of its winds--was not reduced. It would appear reasonable, then, that gale force winds should arrive earlier than would be normally expected for a Category 3 storm.

The times of arrival for gale force winds are shown in the table below:

| | Hours Before Arrival of Storm Center |
|---|---|
| Category 1 | 6-7.5 |
| Category 2 | 5-9 |
| Category 3 | 7-11 |

Additional information on the winds produced by exiting storms is provided in Table 6.

## Paralleling Hurricanes

### Storm Surge

A paralleling storm generates a smaller surge in comparison to a landfalling storm. However, because the storm moves along shore, hundreds of miles of coastline may be affected. Figure 10 presents a surge profile for a paralleling storm moving north, 20 miles inland. As can be noted, the peak surge values produced along the coast are similar to those of the exiting storms modeled by SPLASH II. A noticeable difference in the surge heights around the Cape Canaveral area occurs, which decreases for each category of storm. As mentioned previously, this is due to the decrease in the continental shelf width off the Cape.

For a paralleling storm moving along the coast, as shown in Figure 11, the surge heights increase slightly but still remain well below those experienced by a landfalling storm. Once again, the Cape mitigates the surge produced in its vicinity.

As paralleling storms move off the coast, the surge heights decrease. These are shown in figures 12 through 14, which illustrate expected peak surge heights for hurricanes 20, 40, and 60 miles offshore.

The SPLASH II model computations are only valid along the open coast. That is, the model is not able to predict what storm surge heights may be expected within the tidal rivers or basins for the various storms modeled. It is important that this limitation be noted, for a major storm

FIGURE 10

SURGE PROFILE - PARALLELING HURRICANE: 20 MILES INLAND

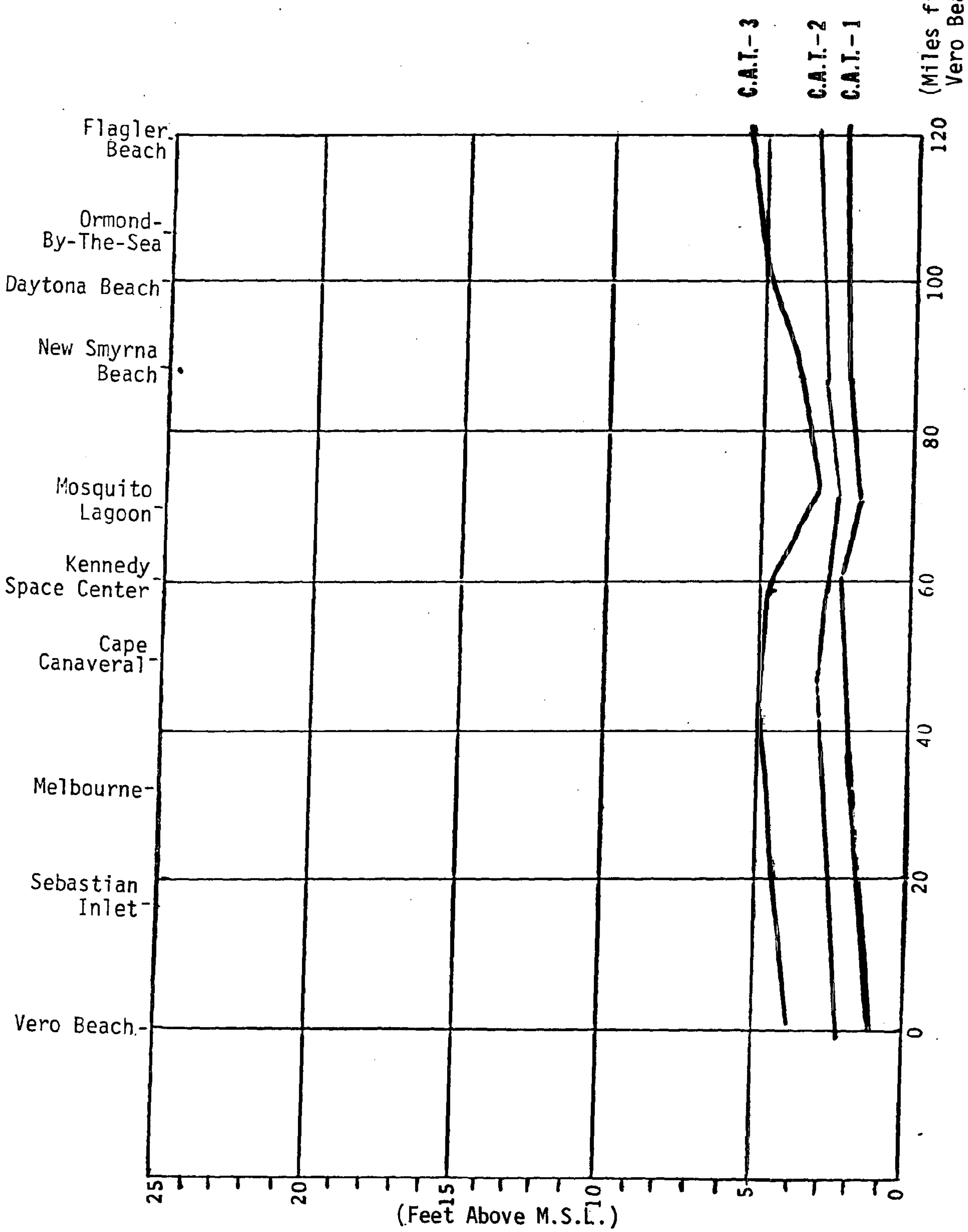


FIGURE 11

SURGE PROFILE - PARALLELING HURRICANE: ON COASTLINE

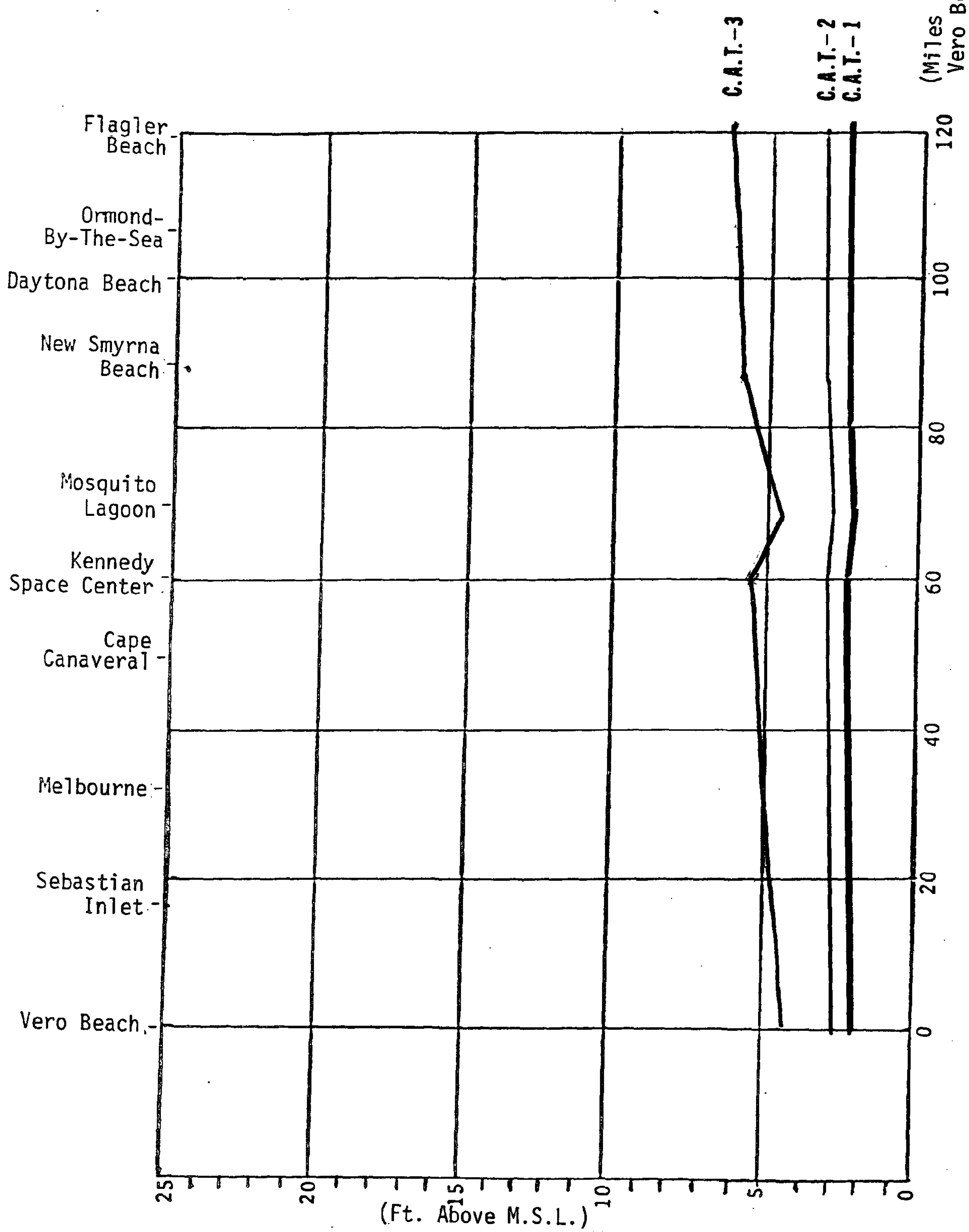


FIGURE 12

SURGE PROFILE - PARALLELING HURRICANE: 20 MILES OFFSHORE

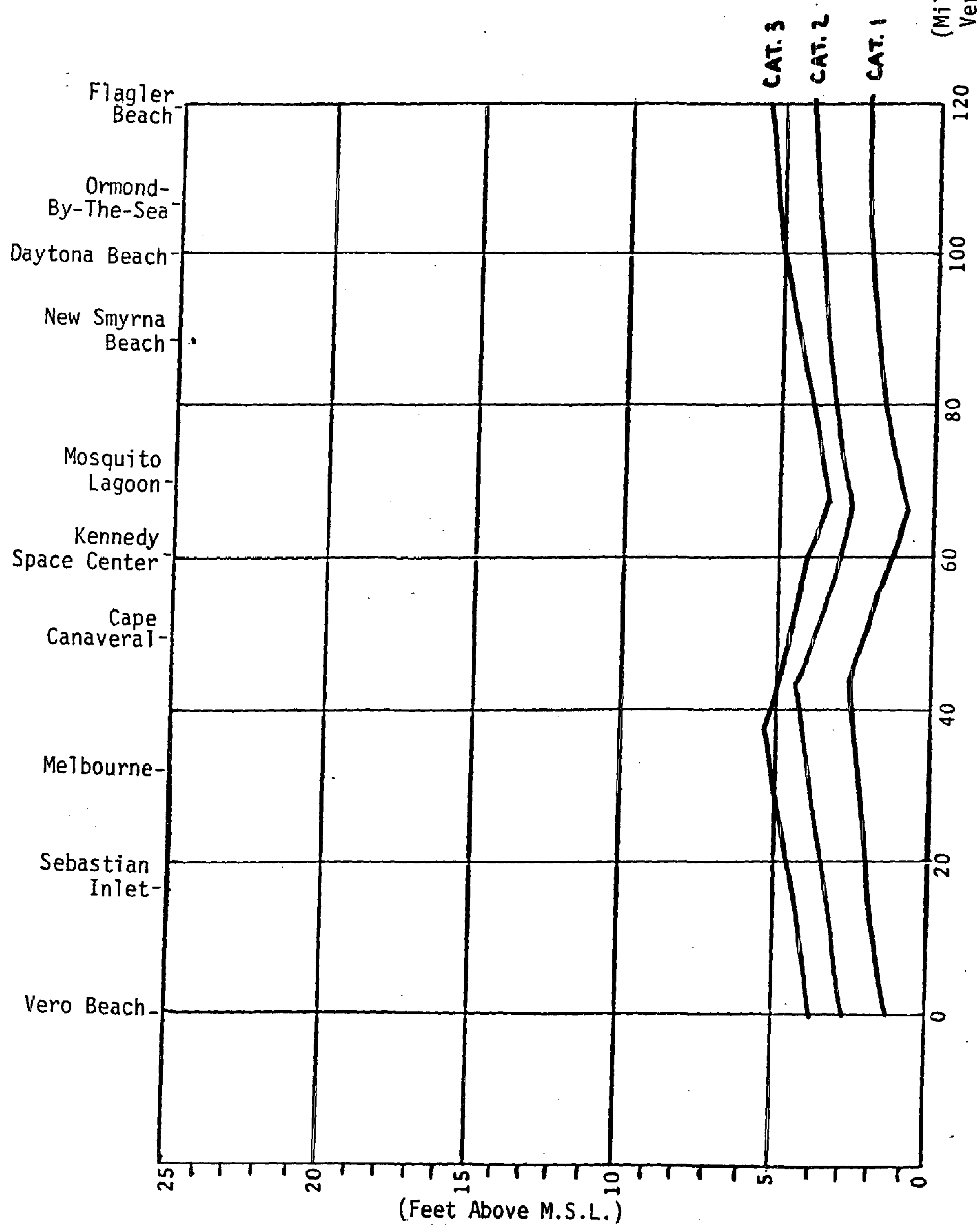


FIGURE 13

SURGE PROFILE - PARALLELING HURRICANE: 40 MILES OFFSHORE

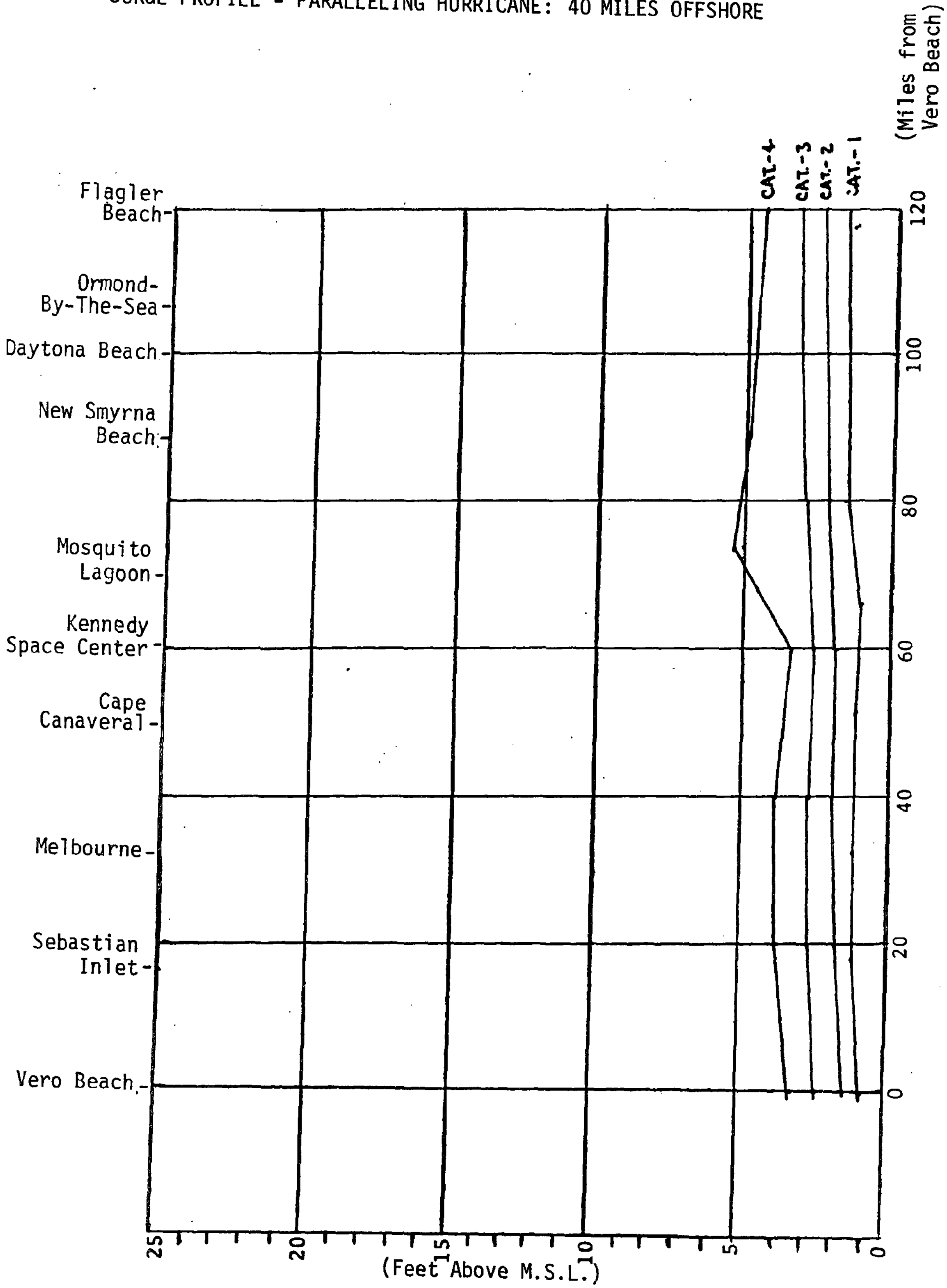
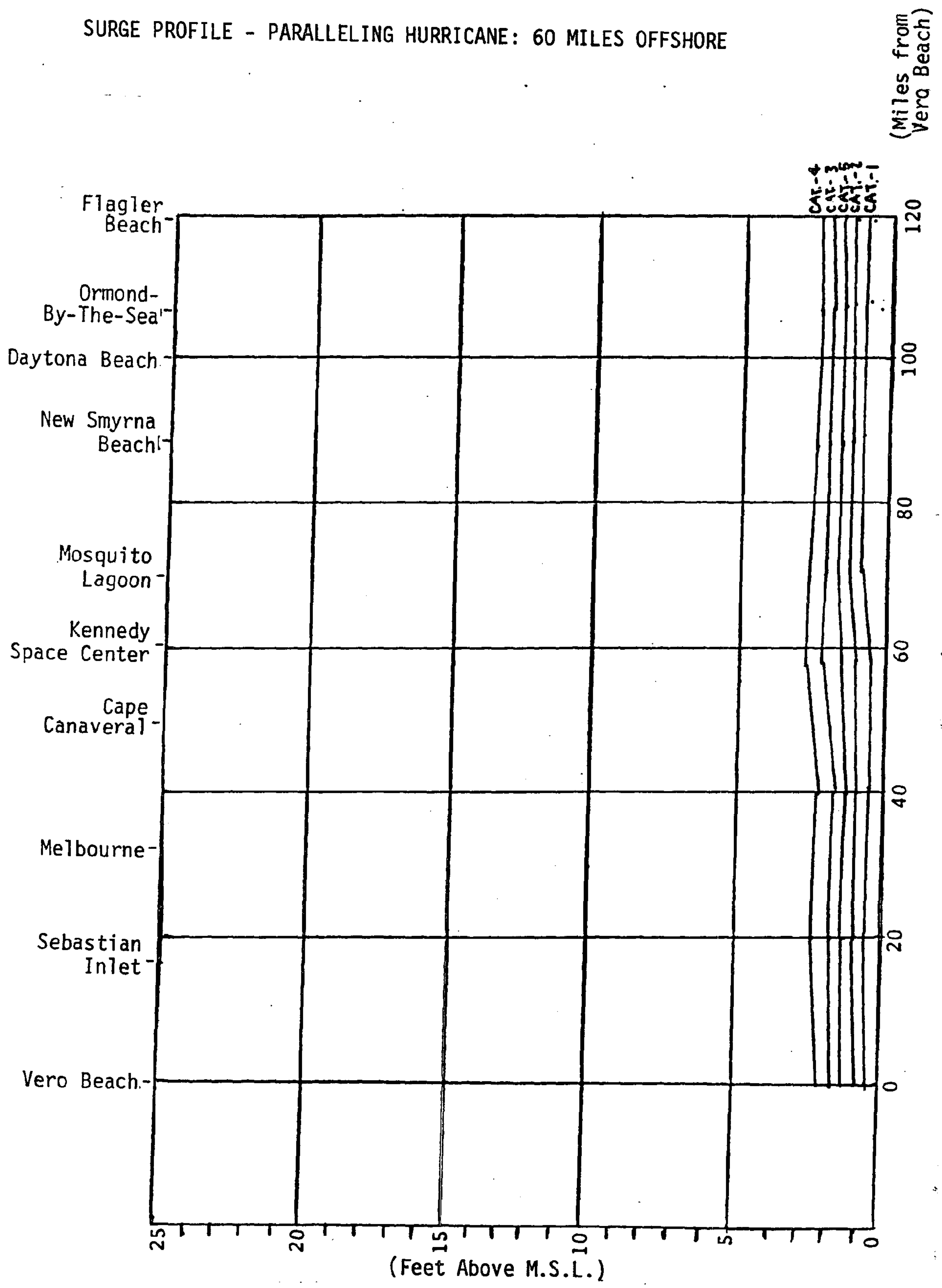


FIGURE 14

SURGE PROFILE - PARALLELING HURRICANE: 60 MILES OFFSHORE



paralleling the coastline may produce surge heights in excess of those computed along the coast.

The increased surge heights within the tidal rivers are the results of winds produced from predominantly one direction for an extended period of time. A storm paralleling the Florida coastline produces northwesterly winds over the rivers for its entire track, causing the waters to be pushed along with it. This is known as a "tilted sea" and can occur in any closed or partially closed basin. This effect may be most notable in the northern reaches of the Indian and Banana rivers.

Pre-Landfall Hazard Times

For any given paralleling track, the arrival of the storm-generated surge will occur, on the average, approximately 2.0 hours before arrival of the storm center. This figure varies, depending on the category of storm considered but, on the average, is similar to the time histories of other stormns. The table below summarizes the expected arrival time of significant surge heights by category:

| | Hours Before Arrival of Storm Center |
|---|---|
| Category 1 | 0.5 |
| Category 2 | 1.0-1.5 |
| Category 3 | 2.0-2.5 |
| Category 4 | 2.5-3.0 |
| Category 5 | 2.5-3.0 |

The time histories of arrival of gale force winds are provided in Table 6 and, as with other movements, arrive well in advance of the storm surge.

# VULNERABILITY ELEMENT

## INTRODUCTION

In the previous section, the hurricane hazards that may adversely impact the coastal areas of East Central Florida were identified and analyzed. This section will identify the areas of the region subject to the effects of those hazards. Included as part of this section are: methodology used in the identification of vulnerable areas; delineation of evacuation zones; identification of vulnerable geographic areas; and an estimation of the population-at-risk.

## METHODOLOGY

The identification of the areas of the region vulnerable to a hurricane's storm surge is the most important criterion for determining those residents who must evacuate from various hypothetical hurricanes. As stated previously, the results from the SPLASH II model provided the primary data by which these areas could be identified. This model produced peak surge values that could then be compared to the elevations of the land mass.

As the SPLASH II model only produced such values along the open coast, a major limitation confronted in the use of the model was the lack of surge ffheight data for inland areas. This resulted in not having a clear indication of those inland areas to be flooded and also an absence of information on the effects of each hypothetical hurricane on the region's inlets and saltwater tide basins. To correct this deficiency, a number of other sources were utilized in the vulnerability analysis. These included:

- o National Ocean Survey Storm Evacuation maps
- o Federal Emergency Management Administration Flood Insurance rate maps
- o U.S. Army Corps of Engineers Flood Plain Information (Volusia Co.)
- o Past histories of storm surge inundations for Brevard and Volusia counties

The application of the storm surge values to inland areas was completed with the assistance of the U.S. Army Corps of Engineers. The engineering judgment provided by the Corps engineers allowed for a reasonable prediction of the potential flooding that may be expected to occur for each category of storm.

Due to the limitations of the SPLASH II model in regard to inland flooding, identification of a threshold level which would require residents to evacuate was not appropriate. While the importance of not requiring residents in structurally sound homes experiencing only minimal amounts of flooding to evacuate is recognized, an accurate determination of these areas was not possible through the model. However, due to the small area in each county that would be required to evacuate and the short distance required to travel to safety, the impact of persons on the outer edges of vulnerable areas not needing to evacuate is expected to be minimal.

## LEVELS OF VULNERABILITY

Prior to the delineation of threatened areas, two major changes were made with regard to the identified levels of vulnerability in the study area. First, the five Saffir-Simpson categories of storms used during the modeling phase of the study were collapsed into two ranges for both Brevard and Volusia counties. This was done recognizing the similarities of storm surge heights for different intensities of storms and realizing the manner in which storms may change intensity over time. For both Brevard and Volusia counties, storms were grouped into Category 1-2 or Category 3-5.

The second change to the vulnerability levels involved development of a level of threat concept for the study area. In reviewing the storm surge heights expected along the coastline for a particular storm, it is apparent that a storm event does not represent the same level of threat to every area on the coast. For instance, a category 3-5 storm landfalling at Melbourne may produce a 13.0-foot surge in that area, while producing only a 3.0-foot surge in Daytona Beach. To accommodate the range of surge heights that may be experienced by different areas from the same storm, it was necessary to use a standard measure based upon the height of the storm surge rather than category of storm. The correlation of category of hurricane to level of threat is shown below. This measure of hurricane threat is applied throughout the following chapters of the technical data report.

TABLE 7

Category of Hurricane/Level of Threat
Conversion Table

| Saffir-Simpson Category | Storm Surge | Level of Threat |
|---|---|---|
| 1-2 | 3-8 ft. above MSL | A |
| 3-5 | 9-15+ ft. above MSL | B |

EVACUATION ZONES

Development of evacuation zones is an essential element of the Hurricane Evacuation Study. By grouping areas of a county into zones, a particular area will be able to be identified as receiving a common level of storm surge and as using the same major evacuation route. Delineating zones will also allow residents to identify the zone in which they live, thereby assisting in the effort to inform residents of their immediate vulnerability to a storm and elicit the appropriate response.

The delineation of evacuation zones was based on the Urbanized Area Transportation Study Traffic Analysis Zones (TAZ's) which have been established throughout the two-county study area. The extent of the area to be evacuated for each storm situation and the boundaries of each evacuation zone were determined by clustering TAZ's which would receive a common level of flooding. In combining TAZ's, consideration was also given to population densities and locations in relation to major east-west arterials.

Table 8 presents a listing of evacuation zones for Brevard and Volusia counties and their corresponding urban area traffic analysis zones. Although efforts were made to include entire TAZ's into an evacuation zone, this was not always possible due to major differences between the simulated flood limits and zonal boundaries. A traffic analysis zone may therefore be listed beside more than one evacuation zone number, indicating a split TAZ. In addition, for Volusia County, TAZ's were only available for the coastal area. Therefore, in delineating evacuation zones for the inland portion of that county, census tract boundaries were used.

Table 9 provides a description of the geographic limits of each evacuation zone for the two counties. These limits generally follow widely recognizable streets, highways, or unique geographic features.

The vulnerability analysis resulted in the delineation of the study area into 19 zones in Brevard County and 43 zones in Volusia County which would require total evacuation under certain scenarios. Within the remaining evacuation zones, all mobile home residents would be required to evacuate for any type or intensity of storm approaching the coast.

The evacuation zones are graphically depicted in the series of maps which follow. The maps also identify the predicted extent of evacuation for each level of threat based on the surge vulnerability analysis. The extent of evacuation required from a hurricane creating Level-of-Threat A is covered by a common color on each of the maps. Level-of-Threat B cumulatively includes the lesser-intensity colored areas indicated by the map legend.

TABLE 8

Evacuation Zones - Traffic Analysis Zones
Equivalency Chart

Brevard County

| Evacuation Zone | Urban Area Traffic Analysis Zone |
|---|---|
| B1 | 311, 312, 313, 314, 315, 323, 336 |
| B2 | 324, 325, 326, 338, 340, 341, 342, 343 |
| B3 | 088, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 210, 220, 223 |
| B4 | 166, 167 |
| B5 | 160, 161, 162, 163, 168, 169, 170, 183 |
| B6 | 085, 159 |
| B7 | 230, 235, 236, 237, 296, 298, 299, 318, 319, 322, 328 335 |
| B8 | 253, 254, 297, 316, 320, 321 |
| B9 | 222, 252, 310, 328, 327, 329, 330, 331, 334 |
| B10 | 199, 200 |
| B11 | 001, 002, 003, 004, 005, 010, 011, 012, 013, 014, 015, 017, 018, 019, 021, 022, 023, 024, 026, 027, 028, 029, 031, 032, 033, 034, 035, 036, 037, 038, 039, 040, 041, 042, 043, 044, 045, 046, 047, 048, 049 |
| B12 | 001, 003, 004, 011, 014 |
| B13 | 001, 003, 004, 011, 061 |
| B14 | 031, 032, 033, 034, 035 |
| B15 | 050, 051, 232, 233, 234, 238, 239, 240, 332 |
| B16 | 051, 232, 234, 238 |
| B17 | 224, 225, 244, 245, 246, 247, 248, 249, 251, 257, 258, 259, 260, 261, 262, 263, 265, 266, 267, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295 |
| B18 | 224, 244, 263, 280, 282, 283, 284, 291, 292, 295 |
| B19 | 097, 098, 099, 100, 102, 102, 108, 218 |
| B20 | 098, 099, 108 |
| B21 | 101, 104, 105, 106, 107, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 124, 130, 204, 207 |
| B22 | 109, 110, 111, 112, 130 |

TABLE 8 (cont.)

| | |
|---|---|
| B23 | 122, 123, 125, 126, 127, 128, 129, 131, 132, 133, 134, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 182, 194 |
| B24 | 131, 132, 138, 147, 152, 153, 155 |
| B25 | 156, 157, 158 |
| B26 | 156, 157, 158 |
| B27 | 006, 007, 008, 053, 054, 068, 081, 903, 1009 |
| B28 | 096, 226, 227, 228, 229, 250, 264 |
| B29 | 086, 089, 091, 092, 093, 094, 095, 185, 197, 198, 310, 902 |

TABLE 8 (cont.)

Evacuation Zones - Traffic Analysis Zones
Equivalency Chart

Volusia County

| Evacuation Zone | Urban Area Traffic Analysis Zone |
|---|---|
| V1 | 001, 002, 003, 004, 006, 007, 008, 011, 012, 013, 015 |
| V2 | 001, 002, 003, 004, 005, 007, 009, 010, 012, 013, 014 |
| V3 | 001, 002, 003, 004, 005, 007, 009, 010, 012, 013, 014 |
| V4 | 016, 020, 021, 028, 033 |
| V5 | 017, 018, 019, 020, 023, 024, 026, 027, 029, 032 |
| V6 | 017, 018, 019, 025, 027, 030, 031 |
| V7 | 035, 041, 043 |
| V8 | 034, 036, 039, 040, 042, 043 |
| V9 | 037, 038, 044 |
| V10 | 045, 049, 050, 054, 055 |
| V11 | 046, 048, 051, 053, 055 |
| V12 | 047, 048, 051, 052, 055 |
| V13 | 057, 060, 061, 062, 063 |
| V14 | 057, 060, 061, 062, 063 |
| V15 | 056, 058, 059, 061, 062, 063 |
| V16 | 087, 088, 089, 107, 110 |
| V17 | 082, 083, 087, 088, 089, 090, 092, 107, 108 |
| V18 | 111, 113, 114, 116, 117, 120, 138, 139 |
| V19 | 117, 120, 137 |
| V20 | 161, 162, 163, 164, 165, 166, 167 |
| V21 | 137, 160, 170 |
| V22 | 185 |
| V23 | 168, 169, 185, 186, 187, 188, 190, 191, 203 |
| V24 | 185, 188, 189, 192, 201, 202 |
| V25 | 204, 209, 210 |
| V26 | 204, 209, 210, 212 |
| V27 | 214, 216 |
| V28 | 078, 079, 080, 082, 083, 084, 085, 086, 091, 092, 093, 094, 095, 096, 097 |
| V29 | 087, 088, 089, 107, 108, 109, 110 |

TABLE 8 (cont.)

| | |
|---|---|
| V30 | 098, 099, 100, 101, 102, 103, 104, 105, 106, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 189, 193, 194, 195, 196, 198, 199, 200, 283 |
| V31 | 197, 205, 206, 207, 208, 211, 212, 213, 215, 216, 217 |
| V32 | 064, 066, 067 |
| V33 | 064, 065, 068, 069 |
| V34 | 064, 065, 069, 225 |
| V35 | 070, 071, 074, 075 |
| V36 | 071, 074, 075 |
| V37 | 072, 073, 075 |
| V38 | 076, 077, 286, 289 |
| V39 | 218, 219, 222, 223 |
| V40 | 220 |
| V41 | 221 |
| V42 | 223, 224, 229, 231, 232, 233, 234, 235, 284 |
| V43 | 226, 227, 245, 246, 251, 285 |
| V44 | 226, 227, 245, 246, 251, 285 |
| V45 | 252, 258, 288, 289 |
| V46 | 252, 258, 288, 289 |
| V47 | 228, 229, 230 |
| V48 | 238 |
| V49 | 226, 227, 236, 237, 239, 240, 241, 242, 243, 244, 247, 248, 249, 250, 253, 254, 255, 256, 257, 259, 285, 287 |
| Evacuation Zone | Census Tract |
| V50 | 832 |
| V51 | 901 |
| V52 | 902, 907 |
| V53 | 903 |
| V54 | 904, 905, 906 |
| V55 | 908 |
| V56 | 910 |
| V57 | 909 |

## TABLE 9

### EVACUATION ZONE BOUNDARIES

### Brevard County

| Evacuation Zone | Zone Description |
|---|---|
| B1 | From Port Canaveral southward to SR 520. |
| B2 | From SR 520 southward to northern limits of Patrick AFB. |
| B3 | From northern limits of Patrick AFB to Yacht Club Blvd. |
| B4 | From Yacht Club Blvd. southward to Pinetree Dr. |
| B5 | From Pinetree Dr. to unincorporated Floridana Beach. |
| B6 | From southern limits of unincorporated Floridana Beach southward to Sebastian Inlet. |
| B7 | From southern limits of Kennedy Space Center to SR 520; East of Indian River and west of Banana River, excluding that portion contained in Evacuation Zone B8. |
| B8 | From SR 524 southward to SR 520; East of SR 3 and west of Sykes Creek. |
| B9 | From SR 520 southward to Leslie Dr. |
| B10 | From Leslie Dr. southward to tip of Merritt Island. |
| B12 | From northern limits of Brevard County southward to US 1; East of Barcelona Dr. and west of SCL railroad. |
| B13 | From northern limits of Brevard County southward to SR 402; East of SCL railroad. |
| B14 | From SR 402 southward to NASA Cswy.; East of US 1. |
| B16 | From NASA Cswy. southward to SR 528; East of US 1. |
| B18 | From SR 528 southward to Wickham Rd.; East of US 1. |
| B20 | From Wickham Rd. southward to Parkway Dr.; East of US 1. |
| B22 | From Parkway Dr. to intersection of NASA Blvd. and US 1 (those areas east of US 1). |
| B24 | From intersection of NASA Blvd. and US 1 southward to southern limits of Malabar. |
| B26 | From southern limits of Malabar to southern boundary of Brevard County. |

# TABLE 9 (cont.)

## EVACUATION ZONE BOUNDARIES

### Volusia County

| Evacuation Zone | Zone Description |
| --- | --- |
| **North Coastal Area** | |
| V1 | From the northern limits of Volusia County southward to Bosarvey Dr.; East of Ocean Shore Blvd. (A1A) |
| V2 | From the northern limits of Volusia County southward to Bosarvey Dr.; East of John Anderson Hwy. and west of Ocean Shore Blvd. (A1A) |
| V3 | From the northern limits of Volusia County southward to Willis Ln.; West of John Anderson Hwy. |
| V4 | From Bosarvey Dr. southward to Oak Ridge Blvd.; East of A1A. |
| V5 | From Bosarvey Dr. southward to Seabreeze Blvd.; East of Peninsula Dr. and west of A1A. |
| V6 | From Willis Ln. southward to Seabreeze Blvd.; East of Halifax River and west of Peninsula Dr. |
| V7 | From Seabreeze Blvd. southward to Silver Beach Ave.; East of Halifax River and west of Halifax Ave. (or Peninsula Dr. at southern one-third of zone) |
| V8 | From Seabreeze Blvd. southward to Silver Beach Ave.; East of Halifax (or Peninsula Dr.) and west of Atlantic Ave. (A1A) |
| V9 | From Oak Ridge Blvd. southward to Silver Beach Ave.; East of A1A. |
| V10 | From Silver Beach Ave. southward to Lantana St.; East of A1A. |
| V11 | From Silver Beach Ave. southward to Lantana St.; East of Peninsula Dr. and west of A1A. |
| V12 | From Silver Beach Ave. southward to Lantana St.; East of Halifax River and west of Peninsula Dr. |
| V13 | From Lantana St. southward to Ponce De Leon Inlet; East of Halifax River and west of Peninsula Dr. |
| V14 | From Lantana St. southward to Ponce De Leon Inlet; East of Peninsula Dr. and west of A1A. |
| V15 | From Lantana St. southward to Ponce De Leon Inlet; East of A1A. |
| V16 | From Tomoka State Park northern boundary southward to Division Ave.; East of N. Beach St. |
| V17 | From Old Dixie Hwy. southward to SR 40; East of US 1 and SR 5A; West of the Tomoka River tributary. |
| V18 | From Division Ave. southward to Fairview Ave.; East of S. Beach St. or Riverside Dr. |
| V19 | From 11th St. southward to Fairview Ave.; East of Daytona Ave. and west of Riverside Dr. |
| V20 | From Fairview Ave. southward to Orange Ave.; East of Daytona Ave. or Palmetto Ave. |
| V21 | From Fairview Ave. southward to San Juan Ave.; East of Ridgewood Ave. and west of Daytona Ave. or Palmetto Ave. |
| V22 | From San Juan Ave. southward to Loomis Ave.; East of Ridgewood Ave. and west of Palmetto Ave. |

## TABLE 9 (cont.)

| | |
|---|---|
| V23 | From Orange Ave. southward to Canal Rd.; East of Palmetto Ave. or Ridgewood Ave. |
| V24 | From Loomis Ave. southward to Canal Rd.; East of Ridgewood Ave. or FEC RR line and west of Palmetto Ave. or Ridgewood Ave. |
| V25 | From Canal Rd. southward to Fleming Ave.; East of FEC RR line and west of Lafayette Ave. |
| V26 | From Canal Rd. southward to Commonwealth Blvd.; East of Lafayette Ave. |
| V27 | From Commonwealth Blvd. southward to Turnbull Bay; East of US 1. |

South Coastal Area

| | |
|---|---|
| V32 | From Ponce De Leon Inlet southward to 5th Ave.; East of N. Atlantic Ave |
| V33 | From Surf St. southward to E. 3rd Ave.; East of Peninsula Ave. and west of N. Atlantic Ave. |
| V34 | From Ocean Dr. southward to E. 3rd Ave.; East of Riverside Dr. and west of Peninsula Ave. |
| V35 | From E. 3rd Ave. southward to Hillside Dr.; East of Indian River and west of Saxon Dr. |
| V36 | From E. 3rd Ave. southward to Hillside Dr.; East of Saxon Dr. and west of S. Atlantic Ave. (A1A) |
| V37 | From 5th Ave. southward to Hillside Dr.; East of S. Atlantic Ave. (A1A) |
| V38 | From Hillside Dr. southward to Canaveral Natl. Seashore. |
| V39 | From Spruce Creek/Strickland Bay southward to Columbia St.; East of Robinson St. and west of Indian River, excluding Evacuation Zones 40, 41, and 42. |
| V40 | From Turnbull St. southward to South St.; East of Turnbull Creek and west of US 1. |
| V41 | New Smyrna Beach Municipal Airport. |
| V42 | From FEC RR and Columbia St. southward to Canal St.; East of Glencoe Rd. and west of US 1 and Faulkner St. |
| V43 | From Canal St. southward to Indian River Blvd.; East of Live Oak St. and US 1 and west of Magnolia Ave. and Riverside Dr. |
| V44 | From Canal St. southward to Indian River Blvd.; East of Magnolia Ave. and Riverside Dr. |
| V45 | From Indian River Blvd. southward to junction of US 1 and A1A; East of US 1 and west of Riverside Dr. |
| V46 | From Indian River Blvd. southward to southern limits of Volusia County; East of Riverside Dr. and A1A. |

POPULATION-AT-RISK

In order to calculate the times required to evacuate those areas identified as vulnerable, as well as determine resources needed in an evacuation, an estimation of the threatened population must be made. It is also necessary to enumerate all mobile home residents throughout the study area, even in areas not vulnerable to storm surge, because they must evacuate from hurricane force winds.

Dwelling unit and population counts by traffic analysis zone, where applicable, were obtained from the county planning departments in the study area. As evacuation zones were generally composed of clusters of TAZ's, the appropriate TAZ counts were added, to result in the total population and dwelling units for each evacuation zone. Where TAZ's were split, census block data were used to arrive at the appropriate count. The population residing in each evacuation zone is presented in tables 10 and 11.

It should be noted that the population figures presented in these tables exclude two major groupings. First, the tourist populations residing in hotels/motels or condominiums were excluded from the count under the assumption that they would elect to leave the area well in advance of an evacuation. They would therefore not place a demand on the transportation system or public shelter facilities in the immediate area. Secondly, military personnel at Patrick Air Force Base were also excluded, due to their planned advance evacuation of the area.

TABLE 10

Population & Vehicle Productions
By Evacuation Zone & Destination

Brevard County

| Zone | Cat. | Population 1 | Population 2 | Population 3A | Population 3B | Population 4 | Vehicles 1 | Vehicles 2 | Vehicles 3A | Vehicles 3B | Vehicles 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B1 | 1-2 | 8,684 | 1,963 | 1,945 | 1,737 | 3,039 | 4,559 | 1,031 | 1,021 | 912 | 1,595 |
| B2 | 1-2 | 10,006 | 2,261 | 2,421 | 2,001 | 3,502 | 5,253 | 1,187 | 1,177 | 1,051 | 1,838 |
| B3 | 1-2 | 22,099 | 4,994 | 4,950 | 4,420 | 7,735 | 11,602 | 2,621 | 2,599 | 2,321 | 4,061 |
| B4 | 1-2 | 13,136 | 2,969 | 2,942 | 2,627 | 4,598 | 6,896 | 1,559 | 1,545 | 1,379 | 2,413 |
| B5 | 1-2 | 6,985 | 1,579 | 1,565 | 1,397 | 2,445 | 3,667 | 829 | 822 | 733 | 1,283 |
| B6 | 1-2 | 690 | 156 | 155 | 138 | 242 | 363 | 82 | 81 | 72 | 128 |
| B7 | 1-2 | 15,407 | 3,482 | 3,452 | 3,081 | 5,392 | 8,089 | 1,828 | 1,812 | 1,618 | 2,831 |
| B8 | 3-5 | 7,250 | 1,639 | 1,624 | 1,450 | 2,537 | 3,806 | 860 | 853 | 761 | 1,332 |
| B9 | 1-2 | 11,104 | 2,509 | 2,487 | 2,221 | 3,886 | 5,830 | 1,317 | 1,306 | 1,166 | 2,041 |
| B10 | 1-2 | 1,107 | 250 | 249 | 221 | 387 | 581 | 131 | 131 | 116 | 203 |
| B11 | WIND | 2,082 | 470 | 466 | 416 | 729 | 1,093 | 247 | 245 | 218 | 383 |
| B12 | 3-5 | 59 | 13 | 13 | 12 | 21 | 31 | 7 | 7 | 6 | 11 |
| B13 | 1-2 | 162 | 37 | 36 | 32 | 57 | 85 | 19 | 19 | 17 | 30 |
| B14 | 1-2 | 1,483 | 335 | 332 | 297 | 519 | 779 | 176 | 174 | 156 | 272 |
| B15 | WIND | 1,609 | 364 | 360 | 322 | 563 | 845 | 191 | 189 | 169 | 296 |
| B16 | 1-2 | 964 | 218 | 216 | 193 | 337 | 506 | 114 | 114 | 101 | 177 |
| B17 | WIND | 1,852 | 419 | 415 | 370 | 648 | 972 | 220 | 218 | 194 | 340 |
| B18 | 1-2 | 4,813 | 1,088 | 1,078 | 963 | 1,685 | 2,527 | 571 | 566 | 505 | 885 |
| B19 | WIND | 868 | 196 | 194 | 174 | 304 | 456 | 103 | 102 | 91 | 160 |
| B20 | 1-2 | 172 | 39 | 39 | 34 | 60 | 90 | 20 | 20 | 18 | 32 |
| B21 | WIND | 1,949 | 440 | 437 | 390 | 682 | 1,023 | 231 | 229 | 205 | 358 |
| B22 | 1-2 | 1,912 | 432 | 428 | 382 | 669 | 1,004 | 227 | 225 | 201 | 351 |
| B23 | WIND | 4,305 | 973 | 965 | 861 | 1,507 | 2,260 | 511 | 507 | 452 | 790 |
| B24 | 1-2 | 2,489 | 563 | 558 | 498 | 871 | 1,307 | 296 | 293 | 261 | 457 |
| B25 | WIND | 3,739 | 845 | 838 | 748 | 1,309 | 1,963 | 444 | 440 | 393 | 686 |
| B26 | 1-2 | 430 | 97 | 96 | 86 | 151 | 226 | 51 | 51 | 45 | 79 |
| B27 | WIND | 42 | 9 | 9 | 8 | 15 | 22 | 5 | 5 | 4 | 8 |
| B28 | WIND | 123 | 28 | 28 | 25 | 43 | 65 | 15 | 15 | 13 | 22 |
| B29 | WIND | 76 | 17 | 17 | 15 | 27 | 40 | 9 | 9 | 8 | 14 |

Key: 1 = Total
2 = Public Shelter
3 = Friend/Relative (a--in county; b--out of county)
4 = Hotel/Motel

TABLE 11

Population & Vehicle Productions
By Evacuation Zone & Destination

Volusia County

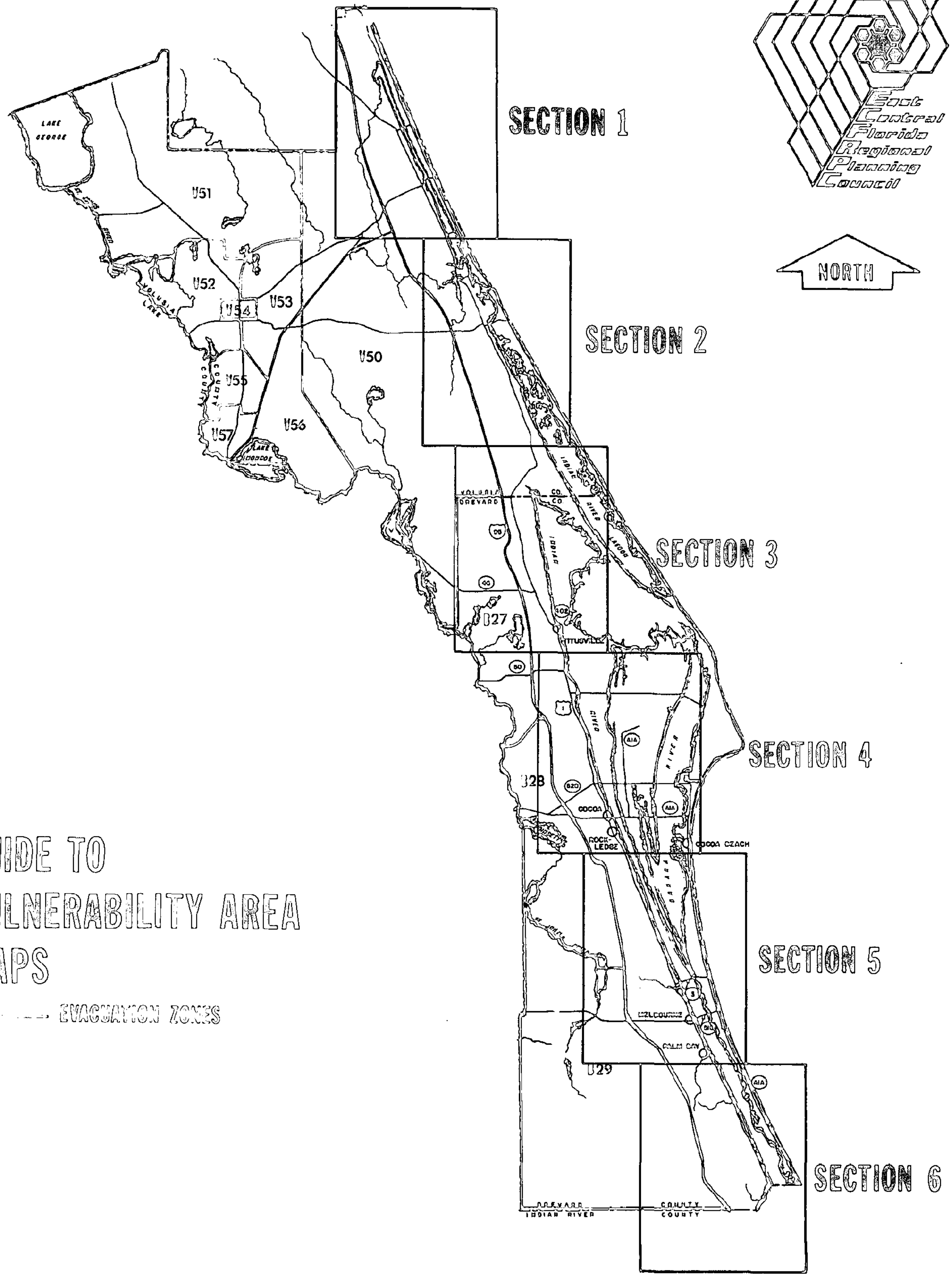
| ZONE | CAT. | Population 1 | Population 2 | Population 3 | Population 4 | Vehicles 1 | Vehicles 2 | Vehicles 3 | Vehicles 4 |
|---|---|---|---|---|---|---|---|---|---|
| V1 | 1-2 | 811 | 183 | 344 | 284 | 368 | 83 | 156 | 129 |
| V2 | 3-5 | 10,510 | 2,375 | 4,456 | 3,679 | 4,765 | 1,077 | 2,020 | 1,668 |
| V3 | 1-2 | 536 | 121 | 227 | 188 | 243 | 55 | 103 | 85 |
| V4 | 1-2 | 901 | 204 | 382 | 315 | 409 | 185 | 173 | 143 |
| V5 | 3-5 | 7,915 | 1,789 | 3,356 | 2,770 | 3,589 | 811 | 1,522 | 1,256 |
| V6 | 1-2 | 1,425 | 322 | 604 | 499 | 646 | 146 | 274 | 226 |
| V7 | 1-2 | 1,129 | 255 | 479 | 395 | 512 | 116 | 217 | 179 |
| V8 | 3-5 | 4,535 | 1,025 | 1,923 | 1,587 | 2,056 | 465 | 872 | 719 |
| V9 | 1-2 | 218 | 50 | 92 | 76 | 99 | 23 | 42 | 34 |
| V10 | 1-2 | 584 | 132 | 248 | 204 | 265 | 60 | 112 | 92 |
| V11 | 3-5 | 2,199 | 497 | 932 | 770 | 997 | 225 | 423 | 349 |
| V12 | 1-2 | 1,141 | 258 | 484 | 399 | 517 | 117 | 219 | 181 |
| V13 | 1-2 | 1,113 | 251 | 472 | 390 | 505 | 114 | 214 | 177 |
| V14 | 3-5 | 2,109 | 477 | 894 | 738 | 956 | 216 | 405 | 335 |
| V15 | 1-2 | 894 | 202 | 379 | 313 | 405 | 91 | 172 | 142 |
| V16 | 1-2 | 578 | 131 | 245 | 202 | 262 | 59 | 111 | 92 |
| V17 | 3-5 | 3,412 | 771 | 1,447 | 1,194 | 1,547 | 350 | 656 | 541 |
| V18 | 1-2 | 433 | 98 | 184 | 151 | 196 | 45 | 83 | 68 |
| V19 | 3-5 | 1,709 | 386 | 725 | 598 | 775 | 175 | 329 | 271 |
| V20 | 1-2 | 154 | 35 | 65 | 54 | 70 | 16 | 30 | 24 |
| V21 | 3-5 | 859 | 194 | 364 | 301 | 389 | 88 | 165 | 136 |
| V22 | 3-5 | 2,468 | 558 | 1,046 | 864 | 1,119 | 253 | 474 | 392 |
| V23 | 1-2 | 4,491 | 1,015 | 1,904 | 1,572 | 2,036 | 460 | 863 | 713 |
| V24 | 3-5 | 794 | 179 | 337 | 278 | 360 | 81 | 153 | 126 |
| V25 | 3-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| V26 | 1-2 | 1,533 | 346 | 650 | 537 | 695 | 157 | 295 | 243 |
| V27 | 1-2 | 1,201 | 271 | 509 | 421 | 545 | 123 | 231 | 191 |
| V28 | WIND | 520 | 118 | 220 | 182 | 236 | 53 | 100 | 93 |
| V29 | WIND | 340 | 77 | 144 | 119 | 154 | 35 | 65 | 54 |
| V30 | WIND | 7,342 | 1,659 | 3,113 | 2,570 | 3,329 | 752 | 1,412 | 1,165 |
| V31 | WIND | 6,905 | 1,560 | 2,928 | 2,417 | 3,131 | 707 | 1,328 | 1,096 |
| V32 | 1-2 | 387 | 87 | 165 | 135 | 175 | 39 | 75 | 61 |
| V33 | 3-5 | 2,006 | 453 | 851 | 702 | 909 | 205 | 386 | 318 |
| V34 | 1-2 | 1,032 | 233 | 438 | 361 | 468 | 106 | 198 | 164 |
| V35 | 1-2 | 582 | 132 | 247 | 204 | 264 | 60 | 112 | 92 |

Key: 1 = Total
2 = Public Shelter
3 = Friend/Relative
4 = Hotel/Motel

TABLE 11 (cont.)

| ZONE | CAT. | Population 1 | Population 2 | Population 3 | Population 4 | Vehicles 1 | Vehicles 2 | Vehicles 3 | Vehicles 4 |
|---|---|---|---|---|---|---|---|---|---|
| V36 | 3-5 | 1,881 | 425 | 798 | 658 | 853 | 193 | 362 | 298 |
| V37 | 1-2 | 226 | 51 | 96 | 79 | 102 | 23 | 43 | 36 |
| V38 | 1-2 | 307 | 69 | 131 | 107 | 139 | 31 | 59 | 49 |
| V39 | 1-2 | 528 | 119 | 224 | 185 | 239 | 54 | 101 | 84 |
| V40 | 3-5 | 880 | 199 | 373 | 308 | 399 | 90 | 169 | 140 |
| V41 | 3-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| V42 | 3-5 | 7,199 | 1,627 | 3,052 | 2,520 | 3,264 | 738 | 1,384 | 1,142 |
| V43 | 3-5 | 1,737 | 393 | 736 | 608 | 788 | 178 | 334 | 276 |
| V44 | 1-2 | 459 | 104 | 194 | 161 | 208 | 47 | 88 | 73 |
| V45 | 3-5 | 1,568 | 354 | 665 | 549 | 711 | 160 | 302 | 249 |
| V46 | 1-2 | 545 | 123 | 231 | 191 | 247 | 56 | 105 | 86 |
| V47 | WIND | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| V48 | 3-5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| V49 | WIND | 2,591 | 586 | 1,098 | 907 | 1,175 | 266 | 498 | 411 |
| V50 | WIND | 129 | 29 | 55 | 45 | 58 | 13 | 25 | 20 |
| V51 | WIND | 488 | 110 | 207 | 171 | 221 | 50 | 94 | 77 |
| V52 | WIND | 1,540 | 348 | 653 | 539 | 698 | 158 | 296 | 244 |
| V53 | WIND | 966 | 219 | 409 | 338 | 438 | 99 | 186 | 153 |
| V54 | WIND | 82 | 19 | 34 | 29 | 37 | 9 | 15 | 13 |
| V55 | WIND | 3,539 | 800 | 1,500 | 1,239 | 1,605 | 363 | 680 | 562 |
| V56 | WIND | 870 | 197 | 369 | 304 | 394 | 89 | 167 | 138 |
| V57 | WIND | 841 | 190 | 357 | 294 | 381 | 86 | 162 | 133 |

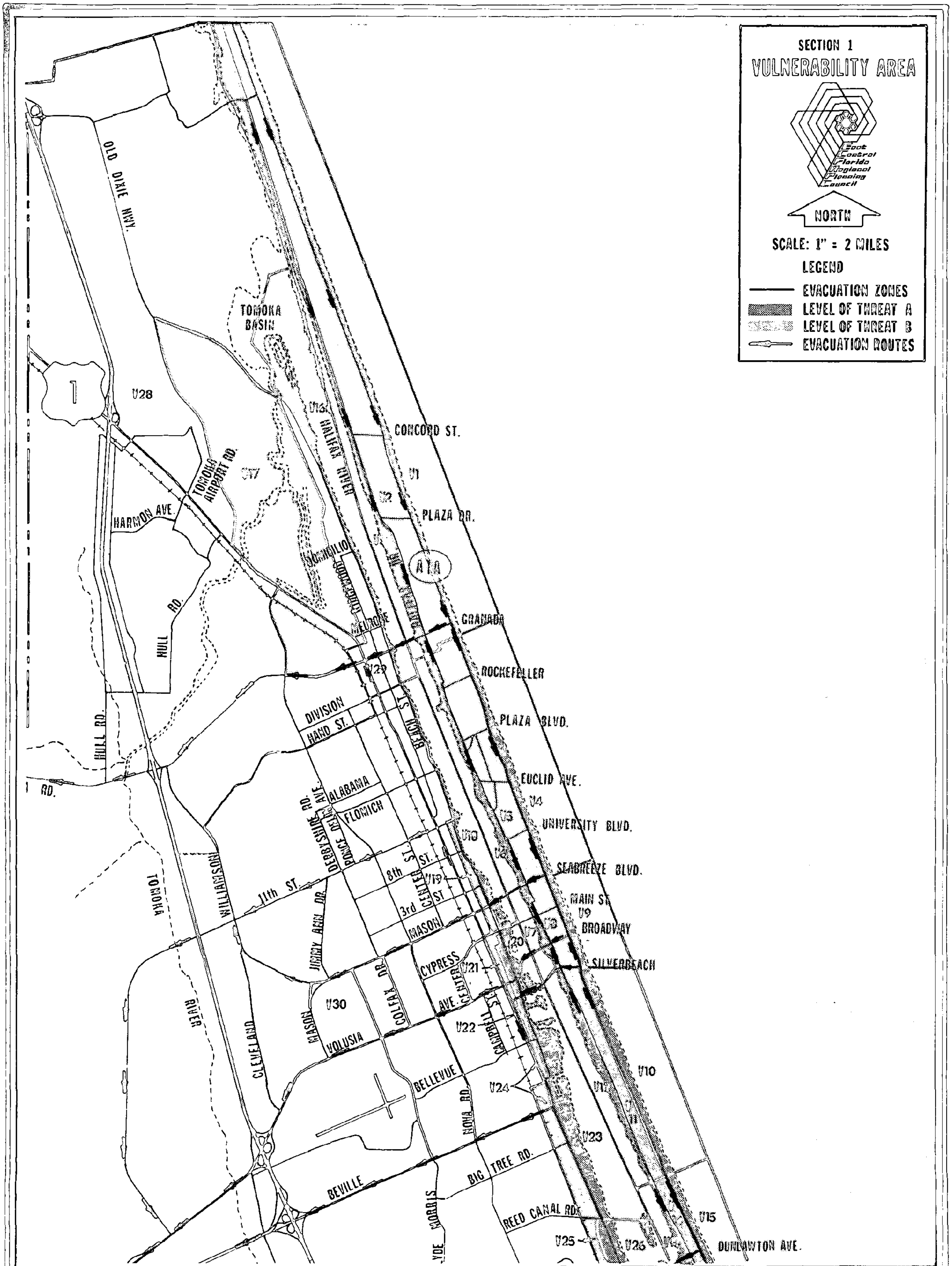
Key:
1 Total
2 Public Shelter 22.63
3 Fr./Rel. 42.43
4 Hot/Mot 35.0

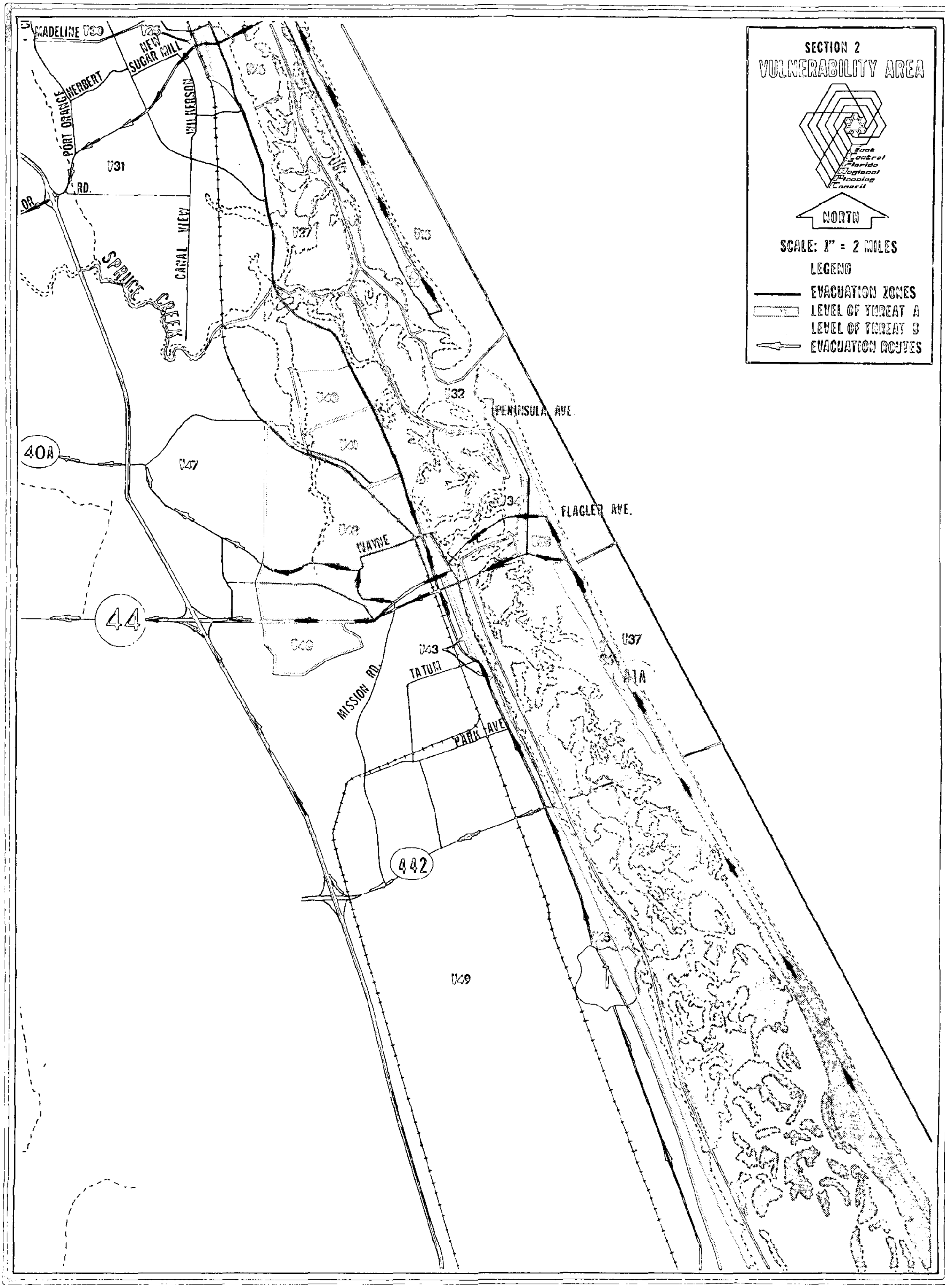



East Central Florida Regional Planning Council

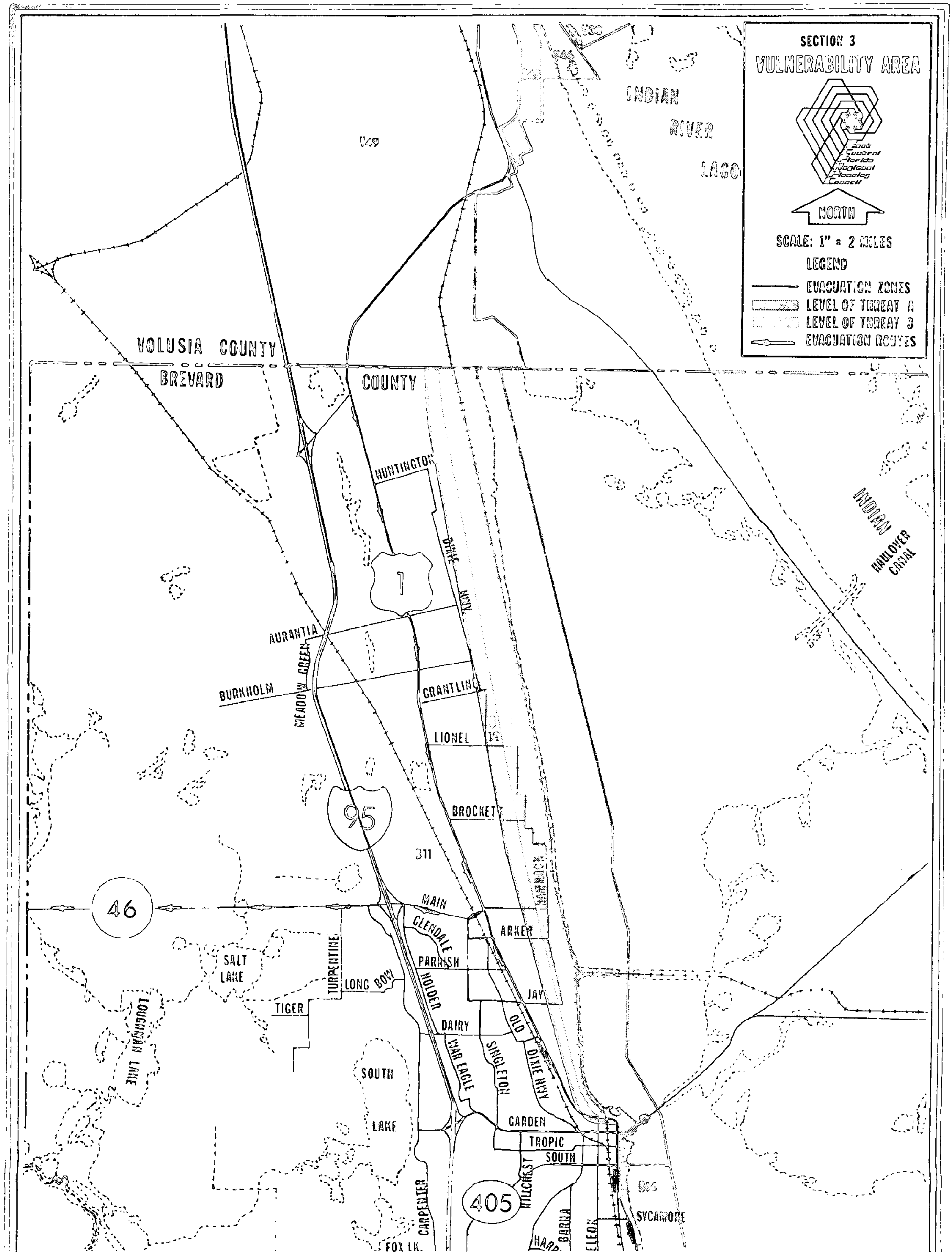
# GUIDE TO VULNERABILITY AREA MAPS

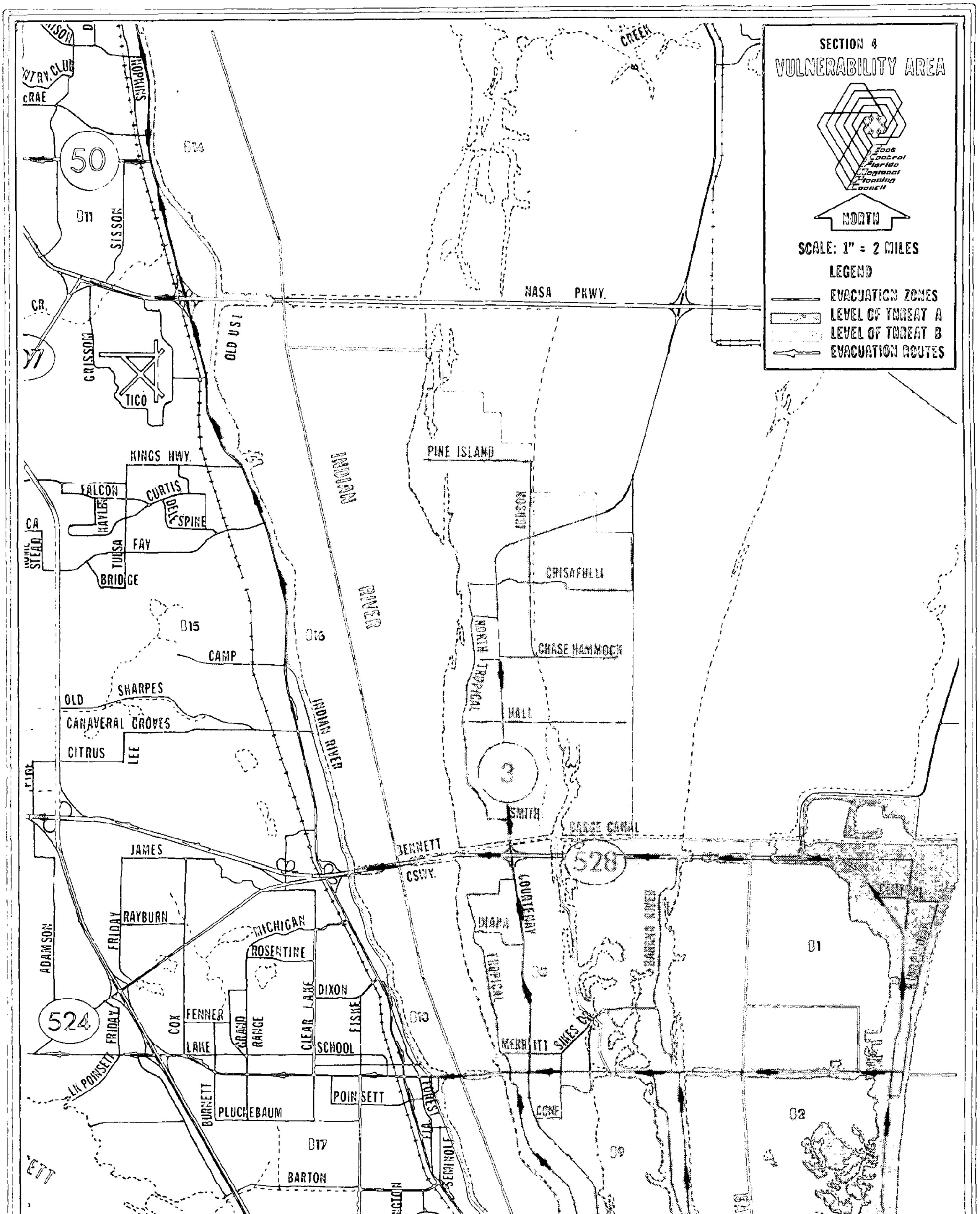
- - - - EVACUATION ZONES

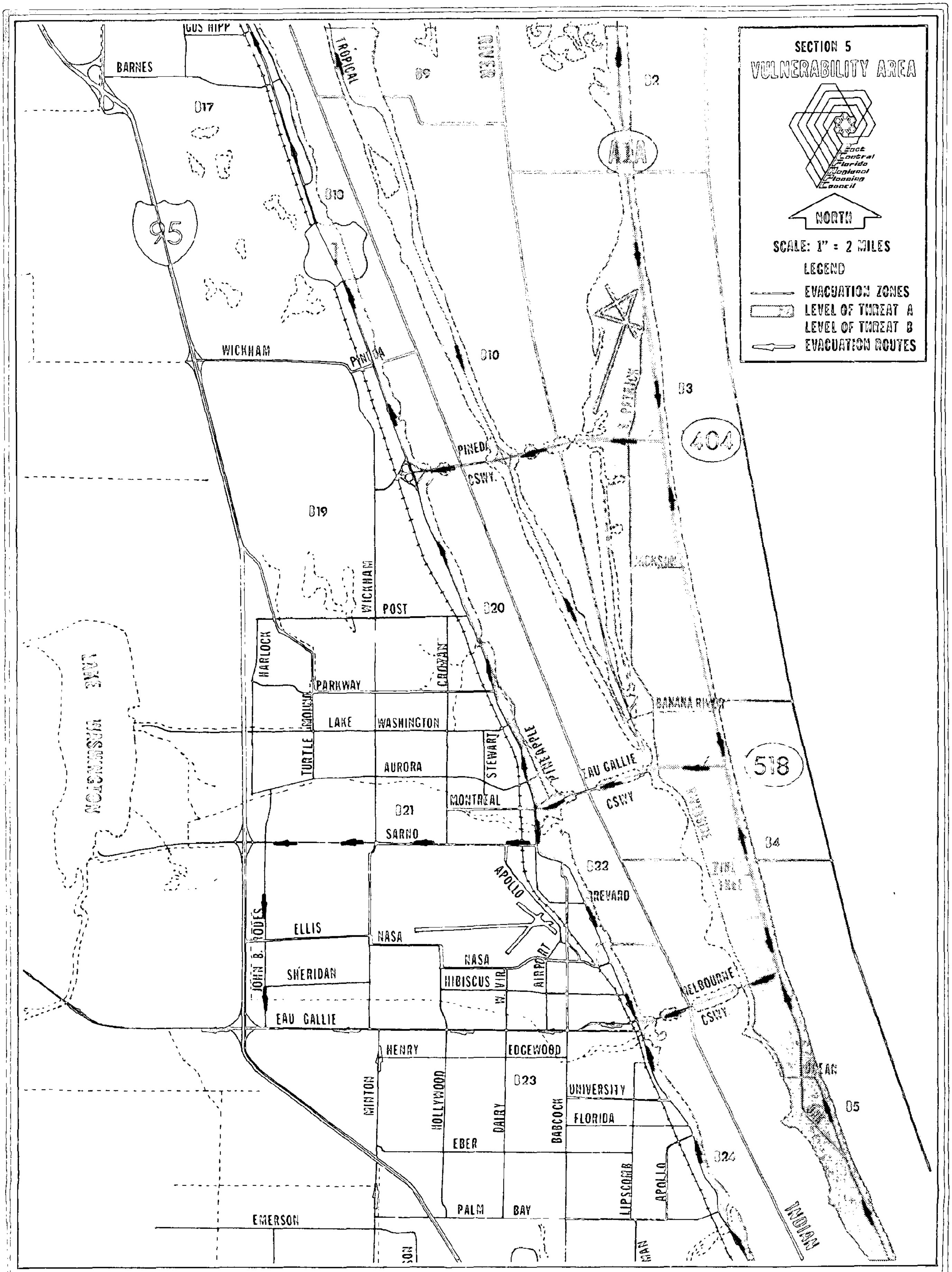

SECTION 1
VULNERABILITY AREA
East Central Florida Regional Planning Council
NORTH
SCALE: 1" = 2 MILES
LEGEND
EVACUATION ZONES
LEVEL OF THREAT A
LEVEL OF THREAT B
EVACUATION ROUTES
OLD DIXIE HWY.
TOMOKA BASIN
U28
CONCORD ST.
HALIFAX RIVER
U17
TOMOKA AIRPORT RD.
PLAZA DR.
HARMON AVE.
A1A
HULL RD.
GRANADA
MELROSE
ROCKEFELLER
PLAZA BLVD.
DIVISION
HAND ST.
BEACH ST.
EUCLID AVE.
ALABAMA
FLOMICH
UNIVERSITY BLVD.
SEABREEZE BLVD.
11th ST.
WILLIAMSON
TOMOKA
8th ST.
3rd ST
MAIN ST
BROADWAY
MASON
SILVERBEACH
CYPRESS
U30
COLFAX DR.
U22
RIVER
CLEVELAND
VOLUSIA
BELLEVUE
U24
U10
U23
NOVA RD.
BEVILLE
BIG TREE RD.
MORRIS
REED CANAL RD.
U15
U25
U26
DUNLAWTON AVE.

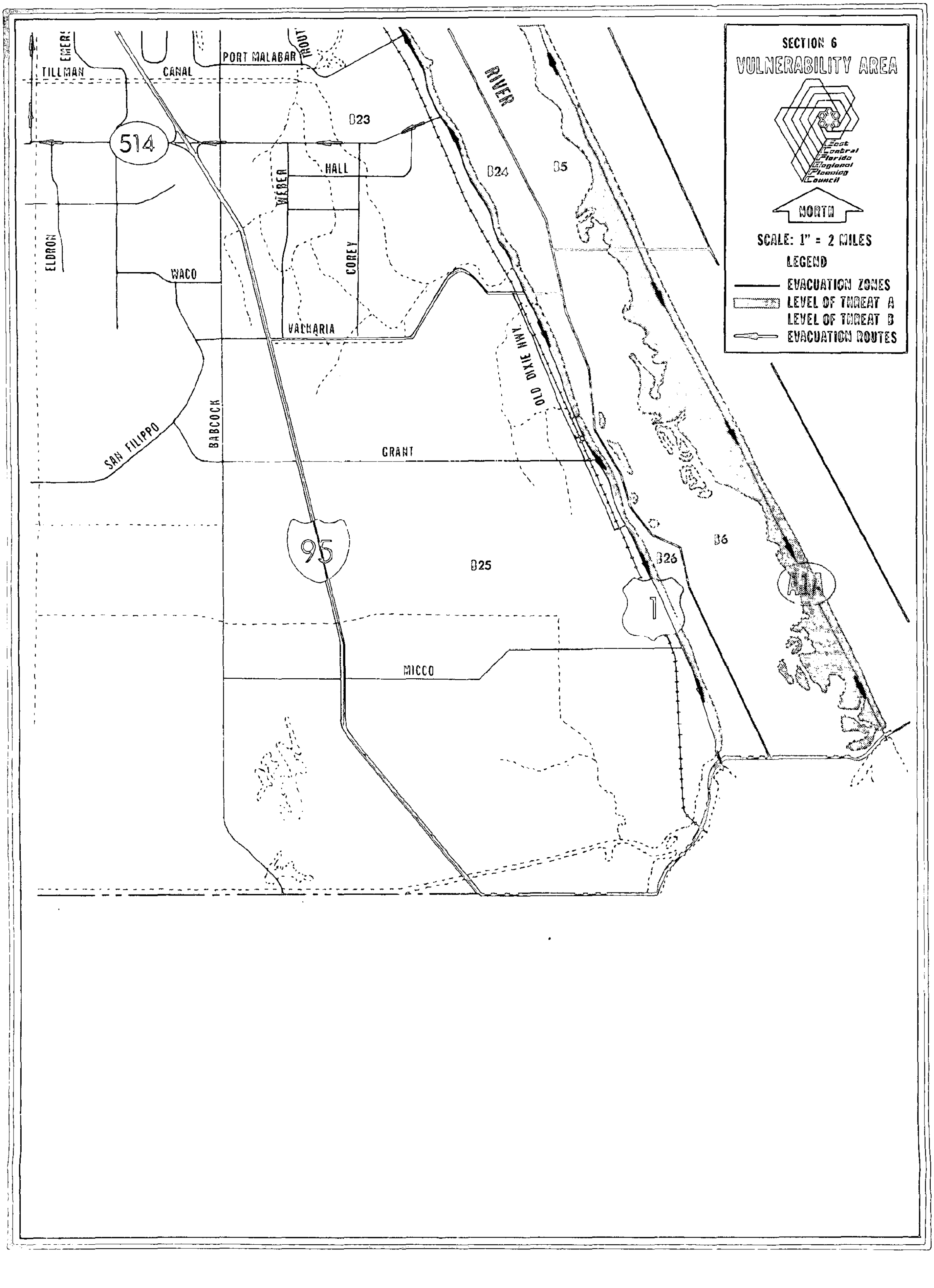


SECTION 2
VULNERABILITY AREA
East Central Florida Regional Planning Council
NORTH
SCALE: 1" = 2 MILES
LEGEND
EVACUATION ZONES
LEVEL OF THREAT A
LEVEL OF THREAT B
EVACUATION ROUTES
MADELINE
NEW SUGAR MILL
HERBERT
PORT ORANGE
WILKERSON
V31
RD.
CANAL VIEW
SPRUCE CREEK
V27
V32
PENINSULA AVE.
40A
V47
V34
FLAGLER AVE.
WAYNE
44
V37
A1A
V43
TATUM
MISSION RD.
PARK AVE
442
V49


SECTION 3
VULNERABILITY AREA
NORTH
SCALE: 1" = 2 MILES
LEGEND
EVACUATION ZONES
LEVEL OF THREAT A
LEVEL OF THREAT B
EVACUATION ROUTES
INDIAN
RIVER
VOLUSIA COUNTY
BREVARD
COUNTY
INDIAN
HAULOVER
CANAL
HUNTINGTON
DIXIE
HWY
1
AURANTIA
BURKHOLM
MEADOW GREEN
GRANTLINE
LIONEL
BROCKETT
95
46
MAIN
GLENDALE
ARKER
PARRISH
SALT
LAKE
TURPENTINE
LONG BOW
HOLDER
JAY
TIGER
LOUGHMAN LAKE
DAIRY
OLD
DIXIE HWY
WAR EAGLE
SINGLETON
SOUTH
LAKE
GARDEN
TROPIC
SOUTH
HILLCREST
405
CARPENTER
BARNA
ELEON
SYCAMORE
FOX LK.


SECTION 4
VULNERABILITY AREA
East Central Florida Regional Planning Council
NORTH
SCALE: 1" = 2 MILES
LEGEND
EVACUATION ZONES
LEVEL OF THREAT A
LEVEL OF THREAT B
EVACUATION ROUTES
50
HOPKINS
SISSON
NASA PKWY.
CREEK
OLD US 1
CRISSOM
TICO
PINE ISLAND
KINGS HWY.
FALCON
CURTIS
SPINE
FAY
BRIDGE
INDIAN RIVER
CRISAFULLI
CHASE HAMMOCK
NORTH TROPICAL
HALL
CAMP
OLD
SHARPES
CANAVERAL GROVES
CITRUS
LEE
3
SMITH
BARGE CANAL
BENNETT
CSWY.
528
JAMES
RAYBURN
MICHIGAN
ROSENTINE
ADAMSON
FRIDAY
DIANA
COURTENAY
TROPICAL
B1
524
COX
FENNER
GRAND
RANGE
CLEAR LAKE
DIXON
FISKE
SCHOOL
LAKE
MERRITT
SYKES CR.
LK POINSETT
BURNETT
PLUCKEBAUM
POINSETT
CONE
B2
B17
B9
BARTON
SEMINOLE
HUNTINGTON
MURRELL
LEVITT
SOUTH
B11
B14
B15
B16
B13


SECTION 5
VULNERABILITY AREA
East Central Florida Regional Planning Council
NORTH
SCALE: 1" = 2 MILES
LEGEND
EVACUATION ZONES
LEVEL OF THREAT A
LEVEL OF THREAT B
EVACUATION ROUTES
GUS HIPP
BARNES
B17
95
B10
B9
B2
A1A
TROPICAL
WICKHAM
PINEDA
B3
404
PINEDA
CSWY.
B19
POST
B20
HARLOCK
PARKWAY
CROTON
LAKE WASHINGTON
LAKE
WASHINGTON
TURTLE MOUND
AURORA
STEWART
PINEAPPLE
BANANA RIVER
EAU GALLIE
CSWY
518
B21
MONTREAL
SARNO
B4
B22
APOLLO
BREVARD
JOHN B. RODES
ELLIS
NASA
SHERIDAN
HIBISCUS
AIRPORT
MELBOURNE
CSWY
EAU GALLIE
HENRY
EDGEWOOD
MINTON
HOLLYWOOD
B23
DAIRY
BABCOCK
UNIVERSITY
FLORIDA
OCEAN
B5
EBER
B24
LIPSCOMB
APOLLO
PALM
BAY
EMERSON
INDIAN


SECTION 6
VULNERABILITY AREA
East Central Florida Regional Planning Council
NORTH
SCALE: 1" = 2 MILES
LEGEND
EVACUATION ZONES
LEVEL OF THREAT A
LEVEL OF THREAT B
EVACUATION ROUTES
TILLMAN
CANAL
PORT MALABAR
TROUT
RIVER
514
B23
HALL
WEBER
B24
B5
ELDRON
WACO
COREY
VALKARIA
OLD DIXIE HWY.
BABCOCK
SAN FILIPPO
GRANT
95
B25
B26
B6
1
A1A
MICCO

# BEHAVIORAL SURVEY ELEMENT

## INTRODUCTION

There are many factors contributing to the hurricane-vulnerability of the coastal areas of East Central Florida. Previous sections of this report have identified and quantified a number of these variables which may be used as a basis for measuring the potential evacuation time of the coastal areas. However, besides defining hurricane hazards, determining their effects on the region, and identifying potential coastal evacuees, an essential type of data that must be examined in order to quantify evacuation time is the human factor of hurricane response. When and if threatened residents would evacuate, how many vehicles would be needed, the preplanned destinations of evacuees, and other behavioral tendencies are added elements in the time required for an evacuation of an area.

One means by which these behavioral characteristics can be determined is through a survey of the threatened coastal area population. The East Central Florida Regional Planning Council employed the firm of H. W. Lochner, Inc., to conduct a statistically significant survey to determine the responses of the coastal population residents to an approaching hurricane. From this population, a random sample was drawn and a telephone survey conducted. The results of the survey were then tabulated and analyzed, forming the basis for making assumptions of the evacuation behavior of the entire threatened population. In conjunction with other background information collected, the survey results provided input to the process for determining evacuation times.

## METHODOLOGY

The behavioral survey for Brevard and Volusia counties focused only on the population at risk. Since most residents of the study area will not be threatened and, consequently, not need to evacuate during a hurricane event, there was no need to determine their behavioral characteristics. For that reason, the survey was limited to, and a sample was drawn from, the region's coastal population.

As with almost any survey, there were three major components involved with undertaking the behavioral survey for the coastal area of East Central Florida. These consisted of designing the survey questionnaire, drawing the sample, and administering the survey. Besides those activities, the survey process also included tabulating the responses and analyzing the results. This section of the report discusses the methodology and presents the behavioral survey results (a copy of the consultant's report providing more details on the survey is available from the Regional Planning Council).

The sample, itself, was drawn from city directories of R. L. Polk and Company and the phone directories in the study area. Starting at a random point in these records, a skip interval was employed to identify residents to be surveyed, assuring not only that the sample would be random but also giving proportional representation in the survey to each of the counties in the study area. In drawing the sample, 20% more names than were needed were identified to ensure that the necessary 400 completed surveys would be obtained despite refusals and other potential problems. Since the survey was to be conducted by telephone, names and addresses of those persons chosen through the skip interval method were simultaneously verified in the phone directory. Only those residents listed in the directories were included in the sample.

## Survey Administration

After the sample had been drawn, notification postcards were sent to all persons to be surveyed. Arriving one to three days before the scheduled interview, the postcards were to inform potential respondents of the survey, generally explain the purpose of the survey, and request their cooperation. At the same time, news releases explaining the Hurricane Evacuation Study program, in general, and the behavioral survey, in particular, were distributed to the media for publication.

Telephone interviews were conducted from April 26, 1982 to May 15, 1982 by a team of professional interviewers. Calls were made during the day, in the evening, and on weekends, and up to four callbacks were made before abandoning a potential respondent. With only a 2.97% refusal rate, the necessary 400 surveys were completed by the interviewers. To ensure accurate results, interviewers were monitored during the surveying process, and completed surveys were examined for quality and consistency.

## Compilation

Upon completion of the survey, the results were compiled and tabulated. Table 12 shows the results. For several of the questions, more information was obtained than was presented in this summary of the results. In the evacuation destination question, for example, respondents indicating that they would go to the home of a friend or relative or to a hotel/motel were asked to specify the county in which their particular destination was located, while respondents indicating that they had experienced a hurricane were asked the date and location of the storm experience. This information was used for planning purposes and/or refining behavioral assumptions.

## Design of Survey Instrument

One of the most important parts of the survey process was design of the survey questionnaire. As the primary tool for collecting behavioral information, the questionnaire had to address all the necessary issues, avoid ambiguity and bias, and be short and simple enough to facilitate

TABLE 12

BEHAVIORAL SURVEY RESULTS

| | | |
|---|---|---|
| 1. *Do you live in a: single-family home? multi-family home? mobile home? other?* | Single-Family<br>Multi-Family<br>Mobile Home<br>Other | 74.6% ±4.1%<br>22.4% ±3.9%<br>1.8% ±1.3%<br>1.2% ±1.0% |
| 2. *If you were ordered by a government authority to evacuate, how soon could you be ready, and when would you leave?* | Immediately:<br>Certain # of Hours:<br>Never: | 64.7% 4.6%<br>27.5% 4.3%<br>7.8% 2.6% |
| 3. *How many vehicles are there in your household?* | One Vehicle:<br>Two Vehicles:<br>Three Vehicles:<br>Four Vehicles: | 192 Households<br>170 Households<br>53 Households<br>5 Households |
| a) *How many vehicles would you use during evacuation?* | Vehicles to be used: | 70.0% |
| b) *Would you need transportation, such as a bus or taxi?* | Yes: | 1.6% ±1.5% |
| 4. *How many people live in your home, including you?* | Average: | 2.28 persons per household |
| 5. *Is there anybody who could not be evacuated without help from outside your home?* | Yes: | 3.7% ±1.8% |
| 6. *After leaving, where would you go?* | To a Red Cross Shelter:<br>To a Friend or Relative:<br>To a Hotel or Motel:<br>Don't Know: | 18.3% ±3.7%<br>38.1% ±4.7%<br>30.6% ±4.5%<br>13.0% ±3.3% |
| 7. *Have you ever experienced a direct hurricane strike?* | Yes: | 48.7% ±4.8% |
| 8. *How old are you?* | Average age of respondents: | 55.4 yrs. |
| 9. *What is your occupation?* | White Collar:<br>Skilled Tradesman:<br>Blue Collar: | 58.1% ±4.7%<br>17.6% ±3.6%<br>24.3% ±4.1% |

administration by telephone. Only with these characteristics could the questionnaire produce acceptable results.

The basis of the questionnaire consisted of the major behavioral issues associated with hurricane evacuation. These included evacuation time, vehicle use, special transportation needs, special assistance needs, planned destinations, prior hurricane experience, and perception of threat. Using other hurricane evacuation surveys as models, a set of questions incorporating all of these issues was developed. Along with these substantive issues, a set of questions to identify general socio-economic and demographic characteristics of the respondents was prepared.

Besides the questionnaire itself, a notification postcard was also prepared. The purpose of the postcard was to maximize the cooperation by potential respondents and minimize the refusal rate. Both the survey instrument and the notification postcard were pretested on a group of 25 households of varying economic and educational backgrounds in different geographic areas. Based upon the results of the pretest, minor changes were made to both the questionnaire and the postcard, and a final version of each was developed.

Drawing the Sample

The primary objective of any survey is to assess the characteristics of the target population. To ensure that the survey is representative of that target population, it is necessary to draw a random sample which will produce results at the desired level of confidence with an acceptable range of error. This involves identifying the target population, determining sample size, and developing an acceptable method for actually drawing the sample.

For the Hurricane Evacuation Study, the segment of the population whose behavioral tendencies must be assessed is the population threatened by hurricane conditions. According to the hazard analysis, there are almost 217,000 people in the two-county area who would be threatened by, and who should evacuate prior to the onset of, hurricane conditions. This target population, therefore, consists of coastal residents in Brevard and Volusia counties.

After identification of the target population, sample size was determined. For planning purposes, it was determined that a 95% confidence level with a margin of error of plus or minus 5% was needed. This would provide results accurate enough to make assumptions to be used in the planning process. Based upon the size of the target population and the diversity of that population which was estimated through researching other similar surveys in Florida, it was determined that a minimum sample size of 400 was needed to ensure that the results corresponded to the desired confidence level and error margin.

As shown in Table 12, the results of each question are given as a percentage along with the margin of error. The 95% confidence level, which was used in this survey, signifies that the survey response, plus or minus the margin of error, produces a range within which responses from the target population would occur 95% of the time. In Question 2, for example, 64.7% of the respondents, plus or minus 4.6%, said that they would evacuate immediately. What this means is that if the entire target population (all coastal residents in the two-county study area) were questioned, it is 95% certain that between 60.1% and 69.3% of them would indicate that they would evacuate immediately if ordered to do so.

## ANALYSIS

A survey of behavioral tendencies is useful for planning purposes only if the results can be used to make assumptions about the expected behavior of the threatened population during hurricane conditions. In order to use the survey results for this purpose, it was necessary to analyze the results, assess their validity, determine their significance, and compare them to similar surveys conducted in Florida. With only nine questions, half of which were to identify socio-economic or demographic characteristics of the respondents, the behavioral survey did not require extensive analysis.

Several questions in the behavioral survey were particularly important to the Hurricane Evacuation Study planning process. These included the questions involving evacuation time, vehicle use, transportation assistance needs, evacuation destination, and prior hurricane experience. Based upon the survey results for these issues, plans were developed for evacuating and sheltering coastal residents of East Central Florida.

### Evacuation Time

Probably the most important issue addressed in the behavioral survey related to evacuation. The specific aspects of evacuation behavior considered most important for the study were when and if most of the threatened population would evacuate. It was particularly important to determine how long it would take the threatened residents to begin evacuating if they were ordered to do so by governmental authorities.

Since the coastal areas had recently experienced an evacuation for Hurricane David in 1979, it was expected that a significant percentage of the residents would choose not to evacuate. Hurricane David caused only minor damage to the coast, and it was thought that many residents might be hesitant to leave during a future hurricane. The results of the behavioral survey, however, showed this not to be the case. Instead of refusing to evacuate, the majority indicated that they would evacuate within two and a half hours of receiving an evacuation order. As shown on Table 12, over 64% of the respondents to the survey indicated in Question 2 that they would leave immediately if ordered to do so. This figure is less than the evacuation response time obtained in other hurricane evacuation surveys conducted in Florida. Several explanations exist for this low response. It could be that the threatened coastal residents, having recently experienced evacuation, are aware of the time involved and responded accordingly. On the other hand, it could be coastal residents are willing to wait a few hours until they verify the need to evacuate through friends or neighbors. One other survey questions hurricane experience, which will be analyzed later in the report and may provide more of an explanation for these results.

Responses to Question 2 also indicated that 27.5% of the threatened residents would evacuate within a certain number of hours. The mean evacuation response time for that group was found to be 2.17 hours. From the results of this question, then, it was found that almost 92.2% of the survey population would evacuate within a few hours if ordered to do so. However, 7.8% of the respondents indicated that they would not evacuate if ordered. This was higher than any area other than Southeast Florida and may reflect past evacuation experiences with Hurricane David.

The major implication of the responses to this question related to transportation. Since the results of Question 2 showed that more than 64% of the threatened population would evacuate immediately and another 27% would leave shortly thereafter, the indications were most evacuees would be on the roads during the first few hours after the evacuation order was issued. That information--along with an estimate of 7.8% of the population presumably refusing to evacuate--was used in developing a viable evacuation plan, establishing a system of evacuation routes, and undertaking other planning activities.

Hurricane Experience

It would seem that there would be a positive correlation between hurricane experience and the willingness to evacuate to a place of safety. Respondents having experienced a direct hurricane strike and understanding the potential damage posed by such a strike would presumably be more inclined to evacuate than those with no hurricane experience. When considering hurricane experience, however, it is necessary to differentiate between actual hurricane experience and perceived hurricane experience. While many people feel they have experienced a direct hurricane strike, oftentimes they have only been exposed to the fringes of the storm.

Since the results of Question 7 indicated that over 48% of the respondents had experienced a direct hurricane strike, the evacuation response derived from Question 2 does not follow. When information collected as part of this question relating to the date and place of the direct hurricane strike was compared to actual hurricane information, however, it was found that only 10% of the respondents had actually experienced a direct hurricane strike and another 7.1% may have. This indicates that many more people think they have experienced the worst part of a hurricane when they actually have not. Hurricane David was not a hurricane over land, although many of the responses referred to that storm. Once again, those residents evacuating from Hurricane David (which they perceived as a direct strike) may account for the low response rate for evacuation in a future storm. This shows the need for more public information on hurricane hazards.

Transportation

A major part of the entire evacuation issue is transportation. Not only is it necessary to know when people will respond to an evacuation order, it is also important to know the means of evacuation, the number of vehicles to be used, and how many households would need some type of assistance in evacuating. A series of questions in the survey attempted to address those issues.

To adequately plan for a hurricane evacuation, it is necessary to know how many vehicles will be on the road. This could vary considerably, depending upon whether families would use only one car during an evacuation, whether they would use more than one car to prevent damage to a vehicle left in a vulnerable area, or whether they would use some form of transportation other than their car. Question 3a specifically addressed the issue of vehicle usage during a hurricane evacuation.

According to the response to Question 3a, 70% of all registered vehicles owned by coastal residents would be used in an evacuation. This means that 30% of all the vehicles registered to coastal dwellers would be off the road during an evacuation. This percentage is consistent with vehicle usage rates obtained from other coastal surveys conducted in Florida.

Besides vehicle usage, other transportation characteristics which are important to know for evacuation planning include the number of households which would need bus or taxi type of transportation to evacuate and the number who could not be evacuated without assistance from outside the household. These factors have implications for transportation planning in general and for disaster preparedness operating agencies in particular. Not only do these figures provide an indication of the number of emergency vehicles which will have to be used in an evacuation, they also provide an indication of the personnel who will be needed.

Question 3b related to the need for bus or taxi transportation. According to the survey results, 1.6% of the respondents would need such transportation to evacuate. Because the margin of error for this factor was plus or minus 1.5%, there is a range of error of plus or minus 94% in the response. This means that the number of households needing bus or taxi transportation can be estimated to range from .1% to 3.1% of all households in the target population. While such a high rate of variation with small numbers would be unacceptable for detailed transit planning, these figures provided the general estimate needed for hurricane evacuation purposes.

Like Question 3b, Question 5 addressed only a small part of the entire population. Responses to Question 5 indicated that 3.7% of the threatened population would need assistance from outside the household to evacuate.

As with Question 3b, there is a high margin of error relative to the percentage answering "yes." At the 95% confidence level, the need for outside help in evacuating can be estimated to range from 1.9% to 5.5% of the target population. While that is a substantial variation, it does provide a general indication of the number of emergency personnel and vehicles required for evacuation.

The implications of the results derived from this series of questions are significant. Since vehicle usage rates can be derived from the behavioral survey, total vehicle usage can be derived by applying these rates to vehicle registration information. When these estimates are added to shelter facilities, total demand on the region's transportation system during an evacuation can be estimated. Based upon these estimates, a viable inter- and intra-regional transportation plan can be developed. When transportation assistance needs derived from the behavioral survey results are incorporated in this process, a comprehensive transportation plan can be prepared.

Destination

For hurricane evacuation planning--and especially for this Hurricane Evacuation Study--it is necessary to know the preplanned destinations of the evacuating population. Question 6 in the behavioral survey addressed the destination issue. It asked respondents where they would go after leaving their homes during a hurricane.

The responses to this question varied considerably from responses to a similar question asked in other hurricane evacuation surveys conducted in Florida. The primary difference related to the number of responses indicating a public shelter would be the destination. In the Hurricane Evacuation Study behavioral survey, 18.3% of the respondents identified a public shelter as their destination, while the same question included in a similar survey focusing on the inland area of East Central Florida produced a shelter usage response almost three times that identified in the coastal area of the region.

Besides the public shelter response, 13% of the respondents indicated that they did not know what their destinations would be upon evacuation. This figure was lower than that derived from the Inland Shelter behavioral survey and fell between the high and low values for other coastal behavioral surveys. These results seem to indicate that there is more awareness of the possibility of a hurricane among coastal residents than among inland residents and they are more prepared in the event of one approaching their area. This may also indicate that due to previous evacuation experience during Hurricane David, individuals are not waiting to the last minute to decide where they will go in the event of an evacuation.

Besides the 18.3% of the respondents who identified a public shelter as their destination after evacuating, and the 13% who indicated that they did not know where they would go, Question 6 showed that 38.1% of the respondents would go to the homes of friends or relatives, while the remaining 30.6% would go to hotels or motels. For that friend/relative and hotel/motel response, the survey obtained additional information. The results showed that 67% of Volusia County residents and 53% of Brevard County residents having homes of friends/relatives or hotels/motels as destinations would stay in the same county, while the remaining would leave their respective county. These results have implications for developing an inter- and intra-regional transportation plan for hurricane evacuation.

## COMPARISONS TO OTHER STUDIES

Several other studies have been conducted in Florida to assess the probable behavioral tendencies of threatened residents during a hurricane event. Several of these studies were referenced in the previous section for purposes of comparing the results of questions included in those studies with similar questions asked in the behavioral survey for the East Central Florida Inland Shelter Study. This section will examine those surveys in more detail while identifying some of the main similarities and differences between the Inland Shelter Study behavioral survey and the other surveys.

The first major behavioral survey conducted as part of the recent hurricane evacuation planning activities undertaken in Florida was administered in the southwest Florida area as part of the "Lee County Flood Emergency Evacuation Plan" (SWFRPC, 1979). That survey was then used as a base for developing a similar survey for the Tampa Bay region, the "Behavioral Survey for the Tampa Bay Flood Emergency Evacuation Plan." After that, a behavioral survey, modeled after the Tampa Bay study, was undertaken in the Sanibel-Captiva area. Finally, the Southwest Florida Regional Planning Council undertook a survey in 1981 that was essentially an extension of the 1979 Lee County survey.

Besides the behavioral survey of the coastal area of East Central Florida, several other surveys were conducted in the same general time frame as part of other Inland Shelter Study or Hurricane Evacuation Study projects. These include behavioral surveys for the inland area of East Central Florida, Southeast Florida coastal area, the Treasure Coast coastal area, the Central Florida inland area, and both the coastal and inland parts of the Withlacoochee area. Only the results of the Southeast Florida survey and the East Central Florida inland survey, however, are presented here.

Table 13 shows the results of the substantive questions for selected behavioral surveys compared to the East Central Florida coastal area study. Since all of these surveys were based on the Lee County study, the similarity in questions facilitated comparisons of the results. The major differences among the surveys related to survey methodology. Specifically, the Lee County and Southwest Florida studies were voluntary surveys published in the newspaper, while the rest were telephone surveys. Because the Lee County and Southwest Florida studies were not scientific surveys,

TABLE 13

COMPARISON MATRIX OF BEHAVIORAL SURVEYS WITHIN FLORIDA

| | East Central Florida Inland | East Central Florida Coastal | Lee County | Tampa Bay | Sanibel-Captiva | South-west Florida | South-east Florida |
|---|---|---|---|---|---|---|---|
| EVACUATION RESPONSE | | | | | | | |
| Immediate | 80.4% ± 4.1% | 64.7% ± 4.6% | N.A. [1] | 77.1% ± 1.8% | 95.3% ± 2.1% | N.A. | 69.2%[4] % ± 1.3% |
| Certain Number of Hours | 15.3% ± 3.7% | 27.5% ± 4.3% | N.A. | 17.2% ± 1.7% | | N.A. | 4.5% % ± 0.7% |
| Never | 4.4% ± 2.1% | 7.8% ± 2.6% | N.A. | 5.7% ± 1.0% | 2.2% ± 1.5%[2] | N.A. | 26.3% % ± 1.6% |
| Average of the certain number of hours | 2.05 | 2.17 | N.A. | 1.40 | 3.97 | N.A. | 2.3% |
| VEHICULAR USAGE | 81.9% | 70.0% | 81.0% | 71.1% | 77.3% | 74.7% | 70.2% |
| NEED FOR TRANSPORTATION | 2.1% ± 1.5% | 1.6% ± 1.5% | N.A. | 4.0% ± 0.6% | N.A. | N.A. | 18.1% % ± 0.2% |
| NEED FOR SPECIAL HELP | 6.6% ± 2.5% | 3.7% ± 1.8% | N.A. | 3.3% ± 0.5% | N.A. | N.A. | N.A. |
| DESTINATION | | | | | | | |
| Shelter | 45.6% ± 5.1% | 18.3% ± 3.7% | 21.0% | 37.9% ± 1.4% | 8.1% ± 2.9% | 24% | 23.1% % ± 1.5% |
| Friend or Relative | 18.2% ± 4.0% | 38.1% ± 4.7% | 53.0% | 25.8% ± 1.3% | 45.4% ± 5.3% | 13% | 28.0% 7% ± 1.6% |
| Hotel or Motel | 14.6% ± 3.6% | 30.6% ± 4.5% | | 18.8% ± 1.1% | 38.1% ± 5.1% | 42%[3] | 10.2% % ± 1.1% |
| Don't Know | 21.6% ± 4.2% | 13.0% ± 3.3% | 26.0% | 17.4% ± 1.1% | 8.4% ± 2.9% | 21% | 11.2% % ± 1.4%[5] |

[1] N.A.: Not Available
[2] The missing 2.5 percent is included in another question. See survey.
[3] Includes "Leave the county" (34%), "Stay home" (2%) and "Motel" (4%).
[4] Includes 20.6% ± 1.5% who would leave before an evacuation order
[5] Not evacuating: 26.8% ± 1.4%

their results could be considered suspect. In addition, the Southeast Florida study included a number of respondents not residing in vulnerable areas.

All of the surveys found that more than 90% of residents in vulnerable areas would evacuate if ordered to do so. There were, however, differences among the studies as to the number who would leave immediately and those who would leave within a certain number of hours. For those noting that their evacuation response time would be a certain number of hours, the average times ranged from a low of 1.4 hours in the Tampa Bay survey to a high of 3.97 hours in the Sanibel-Captiva study.

In all seven surveys, vehicle usage ranged from 70-80%. The highest vehicle usage rate was found in the East Central Florida inland area survey. Its 82% usage rate can be attributed to the high number of one-vehicle households in the study area.

The need for public transportation was below 5% in all but Southeast Florida. In that study, it was found that 18.1% needed transportation. This high figure results from the fact that 16.1% of the surveyed households did not own an automobile. The other major transportation factor--the need for special transportation assistance--was found to be less than 10% of the threatened population in each study area based on the behavioral surveys.

Predictably, the demand for shelter was lowest among the more experienced and relatively wealthy populations on Sanibel and Captiva islands and along the East Central Florida coast. These populations are experienced in the sense that the majority are both vulnerable and had either evacuated or come close to evacuating within the last few years. It appears that many of these people rethink their evacuation plans annually as hurricanes head north out of the Caribbean, and they often make preplanned non-shelter arrangements. This is reflected in the low percentage of respondents in those surveys identifying public shelters as their destinations as well as a low number indicating they do not know where they would go.

A questionable aspect of the Sanibel survey is that 38% of the respondents think that they will find hotel/motel rooms. A follow-up question asking if the respondents had made prior hurricane contingency reservations at some mainland hotel or motel showed that virtually nobody had made such reservations. The implications of that finding are that some potential evacuees in all threatened areas may have planned destinations which will not be available at the time of an actual evacuation.

The relationship of the results of the East Central Florida inland area survey to the observed responses in actual evacuations is extremely important. Actual evacuation behavior provides one means of assessing the validity of the survey results. One issue in which such a comparison is useful is shelter usage. It was found that the highest observed shelter usage in the United States for a given county population was 36% during

Hurricane Carla. This figure is well above the 18.3% shelter usage rate found in the East Central Florida coastal area survey and may lend a certain validity to that figure.

Furthermore, it was found that shelter use increases with the geographic spread of devastation. The wider the path of destruction, the more an evacuee's friends and relatives are similarly impacted and, therefore, cannot be of help.

In contrast to typical hurricanes, geographically compact hurricanes create almost no demand for shelters. Theoretically, a geographically compact category 5 hurricane would create less shelter demand than a more geographically diverse category 4 storm event. In addition, the research literature has also indicated that the public does not comprehend the fine distinctions of hurricane advisories, orders and other such terms. People frequently react to an advisory as if it were an order.

Although there is no specific research on how quickly groups have responded to evacuation orders, certain delay factors have appeared. Specifically, residents will take the time after the order to seek confirmation of the danger through additional sources, including neighbors, friends and relatives. These delays to the order appear to be neither extended nor serious.

Finally, for those persons who say they will not evacuate, the only viable alternative for public officials at this time is to further educate them. There is no documented case in the country in which such persons have been forcibly removed from their homes. Political reasons, tradition, the danger to enforcement officials, and the need for these officials in other pursuits have precluded such action.

## CONCLUSIONS

The behavioral survey for the East Central Florida coastal area addressed a number of major issues and identified the probable behavioral tendencies of the threatened population in the study area during a hurricane event. Although the survey results have been discussed individually, the major conclusions are summarized below. Together with other research and background data, these results were used to develop a workable evacuation plan for the East Central Florida coastal area.

- o The vast majority of the households (92.2%) would respond either immediately or rather promptly to an evacuation order.

- o Of the owned vehicles, 30% would not be used during an evacuation, thereby helping to reduce the traffic problem.

- While the needs for general (bus or taxi) and specialized (handicapped) transportation service are a small percentage, these demands could become a logistical problem involving thousands of persons within an already strained situation. The general transportation service problem, however, can be resolved through increased education, citizen cooperation and advance private arrangements.

- The indicated shelter space needs exceed 31% of the sample population. This amount includes those who plan to use public shelters as well as those not having an evacuation destination, and the figure is most likely higher than what will be experienced during a hurricane.

- A clear minority of the population has experienced the direct hit of a major hurricane, and some of the respondents have a misconception that they were in a major hurricane.

## SHELTER ELEMENT

### INTRODUCTION

The ability to shelter potential evacuees is a major objective of the disaster preparedness programs in Volusia and Brevard counties. Ongoing efforts by the respective Red Cross chapters have resulted in the designation of a substantial number of public buildings that may be used as shelters in the event of a hurricane striking the region's coast. This section will discuss the capability of this existing shelter inventory to absorb the projected number of evacuees expected to seek public shelter. Information developed as part of the study's Behavioral Survey has been used as a basis from which a comparison of shelter demand and shelter capacity may be made.

The purpose in examining shelter preparedness is twofold. First, the information provided through the different work tasks will give local disaster preparedness officials an indication of the adequacy of the existing shelters to accommodate the predicted level of demand. In addition, these activities will facilitate the pre-planning required of officials to ensure that adequate resources are available at the shelters for the duration of the evacuees' stay. Second, the information generated has been utilized in the Hurricane Evacuation Study as part of the Transportation Modeling task to assist in the quantification of evacuation times. To accurately determine evacuation times, the expected vehicle volume movement must be accurately simulated in the model. This requires not only that the destinations of evacuees be known, but that the destinations be realistic in terms of their ability to accommodate the prescribed number of evacuees. By evaluating the capacity of the shelter inventory, shelter assignment and calculation of the time required to travel from the residents' homes to the shelters could be accurately determined.

### SHELTER INVENTORY

Detailed information on the existing designated shelter structures was gathered for this study from the local Red Cross chapters and the local school boards in Volusia and Brevard counties.

Table 14 presents the existing inventory of shelter facilities for each of the coastal counties in the region. The information provided in this table includesshelter location, type of structure, shelter capacity, and shelter facilities.

Although the names, addresses, and telephone numbers for the shelter managers were collected as part of this work effort, they are not included in the information provided. Primarily, this is because personnel assignments are subject to frequent change and an out-of-date listing may

## TABLE 14

### SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- EAST<br>Page 1 of 6. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 1. Burns-Oak Hill Elementary<br>104 Ridge Road<br>Oak Hill<br>904/345-3453 | public school | 468 | X | X | | | well | | septic tank | yes | | 15' | --- |
| 2. Campbell Center<br>601 So. Keech St.<br>Daytona Beach<br>904/253-1686 | public school | 1997 | X | X | | X | | X | | yes | | 10' | --- |
| 3. Chisholm Center<br>577 Ronnoc Lane<br>New Smyrna Beach<br>904/428-2475 | public school | 687 | X | X | | X | | X | | yes | | 8' | Cat. 3 |
| 4. Daytona Beach Comm. College<br>500 Welch Blvd.<br>Daytona Beach<br>(bldgs. 14, 16 25) | college | 2500 | | X | | X | | X | | yes | | 15' | --- |
| 5. Edgewater Elementary<br>550 So. Old Count Road<br>Edgewater<br>904/427-5296 | public school | 644 | X | X | G | X | | X | | yes | | 10' | Cat. 4 |

*Although various provisions have been made for providing food services, in general, food will be brought into the shelters from outside sources.

NOTE: Shelter capacity was based on 40 sq. ft./person, a standard recommended by the American Red Cross and utilized by the local Red Cross chapters within the Study Area. Discussions regarding the availability of capacity reflect this standard.

TABLE 14 (cont.)

S H E L T E R   I N V E N T O R Y

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- EAST<br>Page 2 of 6. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 6. Highlands-Hillcrest Elem.<br>323 Heineman Street<br>Daytona Beach<br>904/253-1891<br>*Note: Medical Shelter only.* | public schools | 665 | X | X | | X | | X | | Highlands, yes.<br>Hillcrest, no. | | 25' | --- |
| 7. Holly Hill Elementary<br>1049 Ridgewood Avenue<br>Holly Hill<br>904/252-6271 | public school | 839 | X | X | | X | | X | | yes | | 15' | --- |
| 8. Holly Hill Junior High<br>1200 Center Street<br>Holly Hill<br>904/252-0421 | public school | 1319 | X | X | | X | | | septic tank | no | | 10' | --- |
| 9. Hurst Elementary<br>1340 Wright Street<br>Holly Hill<br>904/255-3846 | public school | 767 | X | X | | X | | | septic tank | yes | | 10' | --- |
| 10. Knights of Columbus Hall<br>509 No. Orange St.<br>New Smyrna Beach<br>904/427-4211<br>*Note: Medical Shelter Only.* | meeting hall | 100 | | | | X | | X | | no | | 10' | Cat. 4 |

*Although various provisions have been made for providing food services, in general, food will be brought into the shelters from outside sources.

NOTE: Shelter capacity was based on 40 sq. ft./person, a standard recommended by the American Red Cross and utilized by the local Red Cross chapters within the Study Area. Discussions regarding the availability of capacity reflect this standard.

## TABLE 14 (cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- EAST<br>Page 3 of 6. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 11. Mainland Junior High<br>215 Third Avenue<br>Daytona Beach<br>904/255-4561 | public school | 640 | X | X | | X | | X | | yes | | 25' | Cat. 3 |
| 12. Mainland Senior High<br>125 So. Clyde Morris<br>Daytona Beach<br>904/252-0401 | public school | 1354 | X | X | | X | | X | | yes | | 10' | --- |
| 13. New Smyrna Jr. High<br>100 Live Oak Street<br>New Smyrna Beach<br>904/428-5792 | public school | 881 | X | X | | X | | X | | yes | | 10' | Cat. 2 |
| 14. North Ridgewood Elementary<br>365 No. Ridgewood Avenue<br>Daytona Beach<br>904/252-7322 | public school | 271 | X | X | | X | | X | | yes | | 5' | Cat. 2 |
| 15. Ormond Beach Elementary<br>100 Corbin Avenue<br>Ormond Beach<br>904/677-3611 | public school | 373 | X | X | | X | | X | | yes | | 15' | --- |

*Although various provisions have been made for providing food services, in general, food will be brought into the shelters from outside sources.

NOTE: Shelter capacity was based on 40 sq. ft./person, a standard recommended by the American Red Cross and utilized by the local Red Cross chapters within the Study Area. Discussions regarding the availability of capacity reflect this standard.

TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- EAST<br>Page 4 of 6. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 16. Ormond Beach Junior High<br>151 Domicilio Avenue<br>Ormond Beach<br>904/677-7110 | public school | 1413 | X | X | | X | | X | | No | | 10' | --- |
| 17. Ormond Bch. Sr. Citizens Ctr.<br>West Granada Avenue<br>Ormond Beach<br>904/677-0311, Ext. 23b<br>*Note: Medical Shelter only.* | meeting hall | 150 | | | | X | | X | | Yes | | 10' | --- |
| 18. R. Patillo Elementary<br>300 6th Street<br>New Smyrna Beach<br>904/427-1392 | public school | 680 | X | X | | X | | X | | Yes | | 10' | Cat. 2 |
| 19. Port Orange Elementary<br>402 Dunlawton Avenue<br>Port Orange<br>904/767-0113 | public school | 331 | X | X | | X | | X | | Yes | | 10' | Cat. 3 |
| 20. South Daytona Elementary<br>600 Elizabeth Place<br>South Daytona<br>904/767-0221 | public school | 870 | X | X | | X | | X | | Yes | | 10' | --- |

*Although various provisions have been made for providing food services, in general, food will be brought into the shelters from outside sources.

NOTE: Shelter capacity was based on 40 sq. ft./person, a standard recommended by the American Red Cross and utilized by the local Red Cross chapters within the Study Area. Discussions regarding the availability of capacity reflect this standard.

TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER: Gas | POWER: Electricity | POWER: Other | WATER: Dependent | WATER: Independent | WASTEWATER FACILITY: Dependent | WASTEWATER FACILITY: Independent | FOOD CAPABILITY: Kitchen | FOOD CAPABILITY: Food Supply* | VULNERABILITY ANALYSIS: Elevation Above MSL | VULNERABILITY ANALYSIS: Flood Hazard Analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- EAST<br>Page 5 of 6. | | | | | | | | | | | | | |
| 21. South Ridgewood Elementary<br>731 S. Ridgewood Avenue<br>Daytona Beach<br>904/252-0592 | public school | 214 | X | X | | X | | X | | Yes | | 10' | Cat. 2 |
| 22. Spruce Creek Elementary<br>642 Taylor Road<br>Port Orange<br>904/788-1341 | public school | 368 | X | X | | X | | X | | Yes | | 25' | --- |
| 23. Spruce Creek Senior High<br>1484 Taylor Road<br>Port Orange<br>904/761-0220 | public school | 2828 | X | X | | X | | X | | No | | 25' | --- |
| 24. Tomoka Elementary<br>R.F.D. 1 Old Tomoka Road<br>Ormond Beach<br>904/677-3822 | public school | 1133 | | | | X | | X | | Yes | | 25' | --- |
| 25. Turie T. Small Elementary<br>300 South Street<br>Daytona Beach<br>904/252-4738 | public school | 887 | X | X | | X | | X | | No | | 10' | --- |

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# TABLE 14 (cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- EAST<br>Page 6 of 6. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 26. West Side Elementary<br>1210 Jimmy Ann Drive<br>Daytona Beach<br>904/253-1671 | public school | 1361 | X | X | | X | | X | | Yes | | 28' | --- |

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# TABLE 14

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- WEST<br>Page 1 of 3. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 1. Boston Avenue<br>340 No. Boston Avenue<br>DeLand<br>904/734-2060 | public school | 516 | X | X | | X | | X | | Yes | | 85' | --- |
| 2. DeLand Senior High<br>800 No. Hill Avenue<br>DeLand<br>904/734-1100 | public school | 1387 | X | X | | X | | X | | Yes | | 80' | --- |
| 3. Deltona Jr. High<br>250 Enterprise Road<br>Deltona<br>904/574-6626 | public school | 1500 | X | X | | X | | X | | Yes | | 85' | --- |
| 4. Enterprise Elementary<br>211 Main Street<br>Enterprise<br>904/668-8641 | public school | 1090 | X | X | | X | | X | | Yes | | 25' | --- |
| 5. Fla. Lutheran Retirement Ctr.<br>431 No. Kansas Avenue<br>DeLand<br>904/734-0603<br>*Note: Medical Shelter only.* | meeting hall | 200 | X | X | | X | | X | | Yes | | 80' | --- |

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TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER: Gas | POWER: Electricity | POWER: Other | WATER: Dependent | WATER: Independent | WASTEWATER FACILITY: Dependent | WASTEWATER FACILITY: Independent | FOOD CAPABILITY: Kitchen | FOOD CAPABILITY: Food Supply* | VULNERABILITY ANALYSIS: Elevation Above MSL | VULNERABILITY ANALYSIS: Flood Hazard Analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- WEST<br>Page 2 of 3. | | | | | | | | | | | | | |
| 6. Long Lake Helen Elementary<br>307 South Lakeview Drive<br>Lake Helen<br>904/228-2208 | public school | 187 | X | X | | X | | | septic tank | (satellite feeding) | | 65' | --- |
| 7. Louise S. McInnis<br>Highway 17<br>DeLeon Springs<br>904/985-4812 | public school | 544 | X | X | | | well | | package plant | yes | | 65' | --- |
| 8. George Marks Elementary<br>1000 No. Garfield Avenue<br>DeLand<br>904/734-0401 | public school | 587 | X | X | | X | | | septic tank | yes | | 75' | --- |
| 9. Orange City Elementary<br>555 East University Avenue<br>Orange City<br>904/775-3090 | public school | 451 | X | X | | X | | | septic tank | yes | | 65' | --- |
| 10. Seville Elementary<br>Highway 17<br>Seville<br>904/749-2292 | public school | 375 | X | X | | | well | | septic tank | yes | | 55' | --- |

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TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLUSIA COUNTY -- WEST<br>Page 3 of 3. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 11. Southwestern Center<br>605 W. New Hampshire<br>DeLand<br>904/734-7700 | public school | 933 | X | X | | X | | | septic tank | yes | | 65' | --- |
| 12. Starke Elementary<br>730 So. Parson Street<br>DeLand<br>904/734-6700 | public school | 425 | X | X | | X | | X | | yes | | 35' | --- |
| 13. T. DeWitt Taylor High<br>100 E. Washington Avenue<br>Pierson<br>904/749-2223 | public school | 300 | X | X | | | well | | package plant | yes | | 65' | --- |
| 14. Woodward Avenue<br>1201 So. Woodward Ave.<br>DeLand<br>904/734-6176 | public school | 1120 | X | X | | X | | | package plant | yes | | 65' | --- |

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TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER: Gas | POWER: Electricity | POWER: Other | WATER: Dependent | WATER: Independent | WASTEWATER FACILITY: Dependent | WASTEWATER FACILITY: Independent | FOOD CAPABILITY: Kitchen | FOOD CAPABILITY: Food Supply* | VULNERABILITY ANALYSIS: Elevation Above MSL | VULNERABILITY ANALYSIS: Flood Hazard Analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--North<br>Page 1 of 3. | | | | | | | | | | | | | |
| 1. Apollo Elementary<br>3300 Knox McRae Drive<br>Titusville<br>305/267-7890 | public school | 350 | | X | | X | | X | | Yes | | 25' | --- |
| 2. Astronaut High<br>500 War Eagle Blvd.<br>Titusville<br>305/267-5500 | public school | 1000 | | X | | X | | X | | Yes | | 20' | --- |
| 3. Coquina Elementary<br>850 Knox McRae Drive<br>Titusville<br>305/267-7014 | public school | 400 | | X | | X | | X | | Yes | | 20' | --- |
| 4. Imperial Estates Elementary<br>5525 Kathy Drive<br>Titusville<br>305/267-1773 | public school | 300 | | X | | X | | X | | No | | 25' | --- |
| 5. Jackson Middle<br>1515 Knox McRae Drive<br>Titusville<br>305/269-1812 | public school | 450 | | X | | X | | X | | Yes | | 25' | --- |

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## TABLE 14 (Cont.)

### SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--North<br>Page 2 of 3. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 6. Madison Middle<br>3375 Dairy Road<br>Titusville<br>305/267-4077 | public school | 416 | | X | | X | | X | | No | | 30' | --- |
| 7. Mims Elementary<br>2582 U.S. Highway 1<br>Mims<br>305/267-3344 | public school | 300 | | X | | | well | | pckage. plant | Yes | | 20' | --- |
| 8. Oak Park Elementary<br>3395 Dairy Road<br>Titusville<br>305/269-3252 | public school | 350 | | X | | X | | X | | Yes | | 20' | --- |
| 9. Pinewood Elementary<br>3654 Lionel Road<br>Mims<br>305/269-4530 | public school | 300 | | X | | | well | | pckage. plant | No | | 20' | --- |
| 10. Riverview Elementary<br>3000 Jolly St.<br>Titusville<br>305/269-2325 | public school | 400 | | X | | X | | X | | No | | 25' | --- |

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# TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--North<br>Page 3 of 3. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 11. South Lake Elementary<br>3755 Garden St.<br>Titusville<br>305/269-1022 | public school | 375 | | X | | X | | X | | Yes | | 30' | --- |
| 12. Titusville High<br>1850 So. Washington Ave.<br>Titusville<br>305/269-3561 | public school | 900 | | X | | X | | X | | Yes | | 30' | Cat. 3 |
| 13. Brevard Community College<br>North Campus<br>1111 No. Washington Ave.<br>Titusville<br>305/269-5664 | college | 270 | | X | E & gen-era-tor. | | | | | Yes | | 25' | --- |
| 14. First Presbyterian Church of Titusville<br>1300 Golfview Drive<br>Titusville<br>305/267-2745 | church | 186 | | X | | X | | X | | Yes | | 35' | --- |
| | | | | | | | | | | | | | |

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TABLE 14 (cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--Central<br>Page 1 of 4. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 1. Hans Christian Andersen Elem.<br>3011 South Fiske Blvd.<br>Rockledge<br>305/636-5610 | public school | 350 | | X | | X | | X | | No | | 25' | --- |
| 2. Cambridge Elementary<br>2000 Cambridge Drive<br>Cocoa<br>305/636-3443 | public school | 350 | | X | | X | | X | | Yes | | 25' | --- |
| 3. Clearlake Middle<br>1225 Clearlake Rd.<br>Cocoa<br>305/636-4021 | public school | 350 | | X | | X | | X | | No | | 20' | --- |
| 4. Cocoa High<br>2000 Tiger Trail<br>Cocoa<br>305/632-5300 | pgblic school | 900 | | X | | X | | X | | Yes | | 20' | --- |
| 5. Fairglen Elementary<br>201 Indian Trail<br>Cocoa<br>205/631-1993 | public school | 350 | | X | | X | | | pkage. plant | Yes | | 25' | --- |

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## TABLE 14 (Cont.)

### SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--Central<br>Page 2 of 4. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 6. Golfview Elementary<br>1530 So. Fiske Blvd.<br>Rockledge<br>305/632-3880 | public school | 350 | | X | | X | | X | | No | | 25' | --- |
| 7. Kennedy Middle<br>2100 So. Fiske Blvd.<br>Rockledge<br>305/632-9500 | public school | 500 | | X | | X | | X | | Yes | | 25' | --- |
| 8. Poinsett Middle<br>501 Poinsett Drive<br>Cocoa<br>305/636-4982 | public school | 550 | | X | | | | | | | | 20' | --- |
| 9. Pineda Elementary<br>905 Pineda St.<br>Cocoa<br>305/636-3545 | public school | 500 | | X | | X | | X | | Yes | | 25' | --- |
| 10. Rockledge High<br>220 Rockledge Ave.<br>Rockledge<br>305/636-3711 | public school | 900 | | X | | X | | X | | Yes | | 25' | --- |

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## TABLE 14 (Cont.)

### SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--Central<br>Page 3 of 4. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 11. Saturn Elementary<br>880 Range Road<br>Cocoa<br>305/632-6161 | public school | 400 | | X | | X | | X | | Yes | | 15' | --- |
| 12. Brevard Community College--<br>Central Campus<br>1519 Clearlake Road<br>Cocoa<br>305/632-1111, ext. 304/305 | college | 1070 | | X | E | X<br>(lift station required) | | | | No | | 12' | --- |
| 13. Cocoa Presbyterian Church<br>1404 Dixon Blvd.<br>Cocoa<br>305/636-9602 | church | 355 | | X | | X | | | | Yes | | 20' | --- |
| 14. First Baptist Church of Rockledge<br>1810 Cedar Street<br>Rockledge<br>305/636-1493 | church | 350 | | X | | | | X | | Yes | | 25' | --- |
| 15. First United Methodist Church of Cocoa<br>825 Forrest Avenue<br>Cocoa<br>305/636-4811 | church | 166 | | X | | | | | Septic tanks (3) | Yes | | 15' | Cat. 3 |

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TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--Central<br>Page 4 of 4. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 16. Hope United Church of Christ<br>2555 So. Fiske Blvd.<br>Rockledge<br>305/636-0250 | church | 133 | | X | | | | X | | Yes | | 15' | --- |
| 17. Mt. Moriah AME Church--Cocoa<br>305 Magnolia<br>Cocoa<br>305/636-0025 | church | 300 | | X | E | | | X | | Yes | | 20' | --- |
| 18. St. Mary's Church<br>1132 So. Seminole Drive<br>Rockledge<br>305/636-6834 | church | 100 | | X | | | | X | | Yes | | 20' | --- |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |

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TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--South<br>Page 1 of 7. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 1. Central Jr. High<br>250 West Brevard Drive<br>Melbourne<br>305/254-4875 | public school | 575 | | X | | X | | X | | Yes | | 20' | --- |
| 2. Creel Elementary<br>1566 Palmwood Drive<br>Melbourne<br>305/259-3233 | public school | 400 | | | generator. | | | | | Yes | | 20' | --- |
| 3. Croton Elementary<br>1449 Croton Road<br>Melbourne<br>305/259-3818 | public school | 350 | | | generator. | X | | X | | Yes | | 20' | --- |
| 4. Eau Gallie High<br>1400 Commodore Blvd.<br>Melbourne<br>305/254-8421 | public school | 900 | | | generator. | X | | X | | Yes | | 25' | --- |
| 5. Harbor City Elementary<br>1377 Sarno Road<br>Melbourne<br>305/254-5534 | public school | 350 | | | generator. | X | | X | | Yes | | 20' | --- |

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TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--South<br>Page 2 of 7. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 6. Johnson Jr. High<br>2155 Croton Road<br>Melbourne<br>305/259-3338 | public school | 550 | | | generator. | X | | X | | Yes | | 15' | --- |
| 7. Meadowlane Elementary<br>Minton Road<br>West Melbourne<br>(305/723-6354 | public school | 300 | | X | | X | | X | | No | | 20' | --- |
| 8. Melbourne High<br>74 Bulldog Blvd.<br>Melbourne<br>305/723-4151 | public school | 1000 | | X | | X | | X | | Yes | | 25' | --- |
| 9. Palm Bay Elementary<br>515 Allamanda Rd. S.E.<br>Palm Bay<br>305/723-1055 | public school | 350 | | X | | X | | X | | Yes | | 25' | --- |
| 10. Palm Bay High<br>1 Pirate Lane<br>Melbourne<br>305/723-3031 | public school | 925 | | X | | X | | X | | Yes | | 25' | --- |

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## TABLE 14 (Cont.)

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| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--South<br>Page 3 of 7. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 11. Roy Allen Elementary<br>2601 Fountainhead Blvd.<br>Melbourne<br>305/254-4496 | public school | 300 | | | generator. | X | | X | | No | | 25' | --- |
| 12. Sabal Elementary<br>1400 Wickham Road<br>Melbourne<br>305/254-7261 | public school | 325 | | | generator. | X | | X | | Yes | | 25' | --- |
| 13. Sherwood Elementary<br>900 Post Road<br>Melbourne<br>305/254-6424 | public school | 325 | | | generator. | X | | X | | Yes | | 20' | --- |
| 14. Stone Middle<br>1101 East University Blvd.<br>Melbourne<br>305/723-0741 | public school | 650 | | X | | X | | X | | Yes | | 25' | --- |
| 15. University Park Elementary<br>500 W. University Blvd.<br>Melbourne<br>305/723-2566 | public school | 300 | | X | | X | | X | | Yes | | 15' | --- |

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## TABLE 14. (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--South<br>Page 4 of 7. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 16. Brevard Community College<br>South Campus<br>3865 N. Wickham Road<br>Melbourne<br>305/254-0305, ext. 203 | college | 2000 | | X | generator. | | | | | Yes | | 20' | --- |
| 17. Florida Institute of Technology<br>Country Club & University Park Blvd.<br>Melbourne<br>305/723-3701 | college | 250 | | X | E | | | | | No | | 15' | --- |
| 18. Bethel Assembly of Good<br>26 West Fee Avenue<br>Melbourne<br>305/727-2606 | church | 125 | | X | | | | | septic tank | Yes | | 25' | --- |
| 19. Bowe Gardens Baptist<br>2700 Sarno Road<br>Melbourne<br>305/254-5622 | church | 166 | | X | generator. | | | X | | Yes | | 20' | --- |
| 20. First Church of the Nazarene<br>2745 So. Babcock St.<br>Melbourne<br>305/723-3745 | church | 110 | | X | | X | | | septic tank | Yes | | 20' | --- |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--South<br>Page 5 of 7. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 21. First United Methodist of Melbourne<br>110 E. New Haven Avenue<br>Melbourne<br>305/723-6761 | church | 575 | | X | | | | X | | Yes | | 20' | --- |
| 22. Free Will Baptist<br>938 Lytton Road<br>Melbourne<br>305/254-7282 | church | 100 | | X | | | well | | septic tanks (2) | No | | 25' | --- |
| 23. Harbor City Baptist<br>2740 No. Pineapple<br>Melbourne<br>305/494-4774 | church | 287 | | X | gen-era-tor. | X | | X | | Yes | | 25' | Cat. 2 |
| 24. Palm Bay United Methodist<br>702 S.E. Point Malabar Blvd.<br>Palm Bay<br>305/727-8651 | church | 133 | | X | E | X | | X | | Yes | | 25' | --- |

*Although various provisions have been made for providing food services, in general, food will be brought into the shelters from outside sources.

NOTE: Shelter capacity was based on 40 sq. ft./person, a standard recommended by the American Red Cross and utilized by the local Red Cross chapters within the Study Area. Discussions regarding the availability of capacity reflect this standard.

TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER: Gas | POWER: Electricity | POWER: Other | WATER: Dependent | WATER: Independent | WASTEWATER FACILITY: Dependent | WASTEWATER FACILITY: Independent | FOOD CAPABILITY: Kitchen | FOOD CAPABILITY: Food Supply* | VULNERABILITY ANALYSIS: Elevation Above MSL | VULNERABILITY ANALYSIS: Flood Hazard Analysis |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--South<br>Page 6 of 7. | | | | | | | | | | | | | |
| 25. St. Paul's United Methodist<br>1591 Highland Avenue<br>Melbourne<br>305/254-6363 | church | 166 | X | X | E & generator. | X | | X | | Yes | | 20' | Cat. 3 |
| 26. United Church of Christ<br>U.S. 1 & Strawbridge Ave.<br>Melbourne<br>305/723-3575 | church | 100 | | X | | X | | X | | Yes | | 25' | Cat. 3 |
| 27. Wesley United Methodist<br>50 Minton Road<br>West Melbourne<br>305/727-7585 | church | 125 | | X | | | X | | septic tank | Yes | | 20' | --- |
| 28. Our Lady of Lourdes<br>1710 So. Hickory Street<br>Melbourne<br>305/723-3636<br>*Note: for dialysis (kidney machine) patients only.* | church/ hospital | 150 | | | | X | | X | | | | 25' | --- |
| 29. Palm Bay Recreation Center<br>Port Malabar Blvd.<br>Palm Bay<br>305/727-7100 | recreation center | 827 | | X | | X | | X | | Yes | | 20' | --- |

*Although various provisions have been made for providing food services, in general, food will be brought into the shelters from outside sources.

NOTE: Shelter capacity was based on 40 sq. ft./person, a standard recommended by the American Red Cross and utilized by the local Red Cross chapters within the Study Area. Discussions regarding the availability of capacity reflect this standard.

## TABLE 14 (Cont.)

SHELTER INVENTORY

| SHELTER (Address/Phone) | TYPE OF STRUCTURE | CAPACITY | POWER | | | WATER | | WASTEWATER FACILITY | | FOOD CAPABILITY | | VULNERABILITY ANALYSIS | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BREVARD COUNTY--South<br>Page 7 of 7. | | | Gas | Electricity | Other | Dependent | Independent | Dependent | Independent | Kitchen | Food Supply* | Elevation Above MSL | Flood Hazard Analysis |
| 30. Trinity Towers<br>650 E. Strawbridge Ave.<br>Melbourne<br>305/723-7512<br>*Note: For handicapped only.* | senior citizens center | 170 | | X | | X | | X | | Yes | | 15' | --- |
| 31. Veterans of Foreign Wars Post #4206<br>3201 So. Dairy Road<br>Melbourne<br>305/724-4121 | veterans organization | 111 | X | X | | | X | | septic tank | | | 20' | --- |

*Although various provisions have been made for providing food services, in general, food will be brought into the shelters from outside sources.

NOTE: Shelter capacity was based on 40 sq. ft./person, a standard recommended by the American Red Cross and utilized by the local Red Cross chapters within the Study Area. Discussions regarding the availability of capacity reflect this standard.

be confusing in a future emergency. Secondly, as the purpose of this study was to provide an overall framework for plan development, the designation of specific operational manpower was beyond the scope of this work effort.

## SHELTER/MEDICAL FACILITY SURGE ANALYSIS

To determine the availability of shelter/medical facilities for use during a hurricane, a surge analysis was completed. Specifically, the intent of the analysis was to determine under what circumstances which facilities are subject to hurricane-induced storm surge and should not be used. In addition, medical and group homes subject to flooding were identified. Since residents of medical facilities and group homes suffer from a lack of mobility and may need continuous medical attention, their potential for special needs during an evacuation must be identified.

The methodology used in determining the flooding potential of public shelters within the study area consisted of comparing the geographic location of a particular structure to the predicted level of storm surge inundation as identified in the Vulnerability Analysis. First, each structure was pinpointed on a set of vulnerability area maps, which have been included in the appendices. These maps identify each of the 63 shelters in Brevard County and 26 coastal shelters in Volusia County. The site location numbers found on the vulnerability area maps correspond to the public shelter number in Table 15. Fourteen additional Volusia County shelters are located considerably inland and, consequently, were not considered in the surge vulnerability analysis. Each of the 89 shelters was then identified in regard to its potential for flooding from various categories of storms.

The surge vulnerability analysis of public shelters within the two-county study area identified five facilities vulnerable to a category 1-2 storm and 9 facilities vulnerable in a category 3-5 storm. Based on these determinations, recommendations to existing sheltering plans were forwarded to local disaster preparedness officials.

The methodology used in determining the feasibility of public shelters was also used in analyzing group homes, hospitals and nursing homes. The surge vulnerability analysis on health care facilities, however, was conducted in regard to the special evacuation needs of the elderly/disabled; namely, transportation logistics and medical supervision. Facilities determined to be susceptible to hurricane-generated storm surge must develop operational plans for evacuating their patients/residents. Since there will be related demands for trained personnel and proper medical equipment, it is suggested that vulnerable health care facilities (risk facilities) evacuate to similar facilities which are not prone to storm surge inundation (host facilities). Thus, those health care facilities determined not to be located in vulnerable areas must also develop disaster preparedness plans, since they will be called on to accommodate displaced elderly and disabled evacuees.

# TABLE 15

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *BREVARD COUNTY* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Group Homes)* | | | | | | |
| 1. Asbury Arms Apartments<br>1430 Dixon Blvd.<br>Cocoa<br>(305) 632-4943 | | | | | | XX |
| 2. Bethesda Baptist Retirement Home<br>748 Fordham Road<br>Palm Bay<br>(305) 723-3288 | | | | | | XX |
| 3. Brevard Hotel<br>112 Indian River Drive<br>Cocoa<br>(305) 636-1411 | XX | | | | | |
| 4. Titusville Tower<br>1405 Indian River Avenue<br>Titusville<br>(305) 269-2810 | | | XX | | | |
| 5. Tompkins Adult Congregate Home<br>100 Lee Road<br>West Melbourne<br>(305) 724-4950 | | | | | | XX |
| 6. Trinity Towers East<br>700 East Strawbridge Avenue<br>Melbourne<br>(305) 723-7511 | | | | | | XX |
| 7. Trinity Towers South<br>New Haven Drive<br>Melbourne<br>(305) 723-8620 | | | | | | XX |
| 8. Trinity Towers West<br>650 East Strawbridge Avenue<br>Melbourne<br>(305) 723-7512 | | | | | | XX |
| 9. Vereene's Love & Care Home<br>1304 East Gibbs Street<br>Melbourne<br>(305) 727-0708 | | | | | | XX |
| *(Hospitals)* | | | | | | |
| 10. Cape Canaveral Hospital<br>701 West Cocoa Beach Causeway<br>Cocoa Beach<br>(305) 783-7721 | XX | | | | | |

## TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| BREVARD COUNTY *(continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Hospitals--continued)* | | | | | | |
| 11. James H. Holmes Regional Med. Ctr.<br>1350 So. Hickory Street<br>Melbourne<br>(305) 727-7000 | | | | | | XX |
| 12. Jess Parish Memorial Hospital<br>751 No. Washington Avenue<br>Titusville<br>(305) 268-6111 | | | | | | XX |
| 13. Wuestoff Memorial Hospital<br>110 Longwood Avenue<br>Rockledge<br>(305) 636-2211 | | | | | | XX |
| *(Nursing Homes)* | | | | | | |
| 14. Adare Medical Center<br>1775 Huntington Lane<br>Rockledge<br>(305) 632-7341 | | | | | | XX |
| 15. Carnegie Gardens Nursing Home<br>1415 So. Hickory Street<br>Melbourne<br>(305) 723-1321 | | | | | | XX |
| 16. Florida Convalescent Home, Inc.<br>516 East Sheridan Road<br>Melbourne<br>(305) 727-0984 | | | | | | XX |
| 17. Medic-Home Health Ctr. of Melbourne<br>1420 So. Oak Street<br>Melbourne<br>(305) 723-3215 | | | | | | XX |
| 18. Merritt Manor Nursing Home<br>125 Alma Boulevard<br>Merritt Island<br>(305) 453-0202 | | | XX | | | |
| 19. Sunny Pines Convalescent Ctr.,Inc.<br>587 Barton Boulevard<br>Rockledge<br>(305) 632-6300 | | | | | | XX |
| 20. Titusville Nursing & Convalesc.Ctr.<br>1705 Jess Parish Court<br>Titusville<br>(305) 269-5720 | | | | | | XX |

# TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS

| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *BREVARD COUNTY (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Nursing Homes--continued)* | | | | | | |
| 21. West Melbourne Health Care Center<br>125 Alma Boulevard<br>Merritt Island<br>(305) 453-0202 | | | XX | | | |
| *(Public Shelters)* - NORTH | | | | | | |
| 22. Apollo Elementary<br>3300 Knox McRae Drive<br>Titusville<br>(305) 267-7890 | | | | | | XX |
| 23. Astronaut High<br>800 War Eagle Boulevard<br>Titusville<br>(305) 267-5500 | | | | | | XX |
| 24. Coquina Elementary<br>850 Knox McRae Drive<br>Titusville<br>(305) 267-7014 | | | | | | XX |
| 25. Imperial Estates Elementary<br>5525 Kathy Drive<br>Titusville<br>(305) 267-1773 | | | | | | XX |
| 26. Jackson Middle<br>1515 Knox McRae Drive<br>Titusville<br>(305) 269-1812 | | | | | | XX |
| 27. Madison Middle<br>3375 Dairy Road<br>Titusville<br>(305) 267-4077 | | | | | | XX |
| 28. Mims Elementary<br>2582 US Highway 1<br>Mims<br>(305) 267-3344 | | | | | | XX |
| 29. Oak Park Elementary<br>3395 Dairy Road<br>Titusville<br>(305) 269-3252 | | | | | | XX |
| 30. Pinewood Elementary<br>3654 Lionel Road<br>Mims<br>(305) 269-4530 | | | | | | XX |

# TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *BREVARD COUNTY (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Public Shelters - NORTH -- continued)* | | | | | | |
| 31. Riverview Elementary<br>3000 Jolly Street<br>Titusville<br>(305) 269-2325 | | | | | | XX |
| 32. South Lake Elementary<br>3755 Garden Street<br>Titusville<br>(305) 269-1022 | | | | | | XX |
| 33. Titusville High<br>1850 So. Washington Ave.<br>Titusville<br>(305) 269-3561 | | | XX | | | |
| 34. Brevard Comm. College-North Campus<br>1111 No. Washington Avenue<br>Titusville<br>(305) 269-5664 | | | | | | XX |
| 35. First Presbyterian Church of Titusville<br>1300 Golfview Drive<br>Titusville<br>(305) 267-2745 | | | | | | XX |
| *(Public Shelters) - CENTRAL* | | | | | | |
| 36. Hans Christian Andersen Elementary<br>3011 So. Fiske Boulevard<br>Rockledge<br>(305) 636-5610 | | | | | | XX |
| 37. Cambridge Elementary<br>2000 Cambridge Drive<br>Cocoa<br>(305) 636-3443 | | | | | | XX |
| 38. Clearlake Middle<br>1225 Clearlake Road<br>Cocoa<br>(305) 636-4021 | | | | | | XX |
| 39. Cocoa High<br>2000 Tiger Trail<br>Cocoa<br>(305) 632-5300 | | | | | | XX |
| 40. Fairglen Elementary<br>201 Indian Trail<br>Cocoa<br>(305) 631-1993 | | | | | | XX |

| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| BREVARD COUNTY *(continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Public Shelters - CENTRAL - continued)* | | | | | | |
| 41. Golfview Elementary<br>1530 So. Fiske Boulevard<br>Rockledge<br>(305) 632-3880 | | | | | | XX |
| 42. Kennedy Middle<br>2100 So. Fiske Boulevard<br>Rockledge<br>(305) 632-9500 | | | | | | XX |
| 43. Poinsett Middle<br>501 Poinsett Drive<br>Cocoa<br>(305) 636-4982 | | | | | | XX |
| 44. Pineda Elementary<br>905 Pineda Street<br>Cocoa<br>(305) 636-3545 | | | | | | XX |
| 45. Rockledge High<br>220 Rockledge Avenue<br>Rockledge<br>(305) 636-3711 | | | | | | XX |
| 46. Saturn Elementary<br>880 Range Road<br>Cocoa<br>(305) 632-6161 | | | | | | XX |
| 47. Brevard Comm. College - Central Campus<br>1519 Clearlake Road<br>Cocoa<br>(305) 632-1111, Ext. 304/305 | | | | | | XX |
| 48. Cocoa Presbyterian Church<br>1404 Dixon Boulevard<br>Cocoa<br>(305) 636-9602 | | | | | | XX |
| 49. 1st Baptist Church of Rockledge<br>1810 Cedar Street<br>Rockledge<br>(305) 636-1493 | | | | | | XX |
| 50. 1st United Meth. Church of Cocoa<br>825 Forrest Avenue<br>Cocoa<br>(305) 636-4811 | | | XX | | | |

| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *BREVARD COUNTY (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Public Shelters - CENTRAL - continued)* | | | | | | |
| 51. Hope United Church of Christ<br>2555 So. Fiske Boulevard<br>Rockledge<br>(305) 636-0250 | | | | | | XX |
| 52. Mt. Moriah AME Church - Cocoa<br>305 Magnolia<br>Cocoa<br>(305) 636-0025 | | | | | | XX |
| 53. St. Mary's Church<br>1132 So. Seminole Drive<br>Rockledge<br>(305) 636-6834 | | | | | | XX |
| *(Public Shelters) - SOUTH* | | | | | | |
| 54. Central Jr. High<br>250 West Brevard Drive<br>Melbourne<br>(305) 254-4875 | | | | | | XX |
| 55. Creel Elementary<br>1566 Palmwood Drive<br>Melbourne<br>(305) 259-3233 | | | | | | XX |
| 56. Croton Elementary<br>1449 Croton Road<br>Melbourne<br>(305) 259-3818 | | | | | | XX |
| 57. Eau Gallie High<br>1400 Commodore Boulevard<br>Melbourne<br>(305) 254-8421 | | | | | | XX |
| 58. Harbor City Elementary<br>1377 Sarno Road<br>Melbourne<br>(305) 254-5534 | | | | | | XX |
| 59. Johnson Jr. High<br>2155 Croton Road<br>Melbourne<br>(305) 259-3338 | | | | | | XX |
| 60. Meadowlane Elementary<br>Minton Road<br>West Melbourne<br>(305) 723-6354 | | | | | | XX |

| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *BREVARD COUNTY (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Public Shelters - SOUTH - continued)* | | | | | | |
| 61. Melbourne High<br>74 Bulldog Boulevard<br>Melbourne<br>(305) 723-4151 | | | | | | XX |
| 62. Palm Bay Elementary<br>515 Allamanda Road, SE<br>Palm Bay<br>(305) 723-1055 | | | | | | XX |
| 63. Palm Bay High<br>1 Pirate Lane<br>Melbourne<br>(305) 723-3031 | | | | | | XX |
| 64. Roy Allen Elementary<br>2601 Fountainhead Boulevard<br>Melbourne<br>(305) 254-4496 | | | | | | XX |
| 65. Sabal Elementary<br>1400 Wickham Road<br>Melbourne<br>(305) 254-7261 | | | | | | XX |
| 66. Sherwood Elementary<br>900 Post Road<br>Melbourne<br>(305) 254-6424 | | | | | | XX |
| 67. Stone Middle<br>1101 East University Boulevard<br>Melbourne<br>(305) 723-0741 | | | | | | XX |
| 68. University Park Elementary<br>600 W. University Boulevard<br>Melbourne<br>(305) 723-2566 | | | | | | XX |
| 69. Brevard Comm. College-So.Campus<br>3865 No. Wickham Road<br>Melbourne<br>(305) 254-0305, Ext. 203 | | | | | | XX |
| 70. FL Institute of Technology<br>Country Club & University Park Blvd.<br>Melbourne<br>(305) 723-3701 | | | | | | XX |

| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| BREVARD COUNTY *(continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Public Shelters - SOUTH - continued)* | | | | | | |
| 71. Bethel Assembly of God<br>26 West Fee Avenue<br>Melbourne<br>(305) 727-2606 | | | | | | XX |
| 72. Bowe Gardens Baptist<br>2700 Sarno Road<br>Melbourne<br>(305) 254-5622 | | | | | | XX |
| 73. 1st Church of the Nazarene<br>2745 So. Babcock Street<br>Melbourne<br>(305) 723-3745 | | | | | | XX |
| 74. 1st United Methodist of Melbourne<br>110 E. New Haven Avenue<br>Melbourne<br>(305) 723-6761 | | | | | | XX |
| 75. Free Will Baptist<br>938 Lytton Road<br>Melbourne<br>(305) 254-7282 | | | | | | XX |
| 76. Harbor City Baptist<br>2740 No. Pineapple<br>Melbourne<br>(305) 494-4774 | | XX | | | | |
| 77. Palm Bay United Methodist<br>702 SE Point Malabar Boulevard<br>Palm Bay<br>(305) 727-8651 | | | | | | XX |
| 78. St. Paul's United Methodist<br>1591 Highland Avenue<br>Melbourne<br>(305) 254-6363 | | | XX | | | |
| 79. United Church of Christ<br>US 1 & Strawbridge Ave.<br>Melbourne<br>(305) 723-3575 | | | XX | | | |
| 80. Wesley United Methodist<br>50 Minton Road<br>West Melbourne<br>(305) 727-7585 | | | | | | XX |

# TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *BREVARD COUNTY (continued)* | Cate-gory 1 | Cate-gory 2 | Cate-gory 3 | Cate-gory 4 | Cate-gory 5 | Not Vulnerable to Surge |
| *(Public Shelters - SOUTH - continued)* | | | | | | |
| 81. Our Lady of Lourdes<br>1710 So. Hickory Street<br>Melbourne<br>(305) 723-3636 *(Note: For dialysis (kidney machine) patients only)* | | | | | | XX |
| 82. Palm Bay Recreation Center<br>Port Malabar Boulevard<br>Palm Bay<br>(305) 727-7100 | | | | | | XX |
| 83. Veterans of Foreign Wars<br>Post #4206<br>3201 So. Dairy Road<br>Melbourne<br>(305) 724-4121 | | | | | | XX |
| 8. Trinity Towers West<br>650 E. Strawbridge Ave.<br>Melbourne<br>(305) 723-7512<br>*(Note: For handicapped only)* | | | | | | XX |

# TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *VOLUSIA COUNTY* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Group Homes)* | | | | | | |
| 1. Beach Manor, Inc.<br>331 So. Ridgewood Avenue<br>Daytona Beach<br>(904) 255-2389 | | | | XX | | |
| 2. Big Tree Manor<br>1000 Big Tree Road<br>Daytona Beach<br>(904) 761-0690 | | | | | | XX |
| 3. Clark's Rooming House<br>545 Magnolia Avenue<br>Daytona Beach<br>(904) 253-2139 | | | | | | XX |
| 4. Country Manor<br>1127 West Herbert Street<br>Port Orange<br>(904) 761-7678 | | | | | | XX |
| 5. Golden Days Rest Home<br>834 No. Halifax<br>Daytona Beach<br>(904) 253-6364 | | | | XX | | |
| 6. Lynn's Care Center, Inc.<br>1562 Garden Avenue<br>Holly Hill<br>(904) 672-3135 | | | | | | XX |
| 7. Lynn's Care Center, Inc., Phase II<br>1529 Ridge Avenue<br>Holly Hill<br>(904) 672-3966 | | | | | | XX |
| 8. Mae Walls Care<br>1218 Old Kings Road<br>Holly Hill<br>(904) 255-9225 | | | | | | XX |
| 9. Martin Rest Home<br>1301 Pine Ridge Drive<br>Holly Hill<br>(904) 255-2455 | | | | | | XX |
| 10. Ocean View Manor<br>624 So. Atlantic<br>Daytona Beach<br>(904) 258-5116 | XX | | | | | |

# TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *VOLUSIA COUNTY (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Group Homes - continued)* | | | | | | |
| 11. Port Orange Elderly Guest Home, Inc.<br>414 Orange Avenue<br>Port Orange<br>(904) 767-5604 | | | | XX | | |
| 12. Rastelle Manor<br>934 So. Ridgewood Avenue<br>Daytona Beach<br>(904) 252-2627 | | | | XX | | |
| 13. Shady Oaks Rest Home<br>1208 Kennedy Avenue<br>Daytona Beach<br>(904) 672-9895 | | | | | | XX |
| 14. Signorelli's Elderly Care Home<br>158 Farmbrook Road<br>Harbor Oaks<br>(904) 767-1613 | | | | XX | | |
| 15. Sugar Lake Retirement Home<br>224 Mission Drive<br>New Smyrna Beach<br>(904) 427-2492 | | | | XX | | |
| 16. The Fair Haven<br>86 So. Ridgewood<br>Ormond Beach<br>(904) 677-1022 | | | | | | XX |
| 17. The Greater Love Retirement Center<br>1645 Center Street<br>Holly Hill<br>(904) 673-0957 | | | | | | XX |
| 18. Todd Boarding Home<br>522 Walker Street<br>Daytona Beach<br>(904) 252-5426 | | | | | | XX |
| *(Hospitals)* | | | | | | |
| 19. Daytona Beach General Hospital<br>1340 Ridgewood Avenue<br>Holly Hill<br>(904) 677-5100 | | | | | | XX |
| 20. Daytona Community Hospital<br>400 No. Clyde Morris Boulevard<br>Daytona Beach<br>(904) 255-8192 | | | | | | XX |

| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *VOLUSIA COUNTY (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Hospitals - continued)* | | | | | | |
| 21. Fish Memorial Hospital<br>300 Lytle Avenue<br>New Smyrna Beach<br>(904) 255-8981 | XX | | | | | |
| 22. Halifax Hospital Medical Center<br>Clyde Morris Boulevard<br>Daytona Beach<br>(904) 255-0161 | | | | | | XX |
| 23. Ormond Beach Hospital<br>264 So. Atlantic Avenue<br>Ormond Beach<br>(904) 672-4161 | | XX | | | | |
| 24. Ormond Memorial Hospital<br>875 Sterthaus Avenue<br>Ormond Beach<br>(904) 677-6900 | | | XX | | | |
| *(Nursing Homes)* | | | | | | |
| 25. Bowman's Nursing Center<br>350 So. Ridgewood Avenue<br>Ormond Beach<br>(904) 677-4545 | | | | | | XX |
| 26. Clyatt Memorial Geriatric Center<br>1001 So. Beach<br>Daytona Beach<br>(904) 255-3653 | | | XX | | | |
| 27. Daytona Beach Geriatric Center<br>1055 Third Street<br>Daytona Beach<br>(904) 252-3686 | | | | | | XX |
| 28. Daytona Manor Nursing Home<br>650 Reed Canal Road<br>South Daytona Beach<br>(904) 767-4831 | | | | | | XX |
| 29. Golden Age Nursing Home, Inc.<br>324 Wilder Boulevard<br>Daytona Beach<br>(904) 252-2600 | | | | | | XX |
| 30. Good Samaritan Nursing Center<br>325 So. Segrave Court<br>Daytona Beach<br>(904) 253-6791 | | | | XX | | |

# TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *VOLUSIA COUNTY (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Nursing Homes - continued)* | | | | | | |
| 31. Holiday Care Center<br>1031 So. Beach<br>Daytona Beach<br>(904) 255-2453 | | | XX | | | |
| 32. Huntington Square Convalarium<br>100 Broadway<br>Daytona Beach<br>(904) 255-6571 | XX | | | | | |
| 33. Medic Home Health Ctr. of Ormond Bch.<br>170 No. Kings Road<br>Ormond Beach<br>(904) 677-7955 | | | XX | | | |
| 34. Ocean View Nursing Home<br>2810 So. Atlantic Avenue<br>New Smyrna Beach<br>(904) 428-6424 | XX | | | | | |
| 35. Ormond Lutheran Manor<br>P.O. Drawer 397<br>Ormond Beach<br>(904) 677-9121 | | | | | | XX |
| *(Public Shelters)* - EAST | | | | | | |
| 36. Burns-Oak Hill Elementary<br>104 Ridge Road<br>Oak Hill<br>(904) 345-3453 | | | | | | XX |
| 37. Campbell Center<br>601 So. Keech Street<br>Daytona Beach<br>(904) 253-1686 | | | | | | XX |
| 38. Chisholm Center<br>577 Ronnoc Lane<br>New Smyrna Beach<br>(904) 428-2475 | | | XX | | | |
| 39. Daytona Beach Comm. College<br>500 Welch Boulevard, Bldgs. 14,16,25<br>Daytona Beach | | | | | | XX |
| 40. Edgewater Elementary<br>550 So. Old Count Road<br>Edgewater<br>(904) 427-5296 | | | | XX | | |

## TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *VOLUSIA County (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Public Shelters - EAST - continued)* | | | | | | |
| 41. Highlands-Hillcrest Elementary<br>323 Heineman Street<br>Daytona Beach<br>(904) 253-1891<br>*(Note: Medical Shelter only.)* | | | | | | XX |
| 42. Holly Hill Elementary<br>1049 Ridgewood Avenue<br>Holly Hill<br>(904) 252-6271 | | | | | | XX |
| 43. Holly Hill Junior High<br>1200 Center Street<br>Holly Hill<br>(904) 252-0421 | | | | | | XX |
| 44. Hurst Elementary<br>1340 Wright Street<br>Holly Hill<br>(904) 255-3846 | | | | | | XX |
| 45. Knights of Columbus Hall<br>509 No. Orange Street<br>New Smyrna Beach<br>(904) 427-4211<br>*(Note: Medical Shelter only.)* | | | | XX | | |
| 46. Mainland Junior High<br>215 Third Avenue<br>Daytona Beach<br>(904) 255-4561 | | | XX | | | |
| 47. Mainland Senior High<br>125 So. Clyde Morris<br>Daytona Beach<br>(904) 252-0401 | | | | | | XX |
| 48. New Smyrna Jr. High<br>100 Live Oak Street<br>New Smyrna Beach<br>(904) 428-5792 | | XX | | | | |
| 49. North Ridgewood Elementary<br>365 No. Ridgewood Avenue<br>Daytona Beach<br>(904) 252-7322 | | XX | | | | |
| 50. Ormond Beach Elementary<br>100 Cordin Avenue<br>Ormond Beach<br>(904) 677-3611 | | | | | | XX |

# TABLE 15 (Cont.)

SURGE VULNERABILITY ANALYSIS



| INSTITUTION (address/phone) | FLOOD HAZARD ANALYSIS | | | | | |
|---|---|---|---|---|---|---|
| *VOLUSIA COUNTY (continued)* | Category 1 | Category 2 | Category 3 | Category 4 | Category 5 | Not Vulnerable to Surge |
| *(Public Shelters - EAST - continued)* | | | | | | |
| 51. Ormond Beach Junior High<br>151 Domicilio Avenue<br>Ormond Beach<br>(904) 677-7110 | | | | | | XX |
| 52. Ormond Beach Senior Citizens Center<br>194 West Granada Avenue<br>Ormond Beach<br>(904) 677-0311, Ext. 256<br>*(Note: Medical Shelter only.)* | | | | | | XX |
| 53. R. Patillo Elementary<br>300 Sixth Street<br>New Smyrna Beach<br>(904) 427-1392 | | | | | | |
| 54. Port Orange Elementary<br>402 Dunlawton Avenue<br>Port Orange<br>(904) 767-0113 | | | XX | | | |
| 55. South Daytona Elementary<br>600 Elizabeth Place<br>South Daytona<br>(904) 767-0221 | | | | | | XX |
| 56. South Ridgewood Elementary<br>731 So. Ridgewood Avenue<br>Daytona Beach<br>(904) 252-0592 | | XX | | | | |
| 57. Spruce Creek Elementary<br>642 Taylor Road<br>Port Orange<br>(904) 788-1341 | | | | | | XX |
| 58. Spruce Creek Senior High<br>1484 Taylor Road<br>Port Orange<br>(904) 761-0220 | | | | | | XX |
| 59. Tomoka Elementary<br>R.F.D. 1 Old Tomoka Road<br>Ormond Beach<br>(904) 677-3822 | | | | | | XX |
| 60. Turie T. Small Elementary<br>800 South Street<br>Daytona Beach<br>(904) 252-4738 | | | | | | XX |
| 61. West Side Elementary<br>1210 Jimmy Ann Drive<br>Daytona Beach<br>(904) 253-1671 | | | | | | XX |

With the assistance of the East Central Florida Hospital Council, State Department of Health & Rehabilitative Services, Civil Defense officers and other local officials, health care facilities within the study area were identified. The predicted surge heights provided through the SPLASH II model and the maps of flood-prone areas produced from the SPLASH II results allow for assessing the flooding potential of group homes, hospitals, and nursing homes.

As with public shelters, each health care facility was identified in regard to its location within a vulnerable area. The flooding potential of group homes, hospitals, and nursing homes in Brevard and Volusia counties is summarized in Table 15. As Table 15 illustrates, there are two group homes vulnerable in a category 1-2 storm and seven vulnerable in a category 3-5 storm. This analysis also identified three hospitals vulnerable to storm surge in a category 1-2 storm and one vulnerable in a category 3-5 storm. Finally, nursing homes determined to be susceptible to storm surge included two in a category 1-2 hurricane and six in a category 3-5 hurricane. This information on surge-threatened health care facilities was also forwarded to local disaster preparedness officials and appropriate medical officials. It is recommended that Table 15 be used in defining risk to host evacuation evacuation contingency plans for health care facilities.

SHELTER DEMAND

Residents identified as potential evacuees in the Vulnerability Analysis may seek various alternative forms of shelter at varying distances from their points of origin. These alternatives may include local public shelters, local hotels or motels, local friends' or relatives' homes, or destinations further inland outside the residents' county.

The first step necessary in calculating public shelter demand is to quantify these various shelter preferences. The Behavioral Survey indicated that approximately 18.3% of the coastal residents sampled in the survey intended to utilize public shelter facilities. In addition, another 13% responded that they did not know what their destination would be. It would not be expected that all of the respondents who have not made shelter plans would seek public shelter, although a substantial number undoubtedly would. Therefore, to arrive at possibly a "worst case" situation, one-third of the "do not know" responses were combined with the public shelter-bound responses to provide a total percentage of the evacuation population predicted to seek public shelter. These combined percentages add up to 22.3% of the evacuating population. The balance of the evacuating residents would be expected to seek shelter at the homes of friends/relatives, in hotels/motels, or travel outside the county. This information is summarized in Table 16.

For comparison purposes, the percentage of residents in other coastal areas of Florida seeking public shelter is shown in Table 17. As can be seen,

TABLE 16

BEHAVIORAL SURVEY RESPONSE -- DESTINATIONS

Destination:

| | |
|---|---|
| Shelter | 18.3% |
| Friend or Relative | 38.1% |
| Hotel or Motel | 30.6% |
| Do Not Know | 13.0% |

TABLE 17

COMPARISON OF BEHAVIORAL SURVEYS WITHIN FLORIDA -- DESTINATIONS

<table>
<tr><th>DESTINATION</th><th>East Central Florida Coastal</th><th>East Central Florida Inland</th><th>Lee County</th><th>Tampa Bay</th><th>Sanibel-Captiva</th><th>Southwest Florida</th><th>Southeast Florida</th></tr>
<tr><td>Shelter</td><td>18.3%</td><td>45.6%</td><td>21.0%</td><td>37.9%</td><td>8.1%</td><td>24.0%</td><td>23.1%</td></tr>
<tr><td>Friend or Relative</td><td>38.1%</td><td>18.2%</td><td rowspan="2">53.0%</td><td>25.8%</td><td>45.4%</td><td>13.0%</td><td>28.0%</td></tr>
<tr><td>Hotel or Motel</td><td>30.6%</td><td>14.6%</td><td>18.8%</td><td>38.1%</td><td>42.0%</td><td>10.2%</td></tr>
<tr><td>Do Not Know</td><td>13.0%</td><td>21.6%</td><td>26.0%</td><td>17.4%</td><td>8.4%</td><td>21.0%</td><td>11.2%</td></tr>
</table>

there is a relatively low demand among East Central Florida coastal residents for public shelter facilities when compared to other coastal areas. It has been hypothesized that since many of the Brevard and Volusia county residents had evacuated during Hurricane David in 1979, they may have made plans for future evacuations. These plans often involve making non-public shelter arrangements.

By applying the percentages from the Behavioral Survey to the total number of persons threatened by an approaching hurricane, an assessment of total shelter demand can be made.

## SHELTER CAPACITY

It would be expected that shelter usage would vary, depending on the intensity of the storm confronting the region and its point of landfall on the coast. The identification of vulnerable areas and the population-at-risk allows demand under various scenarios to be applied to the maximum amount of shelter space available under those same scenarios.

In Brevard County, for a category 1-2 storm situation, there are currently estimated to be 26,679 spaces available to meet a projected demand of 26,733 persons--resulting in a deficit of 54 spaces. This deficit increases during a category 3-5 storm situation, where the capacity decreases to 25,347 spaces but the demand increases to 28,385.

Within Volusia County, a sizable excess of shelter space is available during each of the storm scenarios. In a category 1-2 storm, 31,921 spaces exist to meet an anticipated demand by 10,599 persons, resulting in excess capacity of 21,322 spaces. For a category 3-5 storm situation, the excess capacity was calculated to be 7,218, resulting from a demand for 22,301 spaces and available spaces of 29,519.

## PUBLIC SHELTER ASSIGNMENTS

For the purposes of this study, no formal assignment of shelters was made. This was done in response to current policy in both Brevard and Volusia counties, which discourages the designation of a particular shelter location for a particular area of the county. The reasoning behind this policy is that such a designation reduces the flexibility and options available to local officials in opening specific shelters to meet changing demands by limiting their ability to allocate limited manpower and resources on an as-needed basis.

TABLE 18

Shelter Capacity

| | 1-2 Storm | | 3-5 Storm | |
|---|---|---|---|---|
| | Brevard Co. | Volusia Co. | Brevard Co. | Volusia Co. |
| Shelter Capacity | 26,679 | 31,921 | 25,347 | 29,519 |
| minus (-) | | | | |
| Shelter Demand | 26,733 | 10,599 | 28,385 | 22,301 |
| equals (=) | | | | |
| Shelter Capacity Deficit (-) or Excess (+) | -54 | +21,322 | -3,038 | +7,218 |

ALTERNATE SHELTERS

Due to the deficit of public shelter spaces in Brevard County, an assessment of hotel/motel units was made to determine if alternate shelter space was available to accommodate the additional evacuees. Information from the East Central Florida Regional Planning Council's Hotel/Motel Inventory was used to identify the number of units existing in the county, and information on seasonal occupancy rates was provided by Brevard County.

The time frame for calculating the seasonal occupancy rates was June-November, the time period formally designated as hurricane season. According to information provided, Brevard County experienced a 63% occupancy rate during this period. The total number of hotel/motel units which could be expected to be available for shelter may be obtained by applying the 37% vacancy rates to the number of hotel/motel units in the county.

In identifying possible alternate shelter capacities, the units considered for shelter use were only those situated outside the identified vulnerable areas in the inland portions of Brevard County. Generally, due to the format in which the information is collected, this meant that hotel/motel units lying east of I-95 were not considered. In addition, the total number of units identified were delineated by size, double- or single-room occupancy. Following the general rule of thumb utilized in the Inland Shelter Study, 90% of the units will be double rooms accommodating four adults and 10% of the units will be single rooms accommodating two adults. From this information, the capacity of unoccupied hotel/motel rooms was calculated to be 8,561.

In assessing the impact of the potential alternate shelter inventory on the shelter deficit that currently exists in Brevard County, it is important to consider those evacuees whose original intention was to seek shelter in a hotel/motel. From the Behavioral Survey, 30.6% of the residents listed "hotel/motel" as their planned destinations. Adding one-third of the respondents who answered "do not know" increases the figure to 35%. Assuming half would attempt to do so within Brevard County, approximately 21,000 residents would seek alternate shelters and the existing capacity would not be sufficient to accommodate these evacuees. Consequently, a deficit in hotel/motel units would occur without considering the shelter demands of evacuees unable to find public shelter.

Two conclusions can be reached for this assessment. First, provisions must be developed for "passing through" those evacuees unable to be sheltered in Brevard County to inland counties. Second, ongoing efforts should be made to identify and secure additional public shelters within Brevard County to alleviate the anticipated shelter deficit.

TABLE 19

ALTERNATE SHELTER ANALYSIS -- BREVARD COUNTY

(Hotels/Motels)

| | | |
|---|---|---|
| Alternate Shelter Capacity | 8,561 | |
| | Category 1-2 | Category 3-5 |
| minus (-) | | |
| Alternate Shelter Demand | 20,702 | 21,980 |
| equals (=) | | |
| Alternate Shelter Deficit | 12,141 | 13,419 |
| plus (+) | | |
| Public Shelter Deficit | 54 | 3,038 |
| equals (=) | | |
| Total Alternate Shelter Deficit | 12,195 | 16,517 |

# TRANSPORTATION ANALYSIS ELEMENT

## INTRODUCTION

Previous sections of the report have discussed the background conditions which are to be used as the basis for estimating evacuation times. This background data was developed from three major tasks which included: a computer-based storm surge model defining the magnitude and extent of the threat to the region's coast; a statistically significant investigation predicting the probable behavior of coastal residents in a hurricane emergency situation; and an inventory and analysis of the facilities and resources available to local disaster preparedness officials to direct an evacuation.

In performing these tasks, emphasis was placed on measuring as many of the variables as possible to permit construction of a series of quantitative evacuation scenarios. Each scenario developed represents a different situation which may occur in terms of the magnitude of a storm approaching the coast, the number of people affected, the availability of sheltering facilities, and public response during an evacuation. Based upon this information, traffic movements could then be developed which may realistically simulate a one-time movement of evacuating vehicles over the existing highway network.

This section of the report will discuss the assumptions and procedures used in undertaking the transportation analysis and present an estimation of the times required to evacuate the threatened areas of the region's coastal counties. To provide local officials with a useful tool for making decisions, both clearance time and evacuation time estimates have been included as well as an explanatory text as to their significance to a safe evacuation of the coastal areas. Data developed as part of the transportation modeling effort has been included in the appendices.

## STUDY APPROACH

The approach selected for conducting the transportation analysis was the result of investigations of similar studies previously completed in the State as well as a number of evacuation-related studies performed both in Florida and other states. Emphasis was placed on selection of a methodology which would not only provide a comprehensive investigation of selected traffic movements for different hurricane situations but also a methodology which could be packaged for future updating by local governments as population and roadway network changes occur. A major criterion considered in this regard was development of procedures which did not require use of the FDOT main frame computer facilities.

The objective of the transportation analysis is two-fold: first, to identify the period of time that is required to complete the movement of traffic throughout the study area from locations of risk to areas of safety; second, to relate this time to the time available before hurricane conditions pose a threat to evacuating residents. The information presented in this section provides both of these times which will allow local officials an opportunity to amend the times as a situation develops.

## METHODOLOGY

The following methodology was followed in developing the clearance time estimates for the study.

### Establish Evacuation Road Network

Activities performed for this work task focused on developing a basic evacuation road network for the two-county area.

### Inventory Characteristics of Network Links

This task involved an inventory of the evacuation road network links for input into the calculation of roadway capacities. Elements used in this calculation included roadway widths, number of lanes, horizontal and vertical alignment, intersection features such as green time to cycle length ratios, percent trucks, and peak hour factors. Features such as facility type and area type were also recorded for use in the calculations.

### Establish Capacities of Evacuation Road Network

Using the data from the tasks above, calculations were made of the existing capacities of the road network. Capacities were based upon Level of Service D traffic conditions (as defined in the 1965 Highway Capacity Manual), since evacuation traffic involves high volume to roadway capacity situations.

It was uncertain whether the causeways/bridges leading from the barrier islands, or the intersections contained within the evacuation roadway network, created the most restrictive points of traffic flow. Therefore, roadway capacities inventoried in the network links (above) were used to develop intersection approach capacities in addition to link capacities. This capacity determination assisted in developing alternative routing strategies as well as metering traffic at critical links to determine clearance times.

### Trip Generation

This task involved the preparation of productions and attractions by: Evacuation Zone; Hurricane Scenario; and Destination. Socio-economic variables available through the 1980 Census data tapes were utilized to calculate total evacuation vehicles for each evacuating zone according to the selected storm scenario. These data were formatted by the proposed destination of evacuees.

Distribution Analysis

This task distributed trips between evacuation zones (Productions) and shelter destinations (Attractions). The primary inputs for this task were the traffic generated by evacuation zones and probable destinations of evacuees by zone. This information was derived from previous tasks and material developed as part of Phase I of the ECFRPC's Hurricane Evacuation Study.

Trip Assignment

This task assigned trips developed in the previous task to the established evacuation road network. Vehicular trips, as opposed to person trips, were used as the basis for this activity.

Critical Link Identification

Based on the information developed through the previous work tasks, critical links of the evacuation network were identified. A series of volume to capacity ratios (V/C) were calculated to determine which roadway segments would be most congested in moving evacuation vehicles. The volumes calculated incorporated all traffic movements anticipated to occur on a roadway segment to ensure that all impacts were considered. The critical links identified through this task were used to calculate clearance times for each assumed storm scenario and each tested behavioral response parameter.

Clearance Time Analysis

Utilizing the identified critical links, this task estimated the clearance times for each of the five regional scenarios. Traffic assignments developed previously were loaded onto the network in accordance with three public response distribution curves.

Clearance time estimates involved three separate calculations. These included the time required to travel from the evacuation zone to the critical point in the link, movement through the congested point on the link, and travel to an acceptable shelter destination (or out of county).

Arrival times were calculated based on travel distance and travel speed from the evacuating zone to the critical point on the roadway network. Floating car technique measurements taken during peak hour conditions were used to determine travel speed.

In the identified critical links, the total assigned volume exceeds the link capacity, causing a queue to form. The queue will only dissipate at a rate approximately equal to the link capacity, requiring excess vehicles assigned to the link to wait until the following hourly interval. The sum of the intervals required to clear the link is the queuing delay time experienced. In determining the queuing delay time for each of the critical links, two factors were considered. First, as the rate at which traffic enters the critical link dictates the amount of time in which it can be cleared, various arrival rates derived from the behavioral response curves were considered as well as each of the five hurricane scenarios. Second, background traffic influences the amount of congestion experienced at each critical link. Therefore, the arrival rate of this traffic was factored into the analysis.

Link travel time, which is the time necessary to clear evacuation traffic from the critical link once past the critical point of congestion, was calculated based on travel speeds and distance to the most distant destination.

## TRANSPORTATION MODELING INPUT ASSUMPTIONS

The transportation analysis provides clearance times based on a set of assumed conditions and behavioral responses. An actual storm approaching the Brevard and Volusia coastal areas will almost certainly deviate in some way from the scenarios used for this modeling effort. Considering the numerous variables involved in defining a hurricane--such as size, track, intensity and how it is perceived by residents--this should not be surprising.

To accommodate the differences between the scenarios and what may actually occur, and to provide a useful tool for local officals, those variables having the greatest influence on clearance times were identified and then varied. This allowed for a range within which the true clearance time value might fall.

### Regional Storm Scenarios

As mentioned in previous sections of the report, 74 hypothetical hurricanes were simulated using the National Hurricane Center's computer models. Storms were varied by point of landfall, Saffir-Simpson category, and general movement. Calculation of clearance times for all simulated storms, however, would be cumbersome and unusable for local emergency preparedness officials, and also inappropriate, given the limitations of current hurricane forecasting and storm surge simulation. Therefore, five regional storms were selected for use in the transportation analysis.

Table 20 provides the regional storm number, the counties affected, and a brief description of each selected storm. These storms were chosen from the 74 storms modeled by selecting the storm tracks causing the greatest storm surge impacts on various portions of an individual county. A paralleling storm was included to examine the transportation impacts to the region resulting from a progressive evacuation of counties along the east coast of the State.

TABLE 20

TRANSPORTATION MODELING REGIONAL STORM SCENARIOS

| Regional Storm Number | Storm Description | Volusia | Brevard |
|---|---|---|---|
| 1 | Category 1-2 landfalling storm at Melbourne | X | A |
| 2 | Category 3-5 landfalling storm at Melbourne | A | B |
| 3 | Category 1-2 landfalling storm at New Smyrna Beach | A | X |
| 4 | Category 3-5 landfalling storm at New Smyrna Beach | B | A |
| 5 | Paralleling storm regionwide | A | A |

Key:
X = no evacuation required
A = Category 1-2 storm
B = Category 3-5 storm

It is important to note that the five Saffir-Simpson categories of storms have been collapsed into two ranges for each county. This was done recognizing the similarities of storm surge heights for different intensities of storms and realizing the manner in which storms change intensity over time. For both Brevard and Volusia counties, storms were grouped into Category 1-2 and Category 3-5.

Population-at-Risk

One of the key inputs to the transportation analysis was an identification of those residents who should evacuate for a particular storm situation. Through the hazard analysis, those areas subject to flooding from both storm surge and freshwater were delineated and the number of residents in those areas calculated. This allowed for an identification of those residents who must evacuate for each storm scenario as well as those residents who need not evacuate. The transportation analysis then produces clearance times which reflect only needed evacuation movements.

Behavioral and Socio-Economic Assumptions

To perform the transportation analysis, a number of assumptions were made concerning how the population-at-risk would respond relative to an evacuation order, how many of the available vehicles at residential locations would be used for evacuation, and what percentage of the evacuees would go to various categories of destinations. A number of assumptions were made concerning dwelling unit and hotel/motel occupancies and number of persons per mobile home and hotel/motel unit.

To determine the percentage of persons who would leave during each hourly interval of the evacuation, three behavioral response curves were developed for the region. One curve approximated a long lead time provided by the National Weather Service and a slow response by evacuees; a second curve reflected a situation with a short lead time and a quick response required by those choosing to evacuate; a third curve was similar to the response rate provided by the behavioral survey, with some adjustment made to fit between the first and second curves.

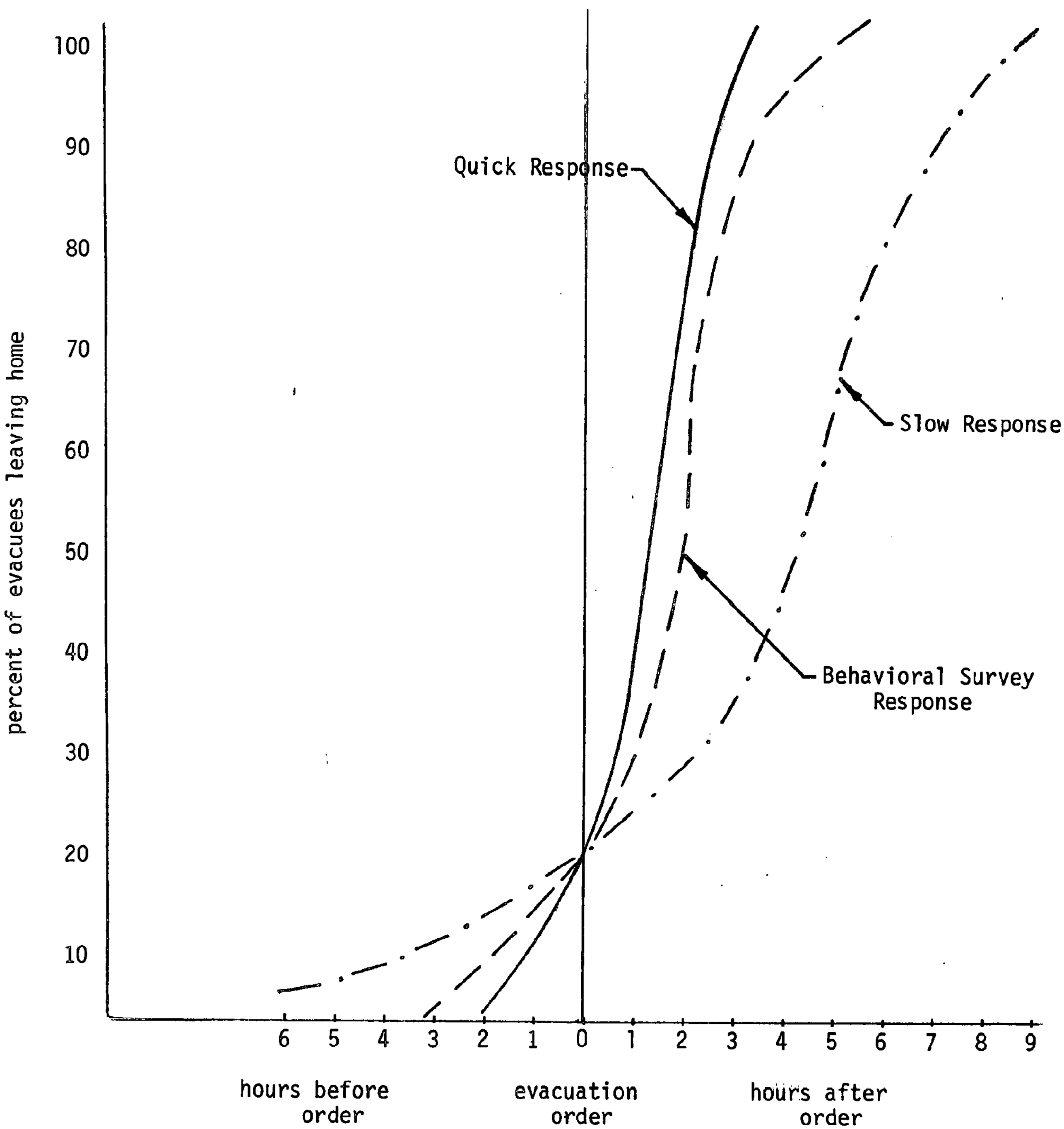
Response curves define the rate at which evacuation vehicles load onto the street network at hourly intervals. By examining three different rates of response, reflecting responses reported during previous hurricane evacuations, a range of times may be provided into which the actual time of an evacuation will fall. The response curves used for this study are depicted in Figure 15.

In addition to evacuating traffic, background traffic was added to the calculations to account for those persons traveling to stores or homes. Consistent with previous hurricane studies completed in the State, this

FIGURE 15

ESTIMATION OF CUMULATIVE DEMAND

Behavioral Response Curves



traffic was hypothesized to load onto street networks in an inverse manner relative to the behavioral response curves. As an example, two to five hours before an evacuation order is given when the first 20-30% of evacuees are leaving home, 70-80% of the background traffic will be loading onto the street network.

Several other assumptions used in developing the transportation model included:

A) 2 persons/household
1.9 persons/mobile home

B) 1.5 vehicles per household
.89 vehicles per person (Brevard County)
.77 vehicles per person (Volusia County)

C) 10% of vehicles will be used in an evacuation
1.905 persons/vehicles (Brevard County)
2.204 persons/vehicles (Volusia County)

D) Due to adverse weather conditions, such as rain and wind, capacity of roads is reduced to about 84% of dry weather capacity.

In developing these assumptions, the total number of vehicles by evacuation zone was derived from information provided by the Division of Motor Vehicles on the number of registered vehicles in each county. This number was compared to the population of the county to arrive at a ratio of vehicles to people and then multiplied by the population of each zone.

Roadway System and Traffic Control Assumptions

In the selection of roadways to be used, an effort was made to include only those street facilities with sufficient elevations, little or no adjacent tree coverage, substantial shoulder width and surface, and those roadways already contained in existing county hurricane evacuation plans. An additional objective was to provide east-west arterials and bridge combinations that would afford the least disjointed traffic flow. In selecting roadways on the mainland, efforts were also undertaken to omit lengthy north-south movements which may interfere with traffic evacuating from the barrier islands.

Relocation of the threatened population required the use of all major east-west routes in the two-county study area. The lack of alternative routing movements, in many instances, prevented the omission of a particular roadway which did not meet all of the established criteria. The major deficiency in this regard was the lack of sufficient elevation at points along a roadway which could prevent freshwater flooding. This was the case for roadways both on the barrier islands as well as on the mainland.

TABLE 21

Vehicle Productions
Category 1-2 Storm Situation

Volusia County

| Zone | 1 | 2 | 3 A | 3 B | 4 |
|---|---|---|---|---|---|
| V1 | 368 | 83 | 105 | 51 | 129 |
| V2 | -- | -- | -- | -- | -- |
| V3 | 243 | 55 | 69 | 34 | 85 |
| V4 | 409 | 185 | 116 | 57 | 143 |
| V5 | -- | -- | -- | -- | -- |
| V6 | 646 | 146 | 184 | 90 | 226 |
| V7 | 512 | 116 | 145 | 33 | 179 |
| V8 | -- | -- | -- | -- | -- |
| V9 | 99 | 23 | 28 | 14 | 34 |
| V10 | 265 | 60 | 75 | 37 | 92 |
| V11 | -- | -- | -- | -- | -- |
| V12 | 517 | 117 | 147 | 72 | 181 |
| V13 | 505 | 114 | 143 | 71 | 177 |
| V14 | -- | -- | -- | -- | -- |
| V15 | 405 | 91 | 115 | 57 | 142 |
| V16 | 262 | 59 | 74 | 37 | 92 |
| V17 | -- | -- | -- | -- | -- |
| V18 | 196 | 45 | 56 | 27 | 68 |
| V19 | 277 | 175 | 220 | 189 | 271 |
| V20 | 70 | 16 | 20 | 10 | 24 |
| V21 | -- | -- | -- | -- | -- |
| V22 | -- | -- | -- | -- | -- |
| V23 | 2,036 | 460 | 578 | 285 | 713 |
| V24 | 50 | 11 | 14 | 7 | 17 |
| V25 | -- | -- | -- | -- | -- |
| V26 | 695 | 157 | 198 | 97 | 243 |
| V27 | 545 | 123 | 155 | 76 | 191 |
| V28 | 236 | 53 | 67 | 33 | 83 |
| V29 | 154 | 35 | 44 | 21 | 54 |
| V30 | 3,329 | 752 | 946 | 466 | 1,165 |
| V31 | 3,131 | 708 | 889 | 438 | 1,096 |
| V32 | -- | -- | -- | -- | -- |
| V33 | -- | -- | -- | -- | -- |
| V34 | 468 | 106 | 133 | 65 | 164 |
| V35 | 264 | 60 | 75 | 37 | 112 |
| V36 | -- | -- | -- | -- | -- |
| V37 | 102 | 23 | 29 | 14 | 36 |
| V38 | 139 | 31 | 39 | 20 | 49 |

TABLE 21 (cont.)

| Zone | 1 | 2 | 3 | | 4 |
|---|---|---|---|---|---|
| | | | A | B | |
| V39 | 239 | 54 | 68 | 33 | 84 |
| V40 | 39 | 9 | 11 | 5 | 14 |
| V41 | -- | -- | -- | -- | -- |
| V42 | 363 | 82 | 103 | 51 | 127 |
| V43 | 37 | 8 | 11 | 6 | 13 |
| V44 | 208 | 47 | 59 | 29 | 73 |
| V45 | 385 | 87 | 109 | 54 | 135 |
| V46 | 247 | 56 | 70 | 35 | 86 |
| V47 | -- | -- | -- | -- | -- |
| V48 | -- | -- | -- | -- | -- |
| V49 | 1,175 | 265 | 334 | 164 | 411 |
| V50 | 58 | 13 | 16 | 9 | 20 |
| V51 | 221 | 50 | 63 | 31 | 77 |
| V52 | 698 | 158 | 198 | 98 | 244 |
| V53 | 438 | 99 | 124 | 62 | 153 |
| V54 | 37 | 8 | 11 | 5 | 13 |
| V55 | 1,605 | 361 | 456 | 225 | 562 |
| V56 | 394 | 89 | 112 | 55 | 138 |
| V57 | 381 | 86 | 109 | 53 | 133 |

Key:

1 = Total Vehicle Productions
2 = Public Shelters
3A = Friend or Relative (in county)
3B = Friend or Relative (out of county)
4 = Hotel or Motel

TABLE 21 (cont.)

Vehicle Productions
Category 3-5 Storm Situation

Volusia County

| Zone | 1 | 2 | 3 A | 3 B | 4 |
|---|---|---|---|---|---|
| V1 | 368 | 83 | 105 | 51 | 129 |
| V2 | 4,765 | 1,077 | 1,353 | 667 | 1,668 |
| V3 | 243 | 55 | 69 | 34 | 85 |
| V4 | 409 | 185 | 116 | 57 | 143 |
| V5 | 3,589 | 811 | 1,020 | 502 | 1,256 |
| V6 | 646 | 146 | 184 | 90 | 226 |
| V7 | 512 | 116 | 145 | 72 | 179 |
| V8 | 2,056 | 465 | 584 | 288 | 719 |
| V9 | 99 | 23 | 28 | 14 | 34 |
| V10 | 265 | 60 | 75 | 37 | 92 |
| V11 | 997 | 225 | 283 | 140 | 349 |
| V12 | 517 | 117 | 147 | 72 | 181 |
| V13 | 505 | 114 | 143 | 71 | 177 |
| V14 | 956 | 216 | 272 | 134 | 334 |
| V15 | 405 | 91 | 115 | 57 | 142 |
| V16 | 262 | 59 | 74 | 37 | 92 |
| V17 | 1,547 | 350 | 439 | 216 | 541 |
| V18 | 196 | 45 | 56 | 27 | 68 |
| V19 | 775 | 175 | 219 | 108 | 271 |
| V20 | 70 | 16 | 20 | 10 | 24 |
| V21 | 389 | 88 | 110 | 55 | 136 |
| V22 | 1,119 | 253 | 318 | 156 | 392 |
| V23 | 2,036 | 460 | 578 | 285 | 713 |
| V24 | 360 | 81 | 102 | 51 | 126 |
| V25 | -- | -- | -- | -- | -- |
| V26 | 695 | 157 | 197 | 98 | 243 |
| V27 | 545 | 123 | 155 | 76 | 191 |
| V28 | 236 | 53 | 67 | 33 | 83 |
| V29 | 154 | 35 | 44 | 21 | 54 |
| V30 | 3,329 | 752 | 946 | 466 | 1,165 |
| V31 | 3,131 | 707 | 890 | 438 | 1,096 |
| V32 | 175 | 39 | 50 | 25 | 61 |
| V33 | 909 | 205 | 259 | 127 | 318 |
| V34 | 468 | 106 | 133 | 65 | 164 |
| V35 | 264 | 60 | 75 | 37 | 92 |
| V36 | 853 | 193 | 243 | 119 | 298 |
| V37 | 102 | 23 | 29 | 14 | 36 |
| V38 | 139 | 31 | 40 | 19 | 49 |

TABLE 21 (cont.)

| Zone | 1 | 2 | 3 | | 4 |
|---|---|---|---|---|---|
| | | | A | B | |
| V39 | 239 | 54 | 68 | 33 | 84 |
| V40 | 399 | 90 | 113 | 56 | 140 |
| V41 | -- | -- | -- | -- | -- |
| V42 | 3,264 | 738 | 927 | 457 | 1,142 |
| V43 | 788 | 178 | 224 | 110 | 276 |
| V44 | 208 | 47 | 59 | 29 | 73 |
| V45 | 711 | 160 | 202 | 100 | 249 |
| V46 | 247 | 56 | 70 | 35 | 86 |
| V47 | -- | -- | -- | -- | -- |
| V48 | -- | -- | -- | -- | -- |
| V49 | 1,175 | 266 | 334 | 164 | 411 |
| V50 | 58 | 13 | 17 | 8 | 20 |
| V51 | 221 | 50 | 63 | 31 | 77 |
| V52 | 698 | 158 | 198 | 98 | 244 |
| V53 | 438 | 99 | 125 | 61 | 153 |
| V54 | 37 | 9 | 10 | 5 | 13 |
| V55 | 1,605 | 363 | 456 | 224 | 562 |
| V56 | 394 | 89 | 112 | 55 | 138 |
| V57 | 381 | 86 | 109 | 53 | 133 |

Key:

1 = Total Vehicle Productions
2 = Public Shelters
3A = Friend or Relative (in county)
3B = Friend or Relative (out of county)
4 = Hotel or Motel

TABLE 21 (cont.)

Vehicle Productions
Category 1-2 Storm Situation

Brevard County

| Zone | 1 | 2 | 3 | | 4 |
|---|---|---|---|---|---|
| | | | A | B | |
| B1 | 4,559 | 1,031 | 1,021 | 912 | 1,595 |
| B2 | 5,253 | 1,187 | 1,177 | 1,051 | 1,838 |
| B3 | 11,602 | 2,621 | 2,599 | 2,321 | 4,061 |
| B4 | 6,896 | 1,559 | 1,545 | 1,379 | 2,413 |
| B5 | 3,667 | 829 | 822 | 733 | 1,283 |
| B6 | 363 | 82 | 81 | 72 | 128 |
| B7 | 8,089 | 1,828 | 1,812 | 1,618 | 2,831 |
| B8 | 124 | 39 | 35 | 22 | 38 |
| B9 | 5,830 | 1,317 | 1,306 | 1,166 | 2,041 |
| B10 | 581 | 131 | 131 | 116 | 203 |
| B11 | 1,093 | 247 | 245 | 218 | 383 |
| B12 | 6 | 2 | 1 | 1 | 2 |
| B13 | 85 | 19 | 19 | 17 | 30 |
| B14 | 779 | 176 | 174 | 156 | 272 |
| B15 | 845 | 191 | 189 | 169 | 296 |
| B16 | 506 | 114 | 114 | 101 | 177 |
| B17 | 972 | 220 | 218 | 194 | 340 |
| B18 | 2,527 | 571 | 566 | 505 | 885 |
| B19 | 456 | 103 | 102 | 91 | 160 |
| B20 | 90 | 20 | 20 | 18 | 32 |
| B21 | 1,023 | 231 | 229 | 205 | 358 |
| B22 | 1,004 | 227 | 225 | 201 | 351 |
| B23 | 2,260 | 511 | 507 | 452 | 790 |
| B24 | 1,307 | 296 | 293 | 261 | 457 |
| B25 | 1,963 | 444 | 440 | 393 | 686 |
| B26 | 226 | 51 | 51 | 45 | 79 |
| B27 | 22 | 5 | 5 | 4 | 8 |
| B28 | 65 | 15 | 15 | 13 | 22 |
| B29 | 40 | 9 | 9 | 8 | 14 |

Key: 1 = Total Vehicle Productions
2 = Public Shelters
3A = Friend or Relative (in county)
3B = Friend or Relative (out of county)
4 = Hotel or Motel

TABLE 21 (cont.)

Vehicle Productions
Category 3-5 Storm Situation

Brevard County

| Zone | 1 | 2 | 3 | | 4 |
|---|---|---|---|---|---|
| | | | A | B | |
| B1 | 4,559 | 1,031 | 1,021 | 912 | 1,595 |
| B2 | 5,253 | 1,187 | 1,177 | 1,051 | 1,838 |
| B3 | 11,602 | 2,621 | 2,599 | 2,321 | 4,061 |
| B4 | 6,896 | 1,559 | 1,545 | 1,379 | 2,413 |
| B5 | 3,667 | 829 | 822 | 733 | 1,283 |
| B6 | 363 | 82 | 81 | 72 | 128 |
| B7 | 8,089 | 1,828 | 1,812 | 1,618 | 2,831 |
| B8 | 3,806 | 860 | 853 | 761 | 1,332 |
| B9 | 5,830 | 1,317 | 1,306 | 1,166 | 2,041 |
| B10 | 581 | 131 | 131 | 116 | 203 |
| B11 | 1,093 | 247 | 245 | 218 | 383 |
| B12 | 31 | 7 | 7 | 6 | 11 |
| B13 | 85 | 19 | 19 | 17 | 30 |
| B14 | 779 | 176 | 174 | 156 | 272 |
| B15 | 845 | 191 | 189 | 169 | 296 |
| B16 | 506 | 114 | 114 | 101 | 177 |
| B17 | 972 | 220 | 218 | 194 | 340 |
| B18 | 2,527 | 571 | 566 | 505 | 885 |
| B19 | 456 | 103 | 102 | 91 | 160 |
| B20 | 90 | 20 | 20 | 18 | 32 |
| B21 | 1,023 | 231 | 229 | 209 | 358 |
| B22 | 1,004 | 227 | 225 | 201 | 351 |
| B23 | 2,260 | 511 | 507 | 452 | 790 |
| B24 | 1,307 | 296 | 293 | 261 | 457 |
| B25 | 1,963 | 444 | 440 | 393 | 686 |
| B26 | 226 | 51 | 51 | 45 | 79 |
| B27 | 22 | 5 | 5 | 4 | 8 |
| B28 | 65 | 15 | 15 | 13 | 22 |
| B29 | 40 | 9 | 9 | 8 | 14 |

Key: 1 = Total Vehicle Productions
2 = Public Shelters
3A = Friend or Relative (in county)
3B = Friend or Relative (out of county)
4 = Hotel or Motel

TABLE 22

EVACUATION ROUTING SCHEME

Brevard County

| Evacuation Zone(s) | Evacuation Route | Routing Scheme: Intra-County Evacuation | Routing Scheme: Leaving the County |
|---|---|---|---|
| B1 | A1A | Exit west on SR 528 (Bennett Cswy/Memorial Cswy) using up to 3 lanes as directed. | Continue west on SR 528. |
| B2 | A1A | Exit west on SR 520 (Hubert Humphrey Brdg/ Merritt Island Cswy) using up to 3 lanes as directed. | Continue west on SR 528. |
| B3 | A1A | Exit west on SR 404 (Pineda Cswy) using up to 3 lanes as directed. | Take Wickham Rd. (SR 509) north to I-95. Head north on I-95 to SR 520. Exit west on SR 520. |
| B4 | A1A & Patrick Dr. | Exit west on SR 518 (Eau Gallie Cswy). | Take Eau Gallie Blvd. west to US 1. Go south on US 1 to Sarno Dr. Head west on Sarno Dr. to John B. Rodes Blvd. (SR 511). Take SR 511 south to US 192. Exit west on US 192. |
| B5 | A1A | Exit west on US 192 (Melbourne Cswy). | Continue west on US 192. |
| B6 | A1A | --- | Exit west on SR 510 (Indian River Co.). |
| B7, B8 | Courtenay Pkwy. (SR 3) & Banana Dr. | Exit west on SR 528 (Bennett Cswy.) using up to 3 lanes as directed. | Continue west on SR 528. |
| B9 | Courtenay Pkwy. (SR 3), Tropical Trl. & New Found Harbor Dr. | Exit west on SR 520 (Merritt Island Cswy/ Hubert Humphrey Brdg.) using up to 3 lanes as directed. | Exit west on SR 520. |
| B10 | Tropical Trl. (SR 3) | Exit west on SR 404 (Pineda Cswy) using up to 3 lanes as directed. | Take Wickham Rd. (SR 509) north to I-95. Head north on I-95 to SR 520. Exit west on SR 520. |

TABLE 22 (cont.)

EVACUATION ROUTING SCHEME
Brevard Co. (cont.)

| Evacuation Zone(s) | Evacuation Route | Routing Scheme | |
|---|---|---|---|
| | | Intra-County Evacuation | Leaving the County |
| B12, B13 | US 1 | Exit west on SR 46. | Continue west on SR 46. |
| B14 | US 1 | Exit west on SR 50. | Continue west on SR 50. |
| B16 | US 1 | Exit west on SR 405 to SR 50. | Continue west on SR 50. |
| B18 | | Exit west on SR 520. | Continue west on SR 520. |
| B20 | US 1 | Exit west on Wickham Rd. (SR 509) | Take Wickham Rd. (SR 509) north to I-95. Head north on I-95 to SR 520. Exit west on SR 520. |
| B22 | US 1 | Exit west on Eau Gallie Blvd. | Take Eau Gallie Blvd. west to US 1. Go south on US 1 to Sarno Dr. Head west on Sarno Dr. to John B. Rodes Blvd. (SR 511) Take SR 511 south to US 192. Exit west on US 192. |
| B24 | US 1 | Exit west on US 192. | Continue west on US 192. |
| | | Exit west on Malabar Rd. (SR 514) | Take SR 514 to Minton Dr. (SR 509) Go north on SR 509 to US 192. Exit west on US 192. |
| B26 | US 1 | Exit west on Malabar Rd. (SR 514) | Take SR 514 to Minton Dr. (SR 509) Go north on SR 509 to US 192. Exit west on US 192. |

TABLE 22 (cont.)

EVACUATION ROUTING SCHEME

Volusia County

| Evacuation Zone(s) | Evacuation Route | Routing Scheme: Intra-County Evacuation | Routing Scheme: Leaving the County |
|---|---|---|---|
| V1, V2, V3 | A1A & John Anderson Dr. | Exit west on SR 40 (Ormond Bridge) | Continue west on SR 40. |
| V4, V5, V6 | A1A & Halifax Dr. | Exit west on Seabreeze Blvd. (Seabreeze Bridge) using both lanes as directed. | Continue west on Mason Ave. to Williamson Blvd. Take Williamson Blvd. north to 11th St. Head west on 11th St. to US 92. Exit west on US 92. |
| V7, V8, V9 | A1A & Halifax Dr. | Exit west on US 92 (Carlton Blank Bridge) using up to 4 lanes as directed. | Continue west on US 92. |
| V10, V11, V12 | A1A & Halifax Dr. | Exit west on Silver Beach Ave. (Memorial) Bridge) using both lanes as directed. | Turn south on US 1 to Beville Ave. Head west on Beville Ave. to I-4. Continue west on I-4 |
| V13, V14, V15 | A1A & Halifax Dr. | Exit west on Dunlawton Ave. (Port Orange Bridge, SR 415) | Continue west on SR 415. |
| V32-V38 | A1A & Saxon Dr. | Exit west on either the North Cswy (SR 40A) or South Cswy (SR 44). | Continue west on SR 44. *Note: SR 40A merges into SR 44.* |
| V16, V17 | US 1 | Exit west on SR 40. | Continue west on SR 40. |
| V18, V19 | US 1 | Exit west on Mason Ave.; or<br>Exit west on 11th St. | Continue west on Mason Ave. to Williamson Blvd. Take Williamson Blvd. north to 11th St. Head west on 11th St. to US 92. Exit west on US 92. |
| V20, V21 | US 1 | Exit west on US 92. | Continue west on US 92. |
| V23 | US 1 | Exit west on Beville Ave. | Continue west on I-4. |
| V24 | US 1 | Exit west on SR 415. | Continue west on SR 415. |
| V39, V40, V42 | US 1 & SR 40A | Exit west on SR 40A. | Continue on SR 40A to SR 44. Continue west on SR 44. |

EVACUATION ROUTING SCHEME
Volusia Co. (cont.)

| Evacuation Zone(s) | Evacuation Route | Routing Scheme | |
|---|---|---|---|
| | | Intra-County Evacuation | Leaving the County |
| V43, V44 | US 1 | Exit west on SR 44. | Continue west on SR 44. |
| V 45, V46 | US 1 | Exit west on CR 442. | Continue west on CR 422 to I-95. Take I-95 north to SR 44. Exit onto SR 44 and head west. |
| V48 | SR 44 | Exit west on SR 44. | Continue west on SR 44. |

An important input into the transportation model was the traffic control assumptions. In most cases, these assumptions were based upon the traffic control procedures currently in place in each of the two counties and outlined in each county's Peacetime Emergency Plan. Examples of the assumptions used include: intersections blocked off to allow only east-west traffic movements; light signalization, stationing of traffic control personnel to direct vehicle flow; and number of lanes available for evacuation.

Several other assumptions were used for the transportation modelling. First, all bridges from the barrier islands to the mainland were assumed to be down and to remain down during a hurricane warning period. (U.S. Coast Guard Regulation 33-117-C and FDOT procedure 571-004, 6, p. 15, provide Civil Defense officials with the authority to implement this procedure.) Second, it was assumed that adequate manpower was available for assignment to critical intersections to allow for smooth traffic flow. Last, the transportation model assumed that vehicles breaking down on the roadways would be removed in such manner so as not to cause any significant delays in the movement of evacuating vehicles.

Evacuation Travel Patterns

For the purposes of this analysis, traffic movements associated with hurricane evacuation scenarios were identified. As in previous evacuation studies completed in the State, five general patterns were delineated:

1) In-County Origins to In-County Destinations

Trips made from areas subject to both storm surge and freshwater flooding, and from mobile home units, in an individual county to destinations within the same county. These destinations may be Red Cross shelters, hotel and motel units, and friends or relatives living outside flooding areas.

2) In-County Origins to Out-of-County Destinations

Trips made from areas as in (1) that enter a particular county from another county in the region.

3) Out-of-County Origins to In-County Destinations

Trips made as in (1) that enter a particular county from another county in the region.

4) Out-of-County Origins to Out-of-County Destinations

Trips passing through a county while traveling from another county within or without the region.

5) Background Traffic

Trips made by people anticipating the arrival of hurricane conditions. These may be shopping trips to gather supplies and/or trips from places of work to home to gather the family for evacuation. This traffic also includes transit vehicles (buses) used to pick up auto-less evacuees.

EVACUATION TIME REQUIREMENTS

Evacuation Times by County

As stated previously, the objective of the transportation analysis was to calculate clearance time (the time it takes to clear a county's roadway of all evacuating vehicles) and to relate that clearance time to an evacuation order (the time before hurricane eye landfall at which an evacuation order must be given to allow all evacuees to reach appropriate destinations). With regard to clearance time estimates, the primary factor affecting the amount of time required was the rate by which people responded (evacuated) to a hurricane situation. This meant that the minimum times required to clear a county's roadway network were--depending upon the response curve applied during the analysis--5, 7, or 14 hours. The second most important factor that influenced the initial clearance time calculations was the extremely high vehicle to capacity ratio for certain links of the roadway network. While most roadways could accommodate evacuating traffic within a time approximating the response times tested, a few links greatly surpassed this time. This resulted in an increase of a county's total clearance time above what is actually required to evacuate a majority of a county's threatened population. A third influencing factor was the storm intensity of the various scenarios modeled. For Volusia County, in particular, a larger storm dramatically increased the numbers of persons affected and, therefore, loaded onto the transportation system.

Table 23 provides the evacuation timing data calculated and developed for Brevard and Volusia counties. These tables have been formatted to show both pre-evacuation order clearance time and post-evacuation order clearance time. Post-evacuation order clearance time is calculated by subtracting the pre-evacuation order time, as shown on the behavioral response curves, from total clearance time. Post-evacuation order clearance time is then added to pre-landfall hazards time to arrive at the time required for an evacuation order to be issued. The format of these tables has been developed to provide consistency between this study and previous studies conducted in the State.

As a further explanation of the evacuation time components, the following definitions are provided:

Clearance time: Clearance time is the time required to clear from roadways all vehicles evacuating in response to an approaching hurricane. Clearance time begins when the first evacuating vehicle enters the road network (in accordance with a hurricane evacuation behavioral response curve) and ends when the evacuating vehicle reaches its

TABLE 23

TRANSPORTATION EVACUATION TIMES

BREVARD COUNTY

| Storm Category | Pre-Evacuation Order Clearance Time | Post-Evacuation Order Clearance Time | Pre-Landfall Hazards Time | Time Required for Evacuation Order |
|---|---|---|---|---|
| | Response Curve A: Quick Response/Short Lead Time | | | |
| 1-2 | 2 | 3-6 | 4-6 | 7-12 |
| 3-5 | 2 | 4-6 | 7-11 | 11-17 |
| | Response Curve B: Behavioral Survey Response | | | |
| 1-2 | 3 | 4-7 | 4-6 | 8-13 |
| 3-5 | 3 | 5-8 | 7-11 | 12-19 |
| | Response Curve C: Slow Response/Long Lead Time | | | |
| 1-2 | 6 | 8 | 4-6 | 12-14 |
| 3-5 | 6 | 8 | 7-11 | 15-19 |

TABLE 23 (cont.)

TRANSPORTATION EVACUATION TIMES

VOLUSIA COUNTY

| Storm Category | Pre-Evacuation Order Clearance Time | Post-Evacuation Order Clearance Time | Pre-Landfall Hazards Time | Time Required for Evacuation Order |
|---|---|---|---|---|
| | Response Curve A: Quick Response/Short Lead Time | | | |
| 1-2 | 2 | 3-5 | 4-6 | 7-11 |
| 3-5 | 2 | 3-6 | 7-11 | 10-17 |
| | Response Curve B: Behavioral Survey Response | | | |
| 1-2 | 3 | 4-6 | 4-6 | 8-12 |
| 3-5 | 3 | 5-8 | 7-11 | 13-19 |
| | Response Curve C: Slow Response/Long Lead Time | | | |
| 1-2 | 6 | 8-11 | 4-6 | 12-17 |
| 3-5 | 6 | 9-12 | 7-11 | 16-23 |

destination. Clearance time includes the time required by evacuees to secure their homes and prepare to leave, the time spent by evacuees traveling along the road network, and the time spent by evacuees waiting to clear points of congestion along the network. Clearance time does not relate to the time any one vehicle spends traveling on the road network.

Pre-landfall hazards time: Pre-landfall hazards time is the time frame immediately before eye landfall within which evacuation should not be carried out, due to the adverse effects of the arrival of sustained gale force winds.

Pre-evacuation order time: Pre-evacuation order time refers to a period of time prior to issuance of the evacuation order, in which a certain percent of evacuees have already left home and have entered the road network. This percentage is determined by the behavioral response curve used.

Evacuation order time: Evacuation order time is the time in hours before hurricane eye landfall in which an evacuation order must be given to allow all evacuees to reach their chosen destinations.

Brevard County

During any given hurricane situation, in excess of 90% of the evacuating population in Brevard County will utilize the five bridges/causeways which span the Indian and Banana rivers. Those roadway links leading to the bridges, principally A1A, as well as the bridges themselves, were found to be the most critical in terms of their ability to handle the projected volumes of traffic. Two of the bridges, in particular, were found to experience large amounts of congestion for each of the response curves tested.

In conducting the transportation analysis, initial clearance time estimates were made based upon the evacuation zone configurations previously discussed and traffic movements associated with these configurations. These traffic movements were similar to those currently outlined in the Brevard County Peacetime Emergency Plan which attempts to evenly distribute the traffic from the beachside evacuation zones among the county's five bridges/causeways.

Utilizing these traffic movements, the Eau Gallie Causeway experienced the greatest queuing delay of any of the roadways tested. The following table shows clearance time estimates for the causeway for each response curve by storm situation.

| Response Curve | Storm Situation 1-2 | Storm Situation 3-5 |
|---|---|---|
| Quick Response | 12.63 hrs. | 12.63 hrs. |
| Behavioral Response | 14.36 hrs. | 14.36 hrs. |
| Slow Response | 16.10 hrs. | 16.10 hrs. |

These times greatly exceeded what was required to evacuate other areas of the barrier island--in many cases, doubling the time necessary to clear the roadways. Consequently, efforts were undertaken to redirect portions of

the evacuation zonal population to other roadways experiencing less delay. To reduce the number of vehicles using Eau Gallie Causeway, approximately 60% of the population was distributed to Pineda Causeway to the north and Melbourne Causeway to the south. This allowed for a reduction of the clearance times at Eau Gallie Causeway to that approximating the behavioral response curve lines, while having almost a negligible effect on the times for Pineda and Melbourne causeways.

SR 520 also experienced an inordinate amount of congestion relative to the other bridges/causeways in the county. While not as critical as that found at the Eau Gallie Causeway, the congestion was sufficient to increase clearance times almost five hours above that of the behavioral response times. Therefore, an additional evacuation lane was added to the causeway, providing for an increase of 504 vhp. This allowed the time required for clearing the link to be reduced by approximately three hours.

Volusia County

The situation in Volusia County is almost the reverse of that in Brevard. Whereas the population centers in Brevard County are on the vulnerable barrier islands, the majority of Volusia County's population resides on the mainland. While most of these mainland residents would not be expected to evacuate during the hurricane, their presence as background traffic causes queuing delays to occur at several of the major intersections through which evacuating traffic from vulnerable areas must pass. It is the delay at these intersections which determine the county's overall clearance times. Efforts made by county officials to reduce the background traffic preceding and during an evacuation would have significant effects on the time necessary to clear the county's roadways.

Evacuation Times by Regional Storm Scenario

Five regional storm scenarios were developed for transportation modeling purposes. As mentioned previously, each regional storm scenario involves a different storm track and/or intensity, thereby creating varying storm effects in each of the two counties. Using the evacuation times discussed previously, Table 24 has been developed to provide generalized evacuation order times by each regional scenario. The times are general in that the behavioral survey response curve time has been used.

TABLE 24

REGIONAL STORM SCENARIOS
REQUIRED TIME FOR EVACUATION ORDER BY COUNTY

| Regional Storm Number | Storm Description | Time before Eye Landfall (Hrs.) Volusia | Brevard |
|---|---|---|---|
| 1 | Category 1-2 Storm | X | 8-13 |
| 2 | Category 3-5 Storm | 8-12 | 12-19 |
| 3 | Category 1-2 Storm | 8-12 | X |
| 4 | Category 3-5 Storm | 13-19 | 8-13 |
| 5 | Paralleling Storm Regionwide | 8-12 | 8-13 |

X = No storm surge; little to no evacuation required.

## WARNING ELEMENT

### EXISTING WARNING SYSTEM

The existing warning system is composed of several key entities of federal, state, and local governments. Each of these plays an important role in disseminating and interpreting hurricane hazard information as a storm approaches the State's coast.

In the event of a hurricane threatening the coast of East Central Florida, the following entities would be involved in the warning process:

National Hurricane Center (NHC)
Florida Bureau of Emergency Management
Daytona Beach Area--National Weather Service
Area Coordinator/Florida Bureau of Emergency Management
Volusia County Civil Defense Office
Brevard County Civil Defense Office
Municipal Disaster Preparedness offices
Public Media (radio/TV)

Figure 16 presents a schematic of this warning system.

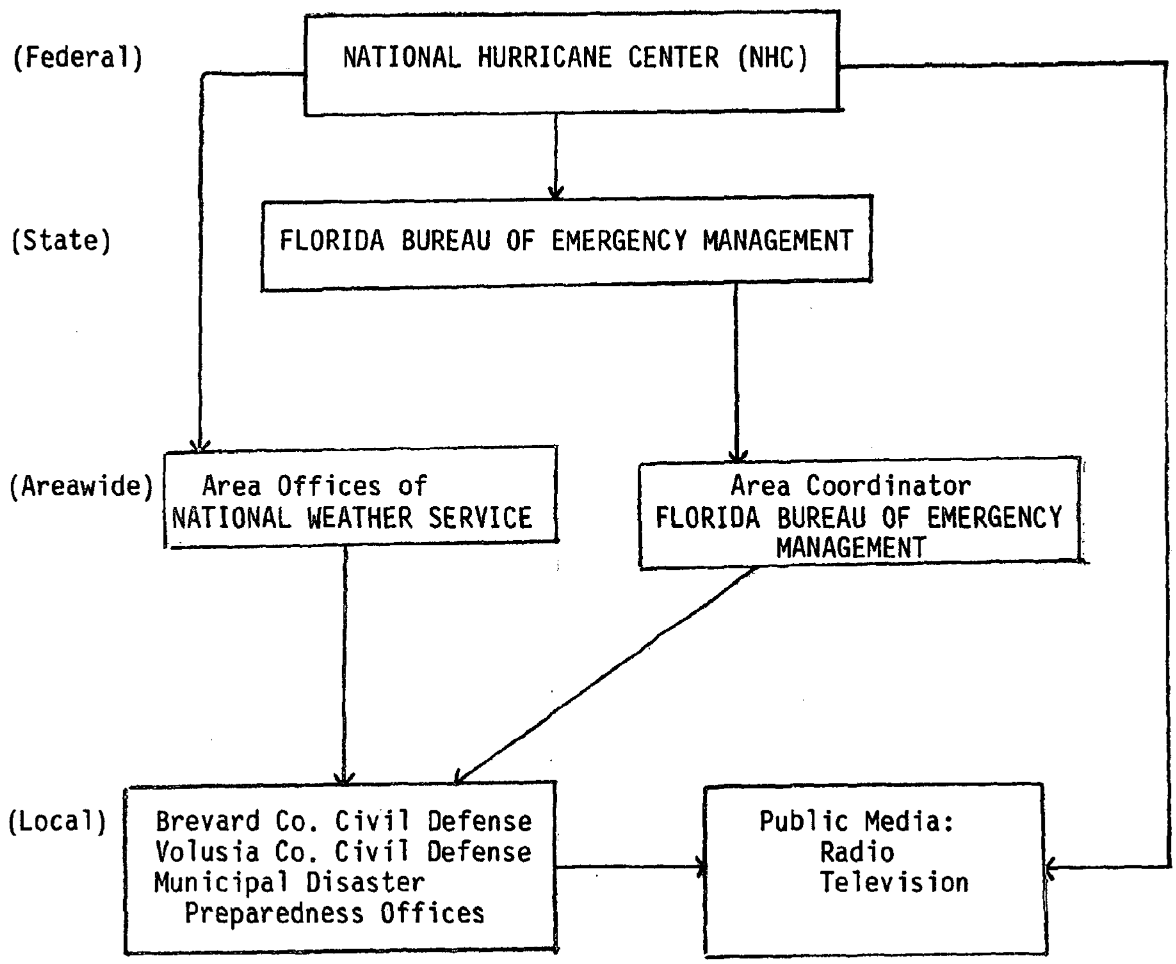
The interpretation and dissemination of emergency information concerning an approaching hurricane by and between the government entities detailed above are geared to the particular characteristics of a storm and resulting conditions assigned to elicit specific and appropriate levels of readiness and response from the local areas placed under these conditions. The two primary conditions are the "hurricane watch" and "hurricane warning." These conditions are announced for a specific stretch of coastline as part of one of the advisories that are normally issued by the NHC every six hours during the approach of a storm. A Hurricane Watch condition placed on a specified area means that hurricane conditions are a real possibility in that area; a Hurricane Warning condition placed on an area (usually a 250-mile stretch of coastline, as opposed to a Watch condition area of 500 miles) means that hurricane conditions can be expected in that area within 24 hours.

The time frame for warning activities is desribed below, with key warning system conditions and activities related to hurricane eye landfall.

- o 72-hour advisory -- Storm-assigned category number on Saffir-Simpson Scale by NHC.
- o 48 hours before projected eye landfall -- Local areas placed under Hurricane Watch condition by NHC.
- o 24 hours before projected eye landfall -- Local areas placed under Hurricane Warning condition by NHC.

Figure 16

HURRICANE WARNING SYSTEM



- 12-24 hours before projected eye landfall -- Local area advised to evacuate by NHC advisory or local National Weather Service office.

- Chief elected official for particular county advised by Disaster Preparedness department to issue evacuation order for its jurisdiction.

- Evacuation order issued.

- Evacuation order disseminated to the public by public media and/or emergency response agencies.

In discussing the existing warning system, two considerations should be noted:

1) Hurricane movement is difficult to predict beyond a certain time frame.

2) Evacuation decisions that are made without accurate information may have adverse effects.

The first consideration often leads to the second. The average landfall point projection error in a 24-hour forecast is in the range of 100 nautical miles. Within that "error" range, some areas will experience flooding conditions and others will not. This uncertainty about which areas will be affected leads to the dilemma facing decision-makers. Areas needlessly evacuating undergo the expense and potential hazards associated with a mass evacuation, while other areas failing to evacuate due to insufficient notice may face the threats to the public safety from the storm.

The information made available through this technical data report provides local officials with an indication of the areas subject to tidal flooding and the steps necessary to carry out an evacuation. Consideration of the evacuation times presented in previous sections of the report are one part of the decision-making process, serving as a tangible basis against which the probabilities and impacts of a hurricane may be weighed before an evacuation order is issued.

## GUIDE FOR EVACUATION DECISION-MAKING

Interpreting NHC hurricane information and implementing proper emergency preparedness measures by local officials require knowledge of the common data base set forth in this study. This data base will enable the coordination of evacuation decisions during a hurricane approach and comparison to SPLASH II computer runs of the actual approaching hurricane by the NHC. This, in turn, will provide local disaster preparedness officials with a high level of information from which the actual storm conditions and impacts may be interpreted.

There are several steps which can be taken by local officials as part of the decision-making process based upon the information contained in this study. These steps are identified and discussed below.

1) Identify Storm Characteristics

Storms are generally assigned a Saffir/Simpson Scale category number by the NHC while the storm is 72 hours away from landfall. A situation may arise where the category changes during the lifetime of the storm, requiring the storm to be re-identified.

The next step will be to eliminate various hurricanes simulated through the SPLASH II model based upon the type of track detected by the NHC for the actual hurricane. As the storm moves toward the State, its potential for approaching the region on a landfalling, paralleling, or exiting track may be more easily discerned. It is important to note that any elimination or focus of preparedness for particular hurricanes must be tentative because of the ability of any storm to rapidly change direction during its movement.

2) Identification of Evacuation Scenario Confronting the Region

The next step in interpreting the expected local effects of an approaching storm is to identify the level of threat that would confront the counties if the actual hurricane continued its current approach.

As the decision-maker focuses upon a certain scenario, the predicted surge heights and wind speeds associated with a probable storm can be identified. This identification may provide the disaster preparedness officials with the first indication of the level of population that must be evacuated, zones to be evacuated, and public shelters which should not be utilized for that particular scenario.

3) Identification of Evacuation Time Confronting the Region

Based upon the preceding steps, it is possible to gauge the minimum time needed for a successful evacuation. This enables the decision-maker to know when an evacuation order must be issued in relation to eye landfall, so that the evacuation is safely completed prior to the arrival of hurricane hazards. These times are provided in the previous section of the report.

4) Adaption to Actual Conditions

The last step to be taken by officials is to adjust the evacuation time based on actual conditions. An adjustment to the times set forth may be necessary due to one or more of the following conditions:

a) Public behavior
b) Early arrival of heavy rains
c) Characteristic changes, forward speed, or conditions close to eye landfall

PUBLIC BEHAVIOR

Past studies have indicated--and investigations of evacuee behavior during hurricanes David and Frederick appear to confirm--that approximately 20% of the population threatened will leave prior to issuance of an evacuation order. This figure was common to each of the behavioral response curves tested in the study and helped determine the mobilization time periods used. The mobilization times represent the lower limit of time required to evacuate a county. For example, in a quick-response situation, the mobilization time was calculated at 3 hours. If a total time is less than 3 hours, due to low travel time to the shelter, a 3-hour minimum evacuation is still assumed. The variable which must be closely monitored by local officials during actual hurricane Watch and Warning conditions is the percentage of evacuees leaving prior to the evacuation order. A decrease in this percentage will increase the mobilization time periods and, hence, the minimum amount of time required to evacuate.

EARLY ARRIVAL OF HEAVY RAINS

Pre-landfall hazard times range from 4 to 11 hours before eye landfall, when flooding or gale force winds might prevent evacuation from being carried out. Depending primarily on the forward speed of the storm, pre-storm rainfall may precede these pre-storm hazard periods. Instances of rainfall occurring as early as 20 hours before eye landfall have been recorded for several past hurricanes. Such rainfall would reduce roadway carrying capacity because of limited driving visibility and wet pavement. Recalculation of roadway capacities were made within this report to compensate for this factor. This capacity reduction was assumed for the entire length of the evacuation. Further adjustments, however, may be necessary should rainfall arrive earlier than the 4-11 hours estimated.

ACTUAL VS. HYPOTHETICAL HURRICANE

The formulation of the evacuation times in this report were based on hypothetical hurricanes of probable characteristics. As mentioned previously, it is improbable that an actual hurricane will fit each of the characteristics used to develop a hypothetical storm. Two parameters which could significantly change expected pre-eye landfall hazards times if they are different are:

1) storm size (in statute miles of the radius of maximum winds); and

2) forward speed (in miles per hour).

As the actual hurricane's characteristics are identified by the NHC, the pre-eye landfall hazard times should be adjusted if conditions warrant it. In all cases, however, local officials can use the "worst case" probable flooding maps as a basis on which to act.

In order that the procedures identified in this section work, constant communication between decision-makers at all levels of government are required. It is also essential that the data base developed by this study be continually reviewed and updated by local disaster preparedness officials and staffs as local conditions change and populations increase.

## PUBLIC INFORMATION AND THE MEDIA

The success of any warning system is dependent on the ability to communicate important information to the public in a timely manner. The public media--television, radio, and newspaper--is the primary means of reaching the public before, during, and after a storm. In order to effectively carry out the procedures discussed in this report, a public information mechanism needs to be developed to inform the public of vulnerability zones, the threats to each zone, evacuation routes, and actions needed to be taken during a storm event as well as general hurricane preparedness measures and precautions.

As a result of this study, public information brochures will be developed providing the detailed information required to complete a successful evacuation. The brochure will consist primarily of an evacuation route map and identify and mark vulnerability zones to enable residents to identify their homes and monitor their vulnerability to various storm types. Additional information regarding shelter availability, both in coastal and inland counties, will be provided as well as general preparedness information.

Additional public information materials will also be developed in the form of television and radio scripts for use by commercial stations during hurricane Watch and Warning periods. These scripts will be specific to the Watch and Warning periods and will detail actions needing to be taken at those times. Information provided in the brochure will be broadcast, either graphically or verbally, at these times.

It is important that the public information brochures be updated regularly, to compensate for changes in evacuation routes or zonal boundary changes.

APPENDICES

APPENDIX A

# APPENDIX A

## SAFFIR/SIMPSON HURRICANE SCALE

1. Winds of 74 - 95 miles per hour
   Storm surge 4 - 5 feet above normal

2. Winds of 96 - 110 miles per hour
   Storm surge 6 - 8 feet above normal

3. Winds of 111 - 130 miles per hour
   Storm surge 9 - 12 feet above normal

4. Winds of 131 - 155 miles per hour
   Storm surge 13 - 18 feet above normal

5. Winds greater than 155 miles per hour
   Storm surge greater than 18 feet above normal

## LEVEL OF THREAT -- A

### Description of Forces

Storm surge 4 to 8 feet above MSL accompanied by winds of 74 to 110 mph.

### Associated Hazards

Principal threat resulting from hurricane force winds and accompanying tornado activity. Areas lying adjacent to the ocean or tidal rivers subject to flooding from storm surge. Low-lying causeways and roads (A1A) may be inundated several hours prior to landfall, impeding evacuation of barrier islands.

### Damage Potential

Majority of damage to result from wind, principally to exposed mobile homes or poorly constructed homes. Considerable damage to signs, street lights, and trees. Buildings lying east of A1A on the barrier islands to suffer damage from rising water and wave action.

### Level of Evacuation

#### Brevard County

All residents of barrier islands (Evacuation Zones B1-B6) and portions of Merritt Island (B7, B9, B10) and mainland (B13). Evacuation of all mobile home residents within the county.

#### Volusia County

Residents of barrier islands (Evacuation Zones V1, V3, V4, V6, V7, V9, V10, V12, V13, V15, V32, V33, V35, V37, V38) and mainland (V16, V18, V20, V23, V36, V27, V32, V34, V35, V37, V39, V44, V46). Evacuation of all mobile home residents within county.

## LEVEL OF THREAT -- B

### Description of Forces

Storm surge ranging from 9 to 18+ feet above MSL, accompanied by winds of 111 to over 155 mph.

### Associated Hazards

Both flooding and winds will produce considerable threat to the area, along with associated tornado activity. Storm surge will cause major erosion of dune line, with the potential for overtopping of barrier islands at several points in Brevard County. Oceanfront and riverfront structures subject to considerable damage. Roadways on the barrier islands and low-lying causeways will be inundated three to seven hours before eye landfall. Extensive flooding around Tomoka Basin and Strickland Bay in Volusia County.

### Damage Potential

Extensive damage to structures (roofs, windows, etc.) from high winds. Complete destruction of mobile homes. Major damage or destruction of oceanfront buildings from storm surge. Erosion of beachfront.

### Level of Evacuation

#### Brevard County

All residents living on barrier islands and Merritt Island (Evacuation Zones B1-B10) and mainland residents residing adjacent to tidal rivers (B12-B26). Evacuation of all mobile home residents within county.

#### Volusia County

All residents living on barrier islands (Evacuation Zones V1-V15 and V32-V38) and mainland residents living adjacent to tidal rivers or bays (V16-V24 and V39-V47). Evacuation of all mobile home residents within county.

APPENDIX B

APPENDIX B

## PRE-LANDFALL HAZARDS TIME ADJUSTMENT RATES

### Storm Size (radius of maximum winds)

| Hypothetical Hurricane Radius of Max. Winds (statute miles) | Arrival of Gale Force Winds Time before Eye Landfall (hours) | Actual Radius of Maximum Winds (statute miles) | Adjusted Arrival Time of Gale Force Winds before Eye Landfall (hours) |
|---|---|---|---|
| 15 | 5 | 10 | 4.25 (-.75) |
| | | 20 | 5.75 (+.75) |
| | | 30 | 7.25 (+2.25) |
| | | 40 | 8.75 (+2.75) |

### Forward Speed

| Hypothetical Hurricane Forward Speed (mph) | Arrival of Gale Force Winds Time before Eye Landfall (hours) | Actual Forward Speed (mph) | Adjusted Arrival Time of Gale Force Winds before Eye Landfall (hours) |
|---|---|---|---|
| 15 | 5 | 6 | 12.0 (+7.0) |
| | | 12 | 6.0 (+1.0) |
| | | 18 | 4.0 (-1.0) |

APPENDIX C

## APPENDIX C

### Procedure for Breaking Wave Setup/Astronomical Tide Analysis

Figure C1 is a hurricane surge hydrograph along the East Central Florida coast. The figure shows a still water surge envelope from a SPLASH II computer printout (heavy black line). The SPLASH II results do not include the astronomical tide level or breaking wave set. Also, it does not include the tidal anomaly produced by a hurricane movement over a body of water. However, because the anomaly is a constant .5 feet it is not included.

Also shown on Figure C1 is the astronomical tide and wave setup being superimposed on top of the storm surge envelope. The astronomical tide level shown here is for mean high tide.

Figure C2 is a nomograph of the breaking wave setup versus the breaker height of the significant wave published by the U.S. Army Coastal Engineering Center in 1973. This figure allows for the computation of wave setup based on the predicted tidal level (storm surge and astronomical tide) in an area. The formula used in computing the wave setup is as follows:

$$SW = 0.19 \left[1 - 2.82 \left(\frac{Hb}{gT^2}\right)^{\frac{1}{2}}\right] Hb$$

SW = Breaking wave setup
Hb = Breaker height of the significant wave
g = Gravitational acceleration
T = Wave period

The breaker height of the significant wave (Hb) can be determined from the following:

$$Hb = 0.78\ db$$

db = Depth of water at the breaker point of still water level

Astronomical tide levels were determined for the SPLASH II computer printouts. The range along the East Central Florida coast was approximately 4 feet.

APPENDIX C

STORM SURGE HYDROGRAPH

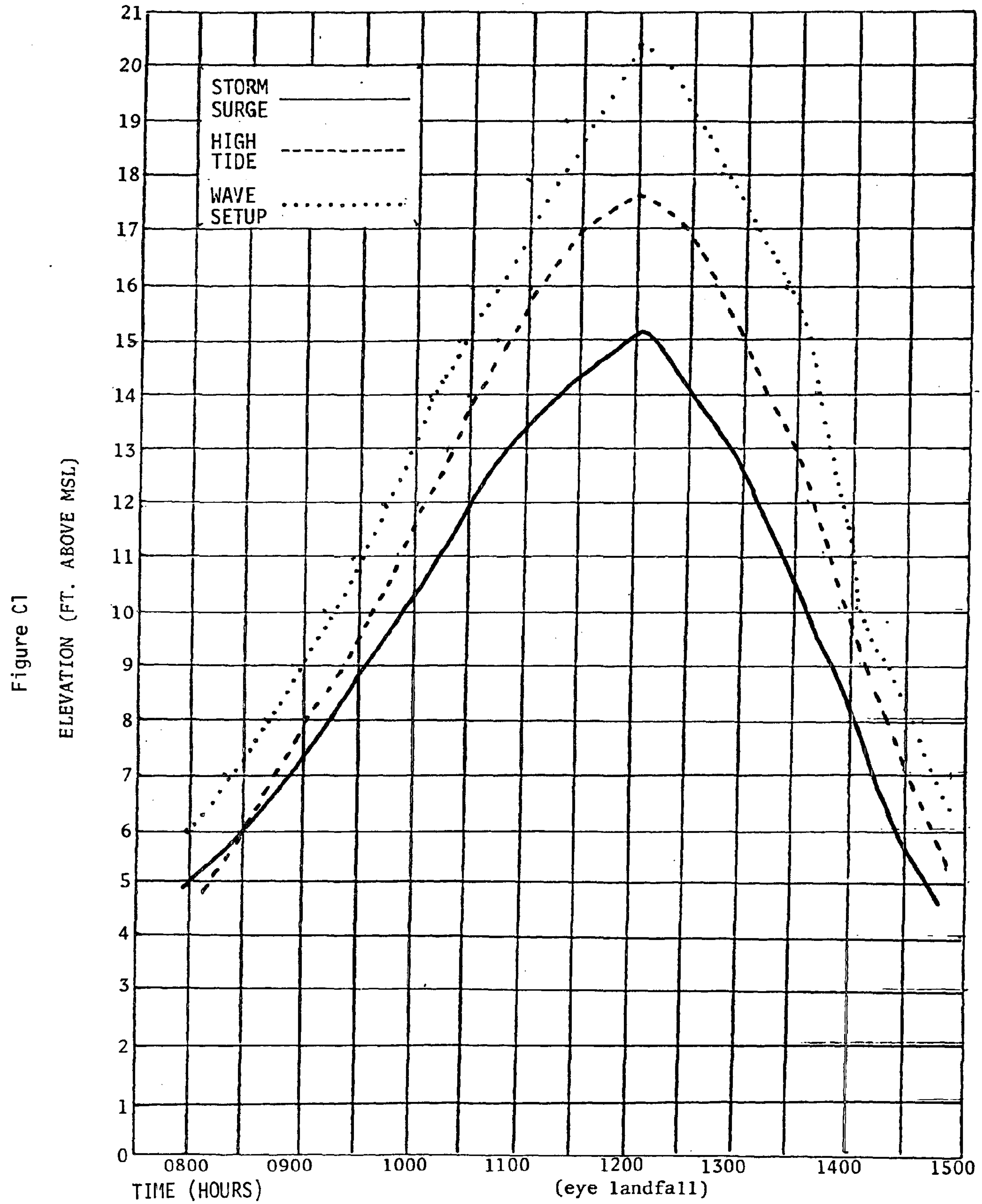



Figure C1

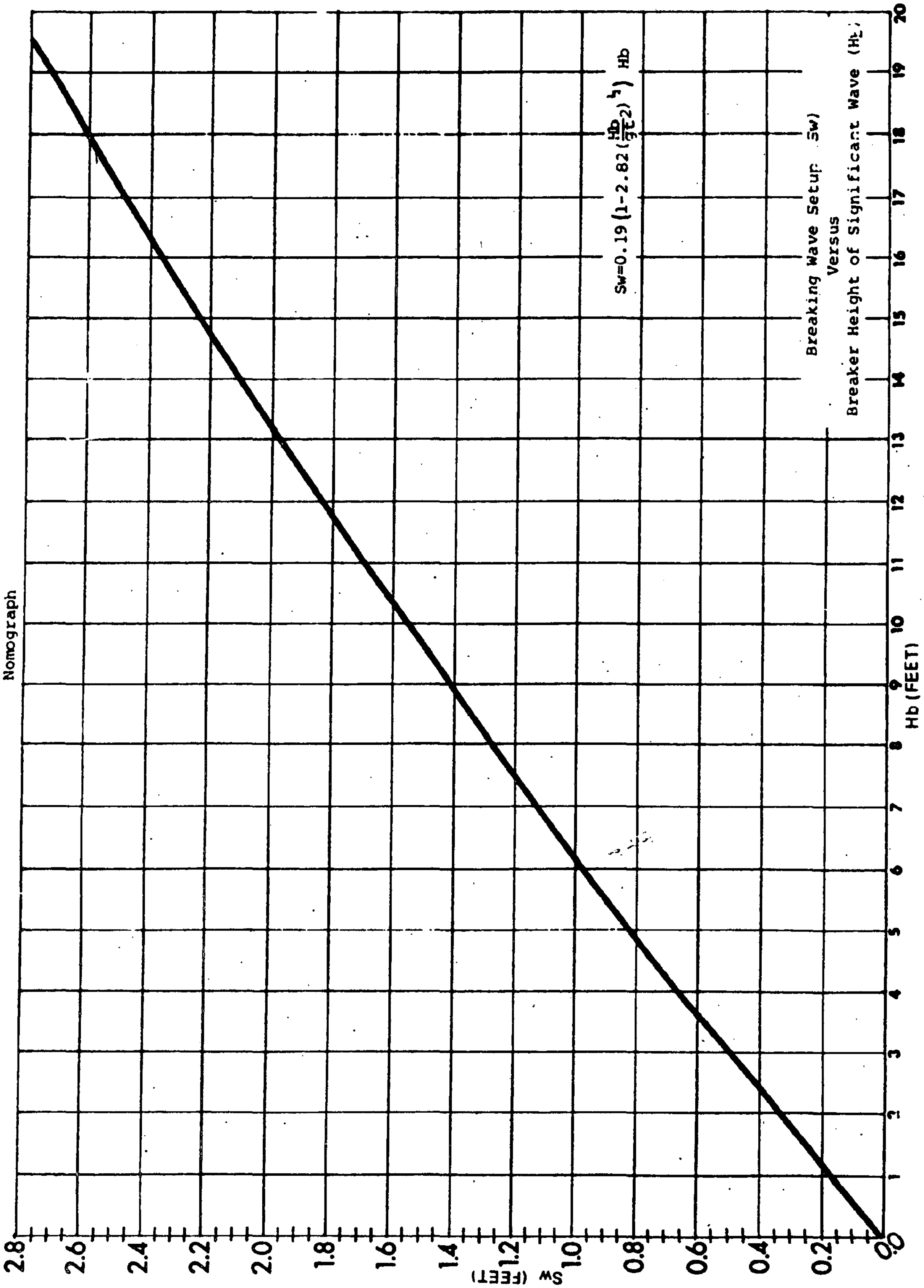
Figure C2

Breaking Wave Setup

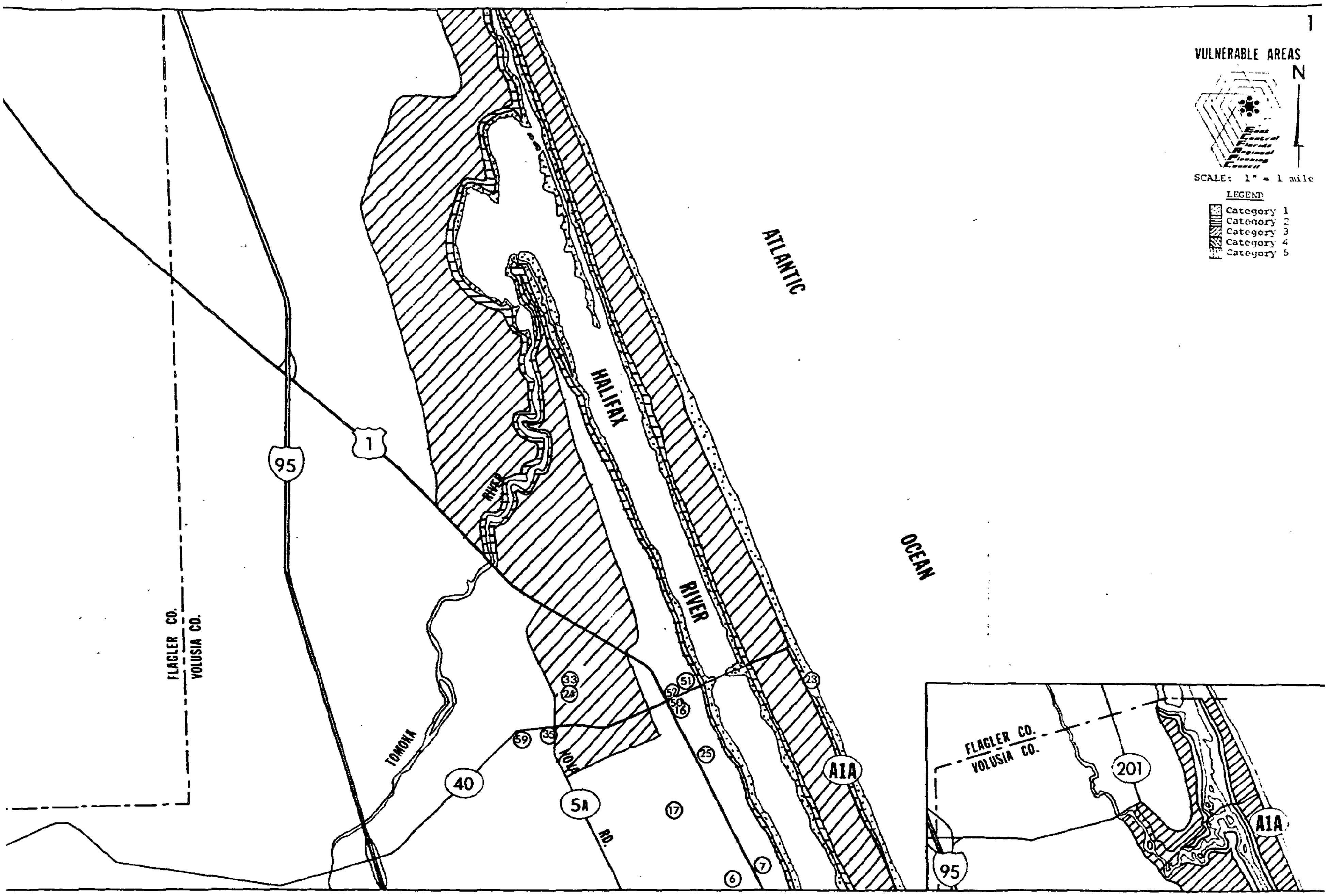
vs.

Breaker Height of Significant Wave

Nomograph



APPENDIX D



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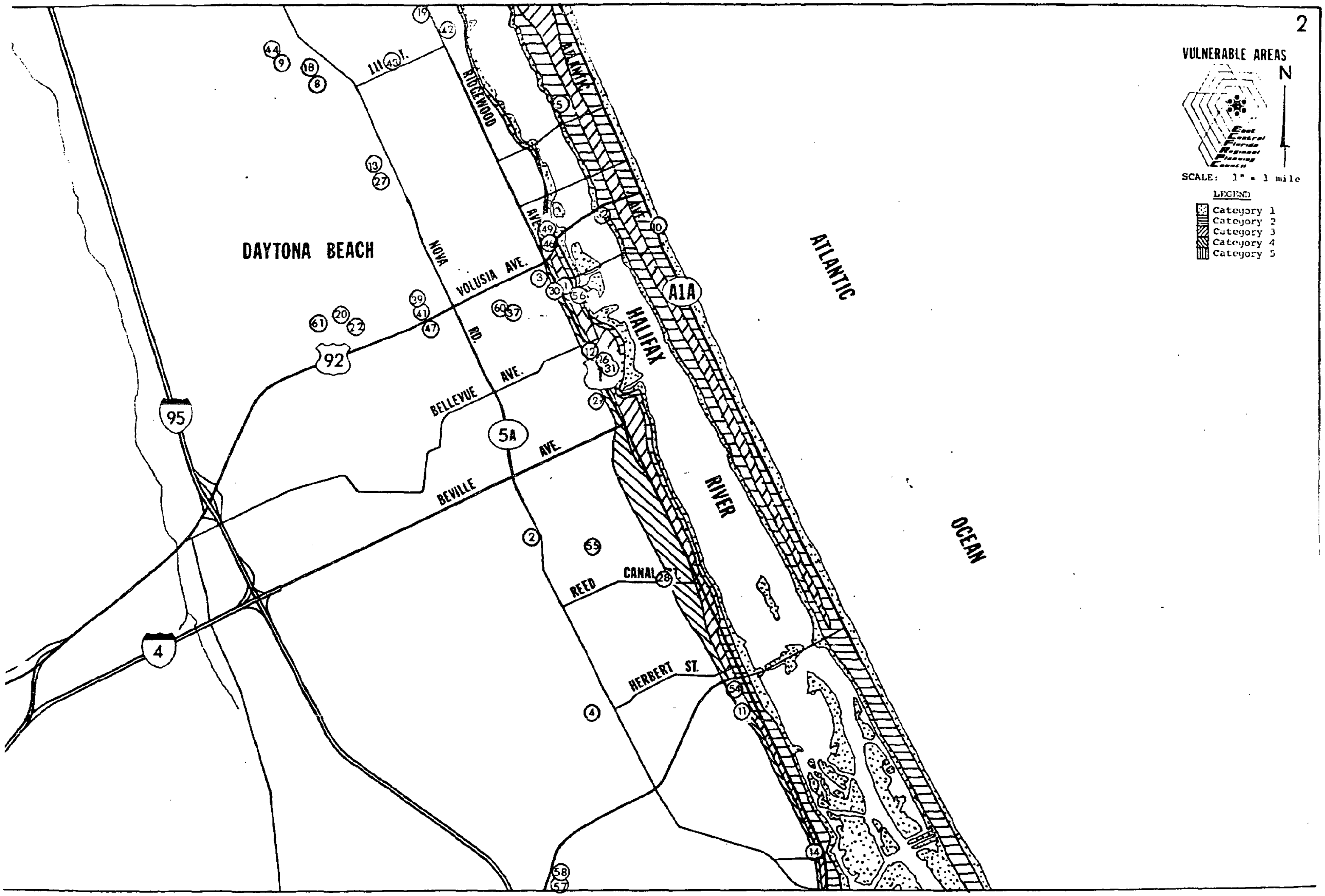
VOLUSIA CO.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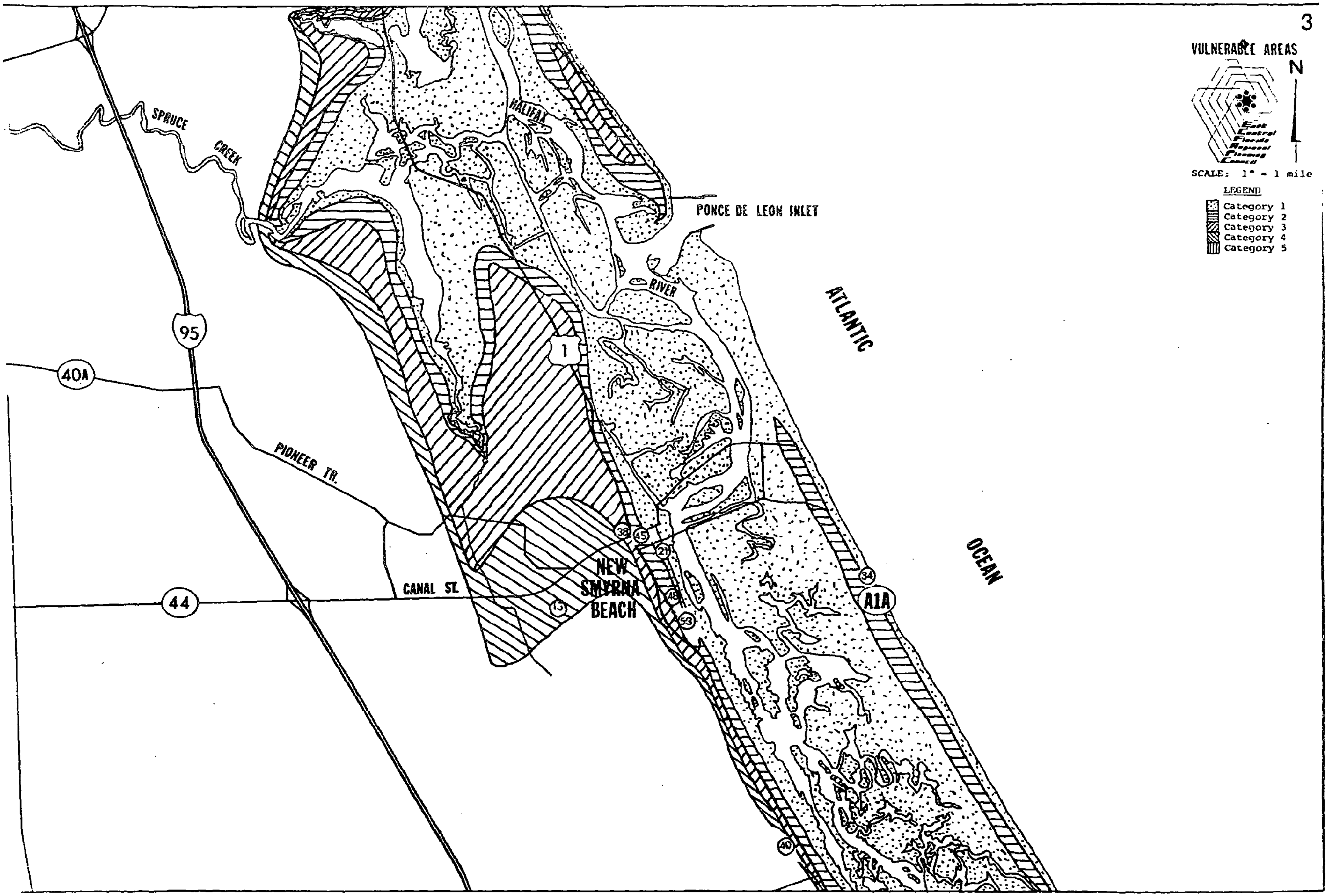
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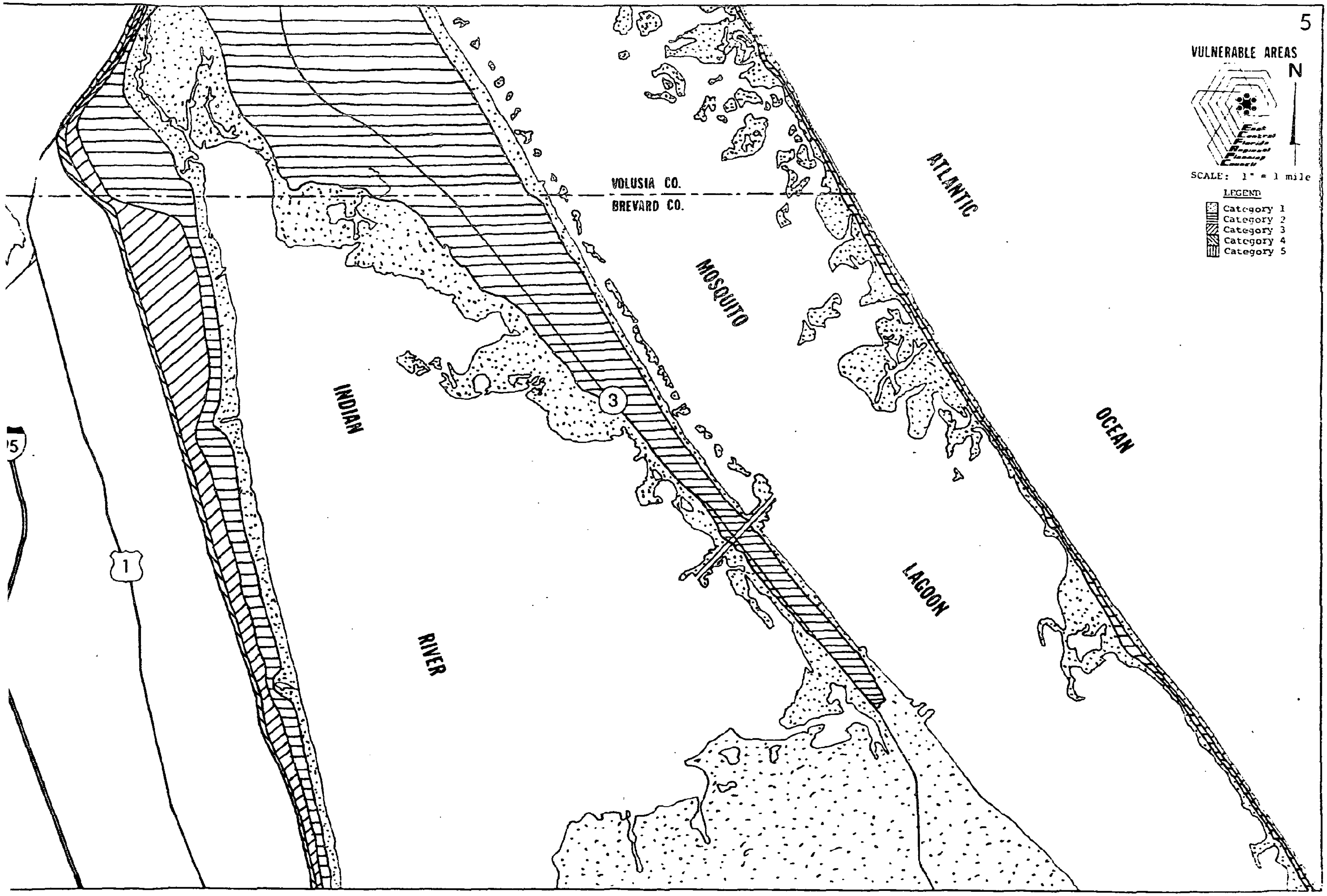
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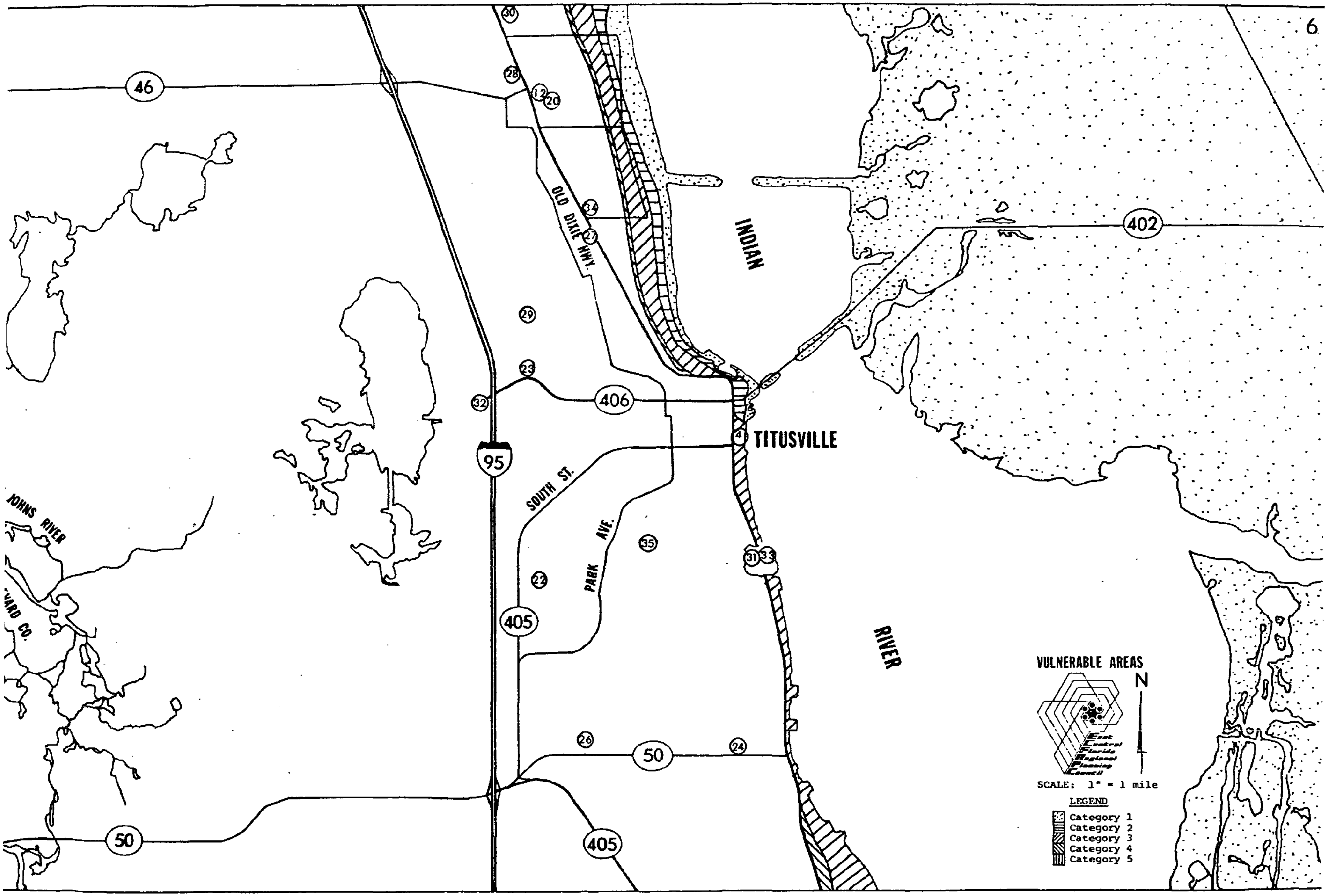
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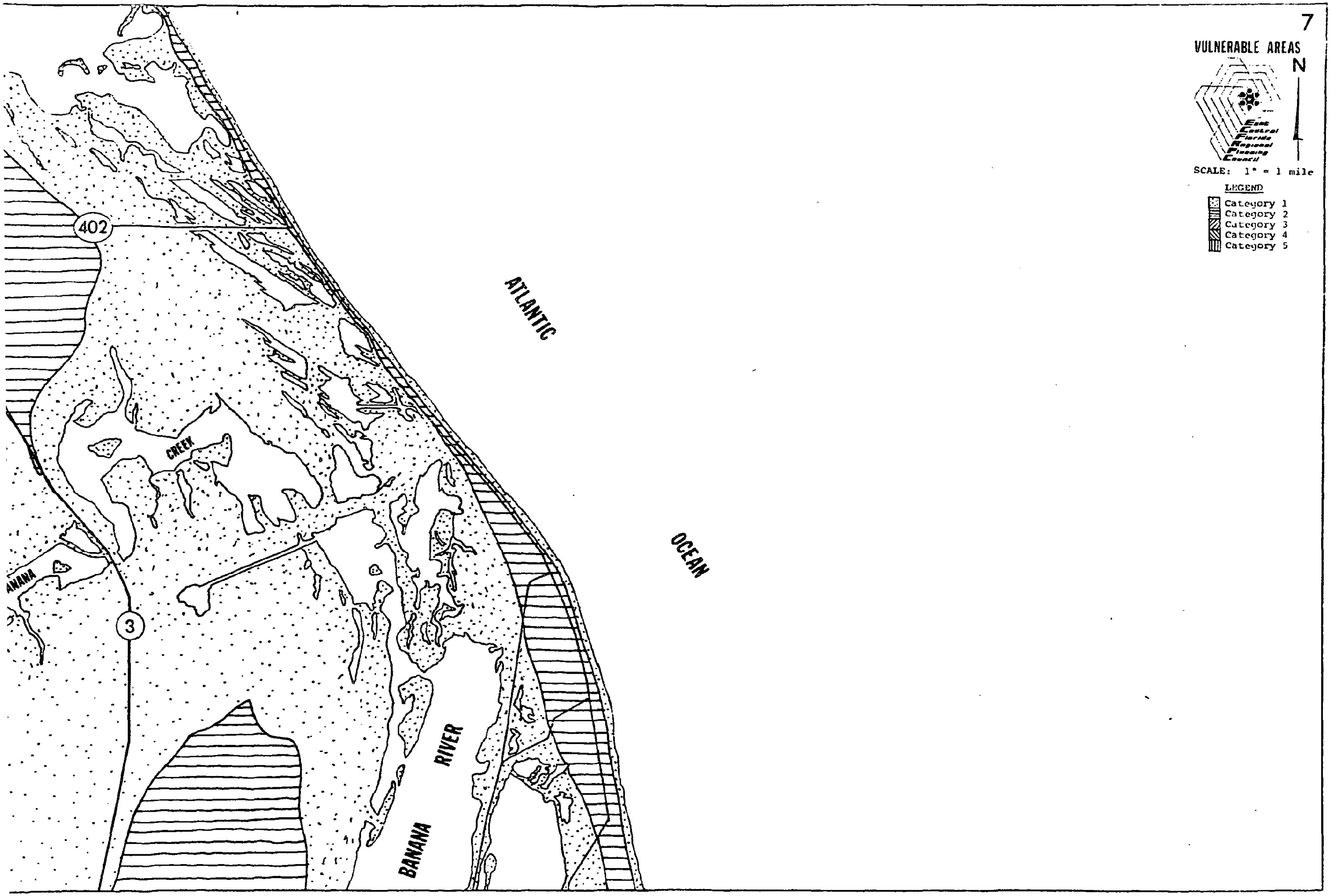
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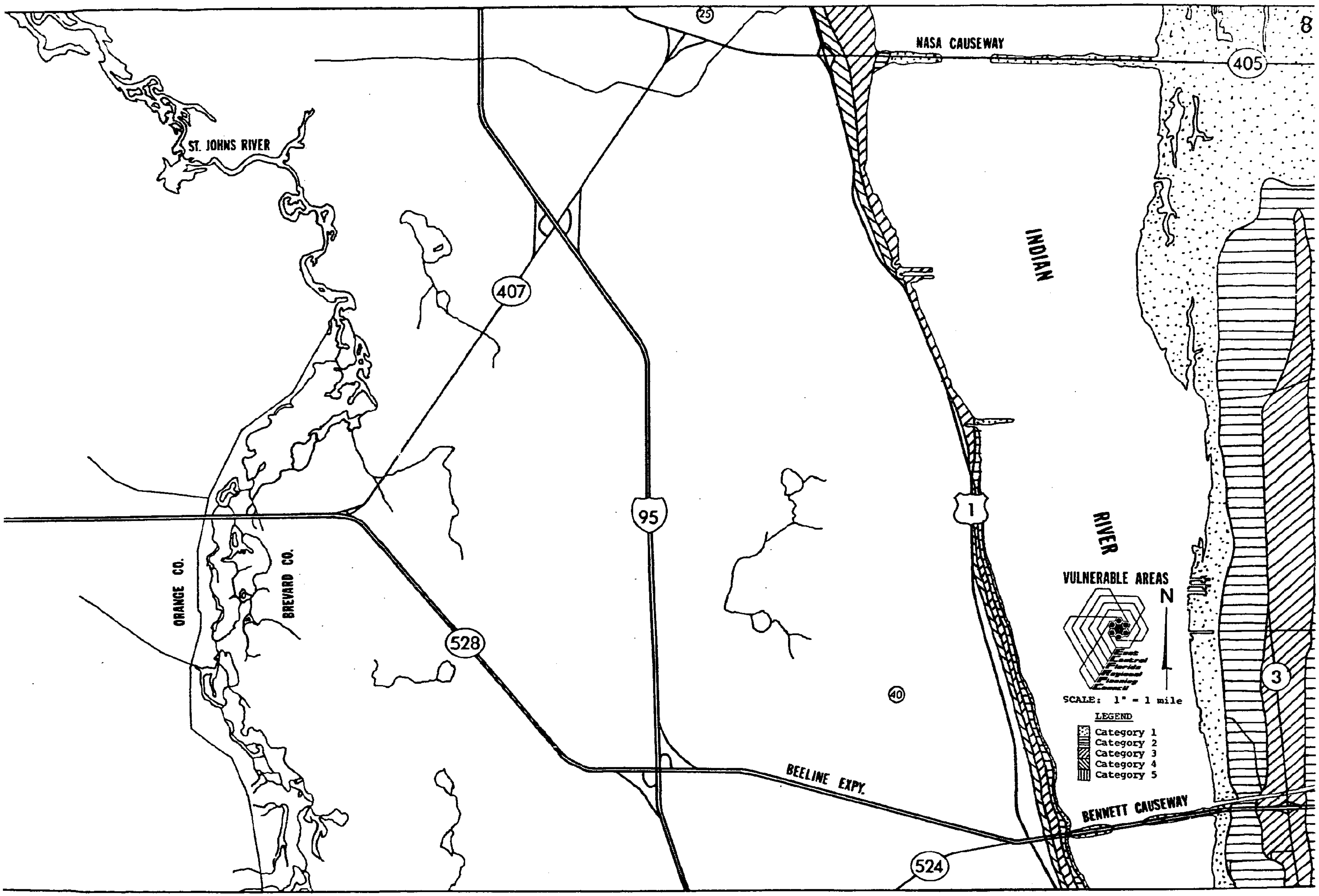

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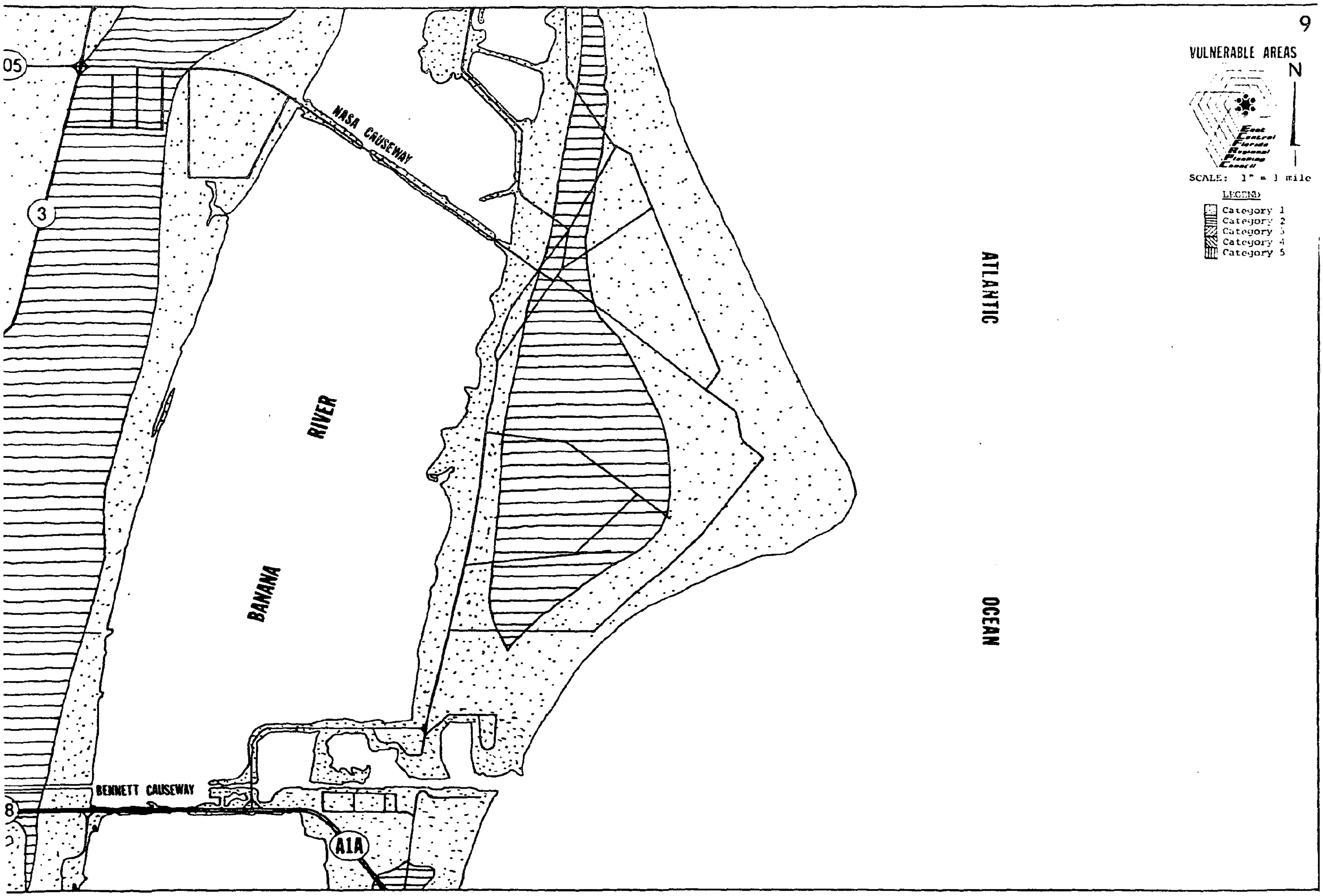
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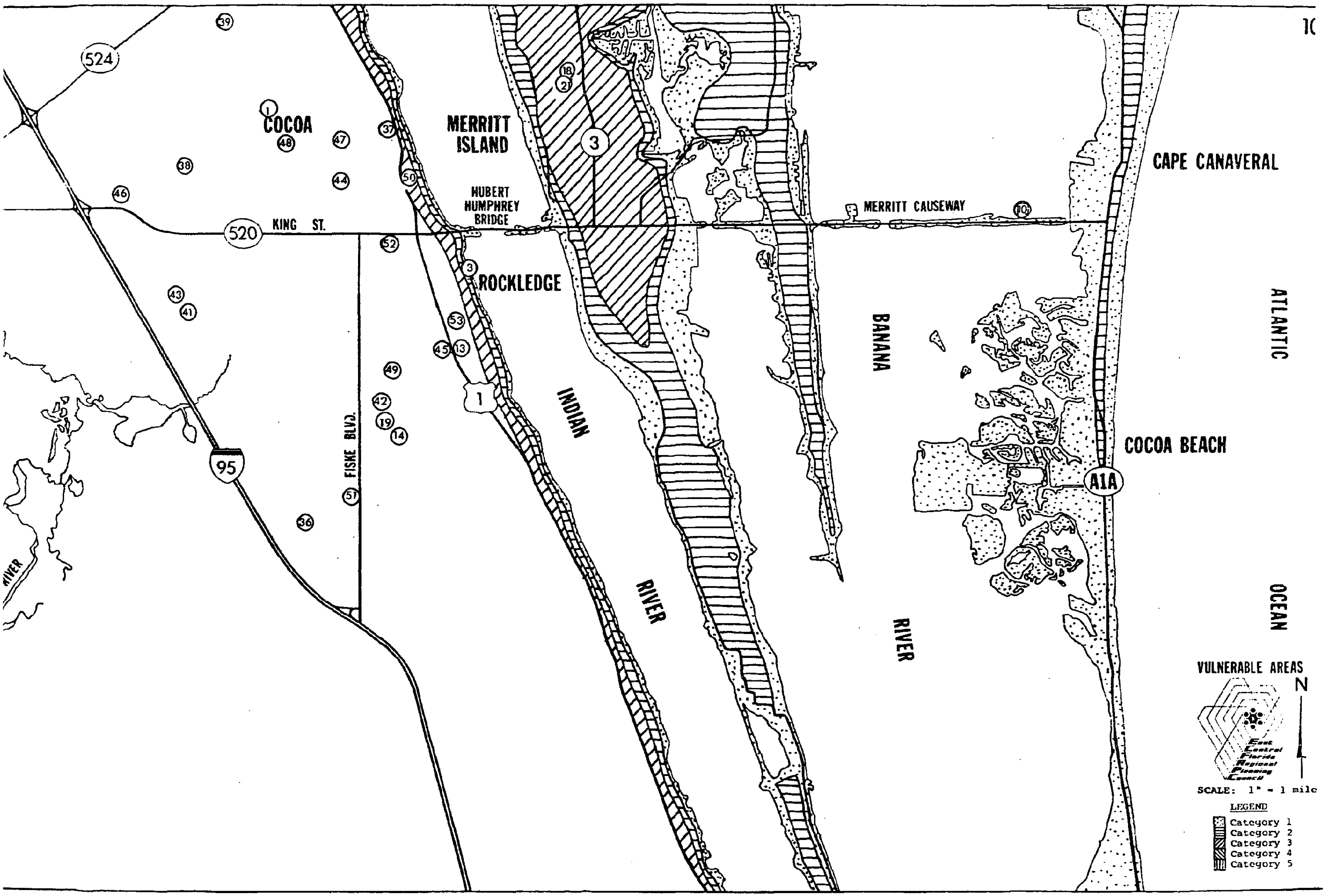
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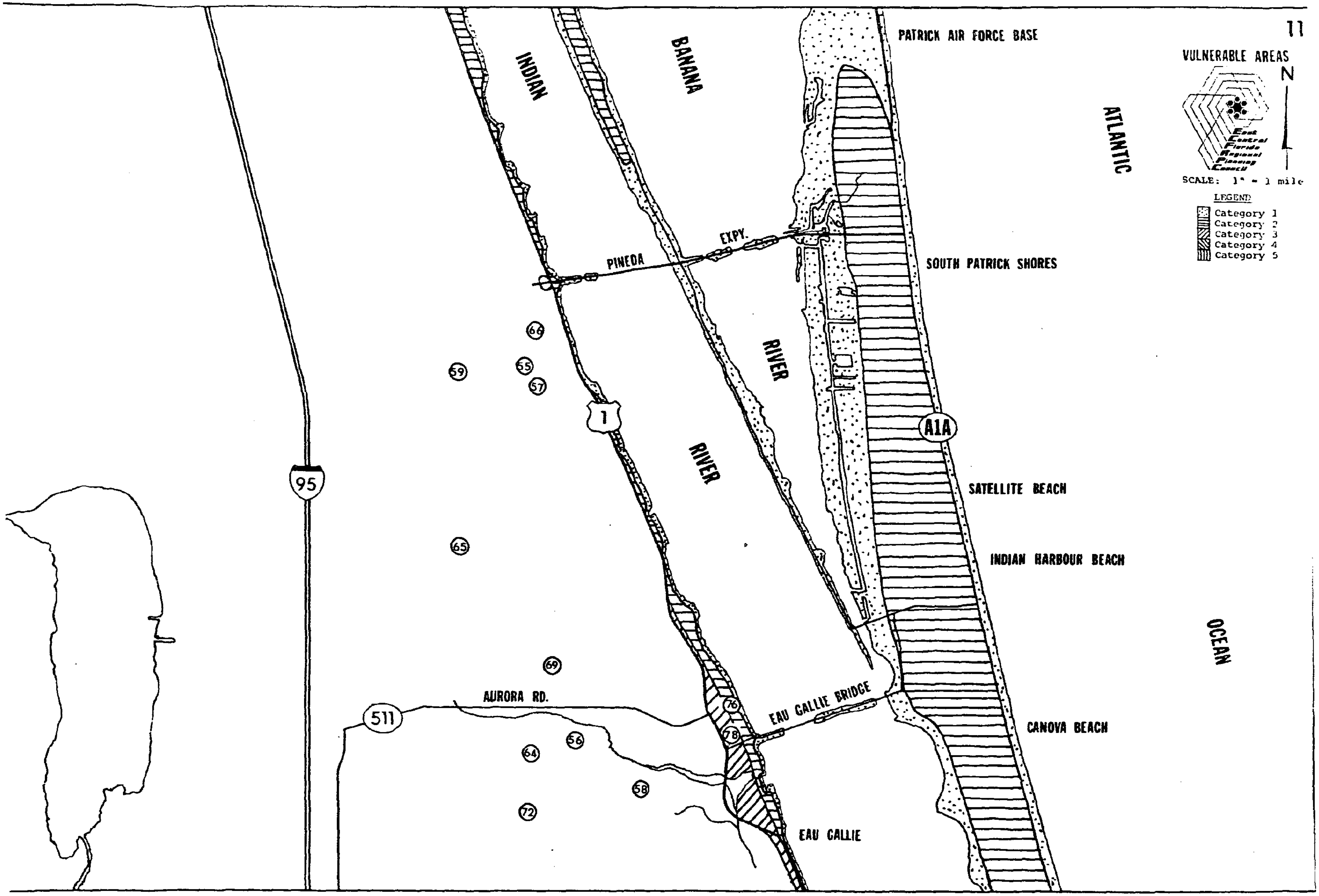
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CANOVA BEACH
A1A
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RIVER
RIVER
PINEDA
EXPY.
EAU GALLIE BRIDGE
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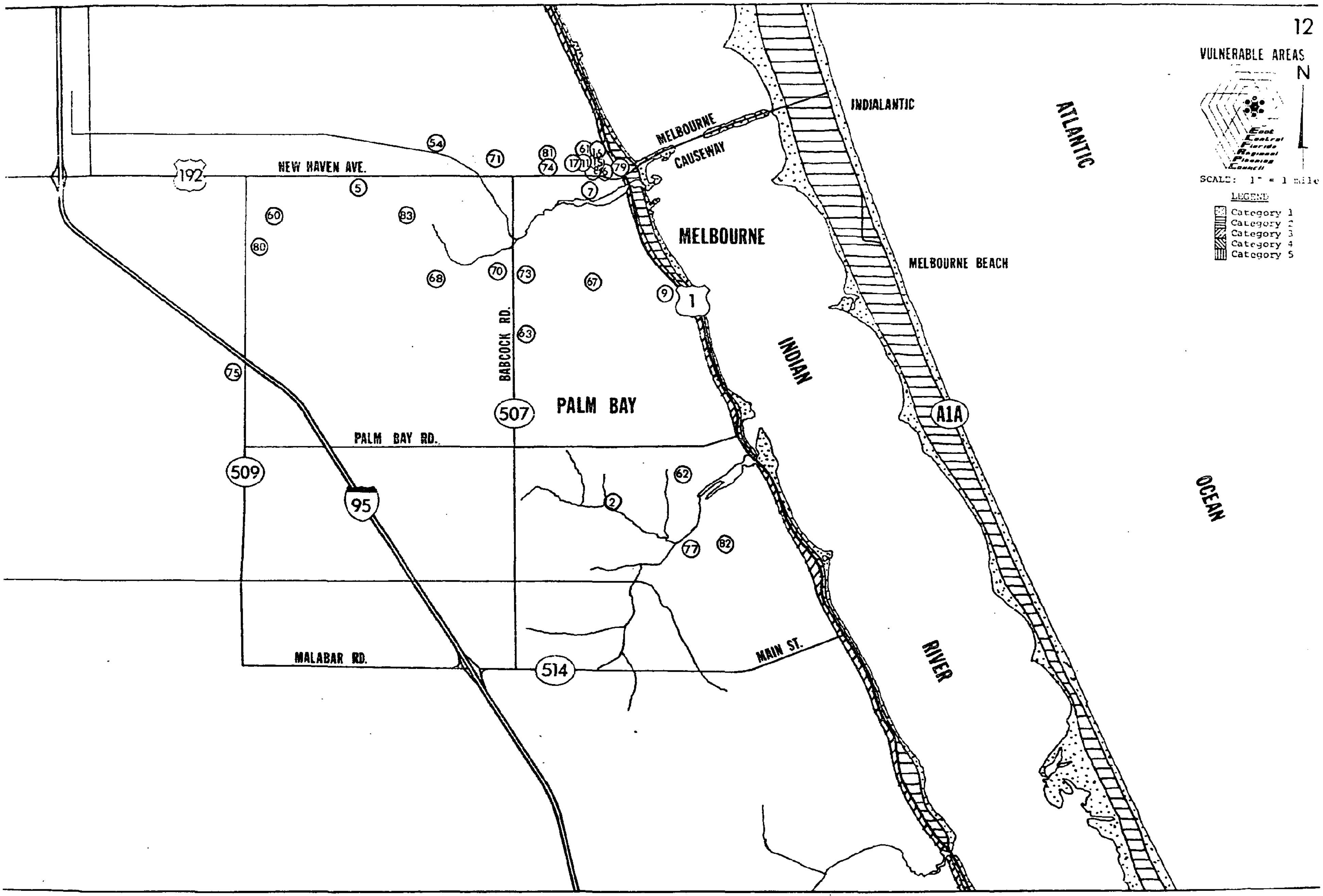
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MELBOURNE CAUSEWAY
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INDIAN
RIVER
PALM BAY
NEW HAVEN AVE.
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BABCOCK RD.
507
PALM BAY RD.
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MALABAR RD.
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MAIN ST.
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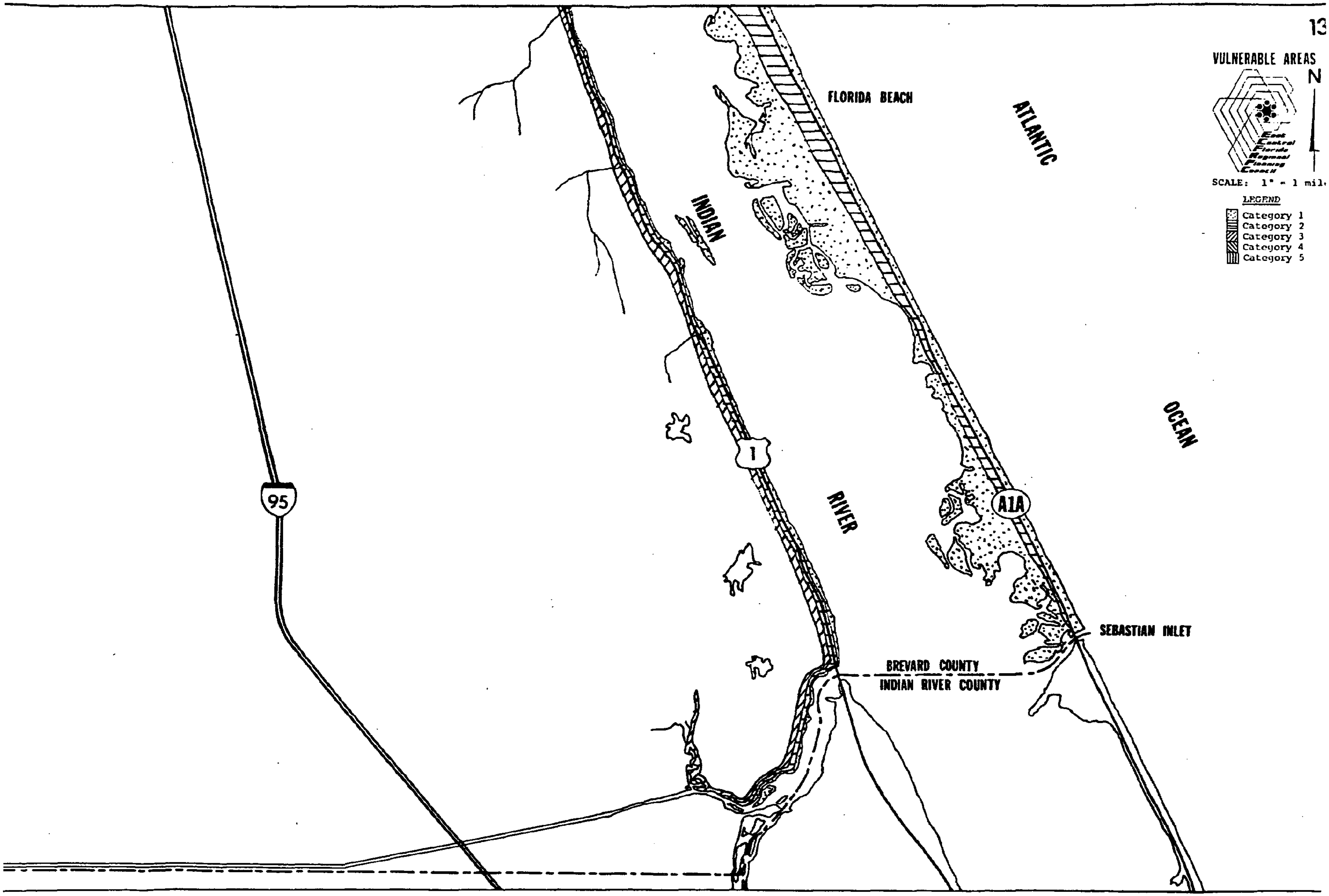

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SEBASTIAN INLET
BREVARD COUNTY
INDIAN RIVER COUNTY

APPENDIX E

# APPENDIX E

## Transportation Analysis
## Carryover Analysis Methodology

Calculation of traffic movements for the transportation analysis involved applying vehicle production numbers to a particular roadway in accordance with a specified behavioral response curve. The hourly loading rates and resulting queuing delays then determined the number of hours required to clear a particular roadway link.

An example of this analysis is shown with Bennett Causeway and S.R. 520 causeway, for a behavioral survey response during a 1-2 storm situation. The number of vehicles anticipated to utilize a particular roadway are identified by evacuation zones and a percentage of usage for each zone during each hourly interval calculated and totaled. The total number of vehicles originating from these zones each hour is then compared in the carryover analysis to the capacity of the roadway. If the number generated exceeds the capacity then a queue is formed which must be absorbed by the roadway during the next hour.

By using this method the time required to clear a roadway link may be calculated. This method was also utilized in examining intersection delays.

BENNETT CAUSEWAY

Capacity: 1470 VPHL (2L)

| ZONE B1 | | ZONE B7 | TOTAL |
|---|---|---|---|
| 4,559 x (.04) | + | 8,089 x (.04) | 506 |
| (.06) | | (.06) | 759 |
| (.10) | | (.10) | 1,265 |
| (.24) | | (.24) | 3,036 |
| (.35) | | (.35) | 4,427 |
| (.12) | | (.12) | 1,518 |
| (.09) | | (.09) | 1,139 |

CARRYOVER ANALYSIS

| HOUR | QUEUE | HOUR | QUEUE |
|---|---|---|---|
| 1 | 0 | 2 | 0 |
| 3 | 0 | 4 | 96 |
| 5 | 1,583 | 6 | 161 |
| 7 | 0 | 8 | 0 |

7.00 hours to clear link

SR 520 CAUSEWAY

Capacity: 504 VPHL (2L)

| ZONE B2 | | ZONE B9 | TOTAL |
|---|---|---|---|
| 5,253 x (.04) | + | 5,830 x (.04) | 444 |
| (.06) | | (.06) | 665 |
| (.10) | | (.10) | 1,108 |
| (.24) | | (.24) | 2,660 |
| (.35) | | (.35) | 3,879 |
| (.12) | | (.12) | 1,330 |
| (.09) | | (.09) | 997 |

CARRYOVER ANALYSIS

| HOUR | QUEUE | HOUR | QUEUE |
|---|---|---|---|
| 1 | 0 | 2 | 0 |
| 3 | 100 | 4 | 1,752 |
| 5 | 4,632 | 6 | 4,954 |
| 7 | 4,943 | 8 | 3,935 |
| 9 | 2,927 | 10 | 1,919 |
| 11 | 911 | 12 | |

11.90 hours to clear link