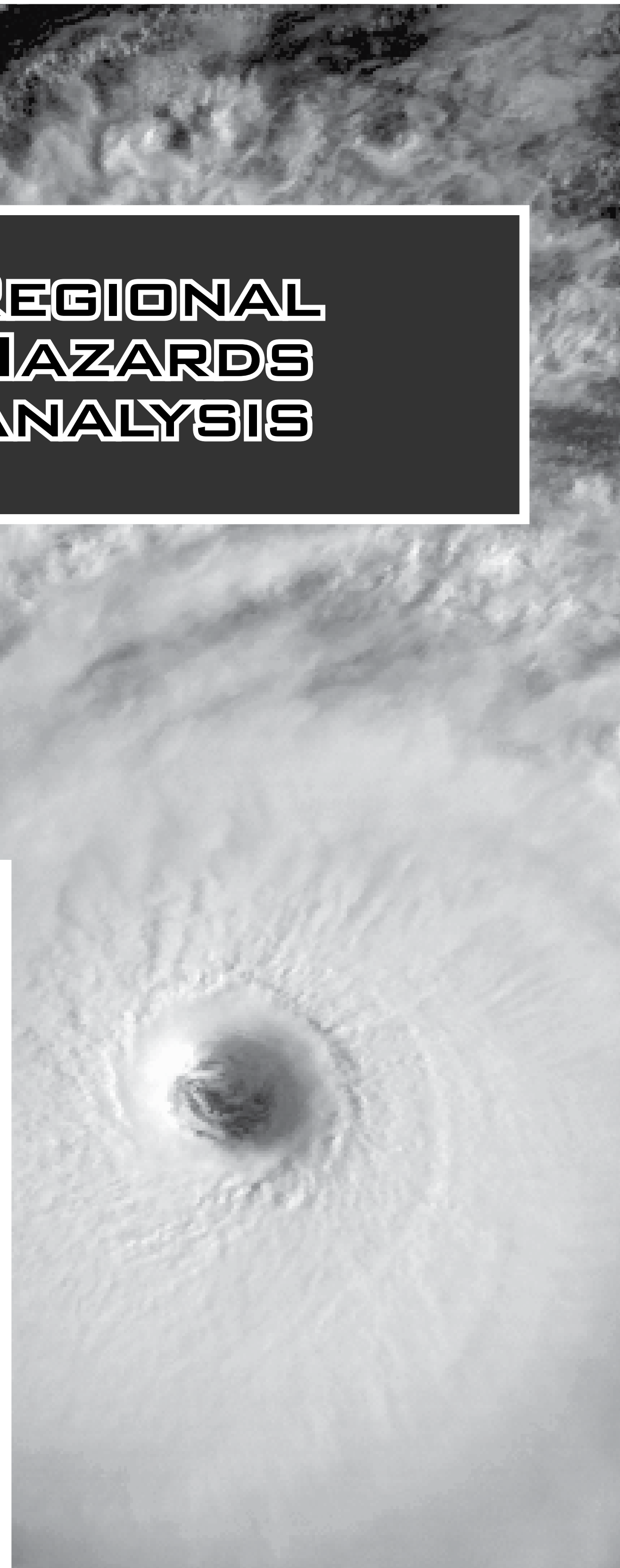
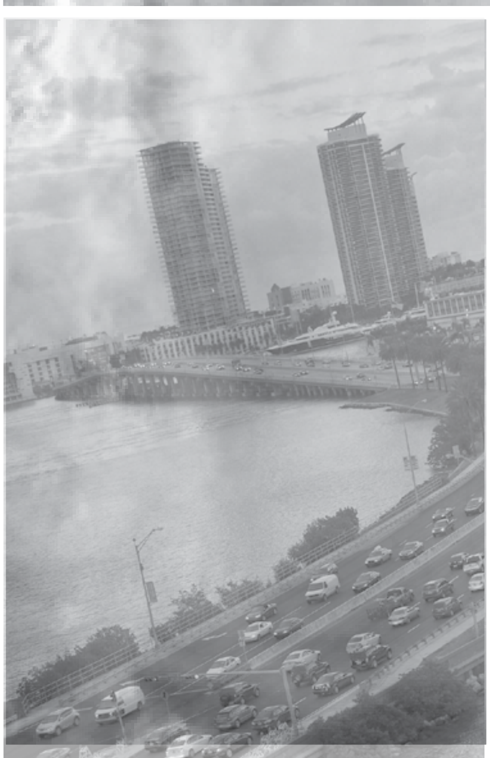
Florida Statewide Regional Evacuation Study Program

Regional Hazards Analysis





Statewide Regional Evacuation Study Program

Volume 1-11
Technical Data Report

South Florida Region

Chapter II
Regional Hazards Analysis

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CHAPTER II

REGIONAL HAZARDS ANALYSIS

A. Hazards Identification and Risk Assessment

The regional evacuation studies in Florida have traditionally focused specifically on the hurricane hazard. Considering the Region's vulnerability to tropical storms and hurricanes, and the complex nature of the evacuation, as well as the emergency response and recovery, the priority of hurricane planning remains a necessity. However, history has also demonstrated the need to address other significant hazards which have the potential for initiating major evacuations.

The Statewide Regional Evacuation Study (SRES), utilizing the *Statewide Hazard Mitigation Plan* (*SHMP* 2009), identified the major hazards facing the state and further focused on those hazards which had the potential for initiating a multi-jurisdictional evacuation. A number of factors were considered in assessing the risk of each hazard event, including the frequency of occurrence, the severity of the event and the areas vulnerable to its impact.

These factors were assigned numerical values in the assessment as follows:

1. **Frequency of Occurrence**
   a. Annual Event
   b. Every 5 years or less
   c. Every 6-10 years
   d. Every 11-30 years
   e. Greater than 30 years
2. **Vulnerability Factors**
   a. Low
   b. Moderate
   c. High
   d. Extreme
   e. Catastrophic
3. **Vulnerability Impact Areas**
   a. Population
   b. Property
   c. Environment
   d. Operations

Twelve major hazards were identified, including floods, coastal storms and hurricanes; severe storms and tornadoes; wildfire; drought and extreme heat; winter storms and freezes; erosion, sinkholes, landslides and seismic events; tsunamis; technological; terrorism and mass migration.

Table II-1
Hazards Identified in Florida[1]

Hazard	Methodology of Identification	Significant Concerns	Potential to Initiate a Regional Evacuation
Floods (including related potential for dam failure)	• Review of past disaster declarations. • Review of federal Flood Insurance Rate Maps (FIRMs). • Input from state floodplain manager. • Identification of National Flood Insurance Program (NFIP) repetitive loss properties in the state.	• Florida is affected by flooding nearly every year. • Floods have caused extensive damage and loss of life in the state in the past. • The most recent federally declared disaster event (Feb. 8, 2007) in Florida included flooding from severe storms. • There are a number of dams in the state that could impact the nearby population.	Yes; although more difficult to determine which areas are vulnerable to a particular event.
Coastal Storms & Hurricanes	• Review of past disaster declarations. • Review of National Climatic Data Center (NCDC) Severe Storms Database. • National Oceanographic and Atmospheric Administration (NOAA) climatology data • Research including new media and the Internet	• Hurricanes and coastal storms affect Florida every year. • Hurricanes have caused extensive damage and loss of life across the state for the last 50 years. • 8 out of the last 10 federally declared disaster events in Florida were hurricanes.	Yes; this hazard requires the evacuation of coastal areas and mobile home residents, even in minor tropical storm events. Major hurricanes can have catastrophic impacts.
Severe Storms & Tornadoes	• Review of past disaster declarations. • Review of National Climatic Data Center (NCDC) Severe Storms Database. • National Weather Service input and data. • Public input including newspapers and media.	• Florida experiences a tornado nearly every year. • Tornadoes have caused extensive damage and loss of life to county residents. • The two most recent federally declared disaster events in Florida (Feb. 8 and Feb. 3, 2007) were a severe storm with tornadoes.	No; these events provide little to no warning and the specific areas cannot be determined prior to the event. Exceptions: Tornado warnings can send residents to safe rooms or mobile home parks community centers, etc.
Wildfire	• Florida Division of Forestry statistics and input. • United State Department of Agriculture (USDA) Forest Service Fire, Fuel, and WUI mapping. • Input from Florida Division of Emergency Management (DEM) about wildfires and the Emergency Operations Center (EOC) activations. • Public input including newspapers and media.	• Florida experiences wildfires every year. • Development in much of the state is occurring at the Wildland-Urban Interface (WUI). • Cyclical drought patterns result in increases of brush and other dry materials. This increases the overall risk for significant fires. • Fires in 2007 were significant due to the number and magnitude including closures to the interstate system.	Yes; while we can determine areas that may be more vulnerable and plan accordingly, it is difficult to predict where a wildfire may ignite.
Drought & Extreme Heat	• National Weather Service data. • National Oceanographic and Atmospheric Administration (NOAA) paleoclimatology data. • The US Drought Monitor • Keetch Byram Drought Index (KBDI) • Agricultural community throughout the state.	• Significant drought trends during the last 10 years including moderate and severe drought index conditions in 2007 and 2008 for parts of the state. • Drought has a severe economic impact on the state due to the large amounts of citrus, agriculture and livestock.	No; this event does not typically initiate an evacuation.

[1] *Statewide Hazard Mitigation Plan* (SHMP), 2009

Hazard	Methodology of Identification	Significant Concerns	Potential to Initiate a Regional Evacuation
Winter Storms and Freezes	• Review of past disaster declarations. • Review of National Climatic Data Center (NCDC) Severe Storms Database. • National Weather Service input and data. • Public input including newspapers and media.	• Florida is affected by winter storms cyclically • Significant freezes particularly during the 1980s that affected the citrus industry • 5 federally declared disasters since 1971 • The population is unprepared for cold weather with many having inadequate heating capabilities.	No; this event does not typically initiate an evacuation, although cold weather shelters may be opened for homeless, special needs or those with no power.
Erosion	• Coordination with the Florida Department of Environmental Protection – Bureau of Beaches and Coastal systems. • Statewide Hazard Mitigation Plan - interview and input. • *Evaluation of Erosion Hazards*, the report from the Heinz Center that was presented to the Federal Emergency Management Agency (FEMA) in April 2000. • Public input including newspapers and media.	• Due to the gradual, long-term erosion, as many as one in four houses along the coast, could fall into the ocean in the next 60 years. • Eighty to 90 percent of the nation's sandy beaches are facing erosion problems. • Significant economic impact for the state due to property damages, loss of actual beach front real estate and effects on tourism.	No; this event does not typically initiate an evacuation, but it may result in a retreat from the coast over long period of time or following a major coastal storm.
Sinkholes, Landslides and Seismic Events	• Coordination with the Florida Geographical Survey • The Florida Sinkhole Database • Coordination with the Florida Department of Transportation (FDOT) • Input from the Central United States Earthquake Consortium • United States Geological Survey (USGS) Landslide Hazard maps	• Sinkholes are a common feature of Florida's landscape. • 2843 sinkholes have been reported in the state since the 1970s. • Growing issues as development continues in high risk areas. • Impact on the roads and physical infrastructure of the state. • Earthquake risk is considered extremely low.	Earthquake is considered very low risk. Sinkholes, while prevalent, will not initiate an evacuation at a regional scale.
Tsunamis	• Input from the National Oceanic and Atmospheric Administration (NOAA) Center for Tsunami Research • Coordination with the Florida Division of Emergency Management • Input from the United States Geological Survey (USGS)	• Tsunamis are common events that occur in large bodies of water. • Almost all perimeters of Florida's boundaries are made up of large bodies of water. • Recent tsunamis from around the world have caused widespread destruction. • Residential and commercial development along Florida's coastlines are at risk to the effects of Tsunamis.	This event has an extremely low probability of occurrence. If a Cumbre Vieja tsunami event were to occur, it could have a catastrophic impact on the east coast of Florida. A maximum of 6 hours would be available for evacuations. Typically, there is little to no warning.
Technological	• Coordination with the State Emergency Response Commission • Interaction with the Local Emergency Planning Committees (LEPC) • Coordination with the Nuclear Regulatory Commission (NRC) • Communications with the Florida Department of Environmental Protection	• Numerous accidental hazardous material releases occur every year. • Potential for human and environmental impacts • Threat of radiation from a nuclear related incident	Yes, these incidents may initiate evacuations, but it is impossible to predict precise location, extent and timing. Nuclear power plant evacuation planning is conducted with NRC

Hazard	Methodology of Identification	Significant Concerns	Potential to Initiate a Regional Evacuation
Terrorism	• Coordination with the Federal Emergency Management Agency (FEMA) and US Department of Homeland Security (DHS) • Coordination with the Florida Department of Law Enforcement (FDLE) • Interaction with local law enforcement agencies	• National priority with federal government requirements • Potential for devastating impacts to life and infrastructure • Protection for the citizens of Florida and the USA	Yes, these incidents may initiate evacuations, but it is impossible to predict precise location, extent and timing.
Mass Migration	• Coordination with the US Citizens and Immigration Service (USCIS) • Data from local law enforcement	• Historic precedence for migration to Florida by boat • Large amounts of unpatrolled coastlines	No; evacuation is not the problem.

For purposes of the Statewide Regional Evacuation Study, the potential evacuation from (1) Coastal storms and Hurricanes, (2) Inland / Riverine floods (including related potential for dam failure) and (3) Wildfires and the Urban Interface will be analyzed in detail.

As indicated above, any evacuation initiated by a tsunami, terrorist event or a hazardous material incident will have little or no warning. In addition, the location, scope and extent of the evacuation response therefore, are difficult to predict or model before the incident. Planning for those events, however, is ongoing at the state, regional and local levels. The identification of key infrastructure and facilities, vulnerable areas, response capabilities and mitigation strategies will be discussed in the hazards profile of each of these potential hazards.

The hazards analysis shall identify the potential hazards to the region and shall include investigations of:

- General Information about each hazard (Hazards Profile);
- History of activity in the region;
- A geo-spatial analysis of the potential effects of the hazard, i.e., inundation areas, wind fields, dam locations, urban interface, etc.

The vulnerability analysis will then identify the following:

- Human and social impacts including the identification of the population-at-risk, potential shelter and mass care demand, evacuee behavioral assumptions and the vulnerability of critical facilities.
- The potential for multiple hazard impacts such as the release of hazardous materials in a wildfire or flooding event or security risks following a hurricane.

B. Coastal Storms and Hurricanes

1. Coastal Storms / Hurricane Hazard Profile

A hurricane is defined as a weather system with a closed circulation developing around a low pressure center over tropical waters. The winds rotate counterclockwise in the Northern Hemisphere (clockwise in the Southern Hemisphere). *Tropical storms and hurricanes act as safety valves that limit the build up of heat and energy in the tropical regions by maintaining the atmospheric heat and moisture balance between the tropics and the pole-ward latitudes.*[2] Tropical cyclones are named when their winds reach tropical storm strength (sustained 39 mph).

- **Tropical Depression**: The formative stages of a tropical cyclone in which the maximum sustained (1-minute mean) surface wind is <39 mph.
- **Tropical Storm**: A warm core tropical cyclone in which the maximum sustained surface wind (1-minute mean) ranges from 39 to <74 mph.
- **Hurricane**: A warm core tropical cyclone in which the maximum sustained surface wind (1-minute mean) is at least 74 mph.

The table below displays the Saffir-Simpson Scale used to define and describe the intensity of hurricanes. The central pressure of the hurricanes is measured in millibars or inches. The wind speed is also a significant indicator in determining the category of the storm. The wind speed is tied to both wind damage and potential storm surge and resulting coastal flooding damages.

It should be noted that the range of storm surge is highly dependent upon the configuration of the continental shelf (narrow or wide) and the depth of the ocean bottom (bathymetry). A narrow shelf or one that drops steeply from the shoreline and subsequently produces deep water in close proximity to the shoreline tends to produce a lower surge but higher and more powerful storm waves. This is the situation along the Atlantic Ocean side of the state. However, the Gulf Coast of Florida has a long gently sloping shelf and shallow water depths and can expect a higher surge but smaller waves. South Dade County is an exception to these general rules due to Biscayne Bay (wide shelf and shallow depth). In this instance, a hurricane has a larger area to "pile up" water in advance of its landfall. Nowhere is the threat of storm surge more prevalent than in Apalachee Bay region. The Big Bend region of the state extends out into the Gulf of Mexico creating a naturally enclosed pocket. This area has some the highest computer projected storm surge heights in the entire nation.

Hurricanes Dennis, Katrina and Ike also demonstrated that the size of the hurricane can significantly impact the potential storm surge. These storms, which had particularly large radii of maximum winds, produced storm surges comparable to much more intense categories of storm if measured using only wind speeds.

[2] *Statewide Hazard Mitigation Plan* (SHMP), 2009

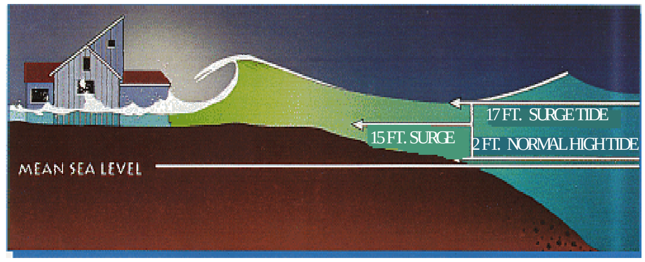
This storm characteristic will be modeled to determine its impact on the ultimate storm surge.

Table II-2
Saffir-Simpson Hurricane Wind Scale

Category		Central Pressure		Winds (mph)	Damage Potential
		Millibars	Inches		
1		>980	>28.94	74-95	Damage primarily to trees & foliage, signs, unanchored mobile homes; flooding in low-lying areas; minor pier damage; some small craft torn from moorings.
2		965-979	28.50-28.91	96-110	Considerable damage to foliage & trees; major damage to mobile homes, signs, roofing materials of buildings; windows; coastal roads and low-lying areas cut off by rising water; considerable damage to piers and marinas.
Major Hurricanes	3	945-964	27.91-28.41	111-130	Foliage torn from trees; large trees uprooted; signs down; roofing, window and door damage; some structural damage to buildings. Mobile homes destroyed. Serious flooding at coast with structures damaged by battering waves and floating debris.
Major Hurricanes	4	920-944	27.17-27.88	131-155	Shrubs and trees blown down; all signs down. Extensive damage to roofing materials, windows and doors. Complete roof failure on many residences. Complete destruction of mobile homes. Major destruction of coastal structures and erosion of beaches.
Major Hurricanes	5	<920	<27.17	>155	Shrubs and trees blown down; considerable damage to roofs of buildings; all signs down. Very severe and extensive damage to windows and doors. Complete failure of many residences and industrial buildings. Extensive shattering of glass. Complete destruction of mobile homes. Major / complete destruction of coastal structures.

2. Hurricane Hazards

The five major hazards produced by a hurricane are the storm surge, high winds, tornadoes, rainfall (freshwater flooding) and the potential for hazardous material incidents.



The **storm surge** is the abnormal rise in water level caused by the wind and pressure forces of a hurricane or tropical storm. Storm surge produces most of the flood damage and drownings associated with storms that make landfall or that closely approach the coastline. Of the hurricane hazards, the storm surge is considered to be the most dangerous, as nine out of ten hurricane-related deaths are caused by drowning.

The **high winds** also can have a devastating effect on persons outside, in mobile homes, in unsound, substandard structures or in structures with unprotected windows or glass exposures. An earlier study[3] concluded that while a fully-engineered multi-story structure could withstand the storm surge of a major storm, without protection on the windows and other cladding, occupants within any structure would be at serious risk. This factor held true for all types of structures exposed to sustained winds in excess of 115 mph. The winds of Hurricane Andrew (1992) caused major destruction in South Florida throwing the insurance industry into a tailspin.

Rainfall associated with hurricanes varies with hurricane size, forward speed and other meteorological factors. The rainfall associated with a hurricane is from 6-12 inches on average, with higher amounts common. **Freshwater flooding** has not historically been considered a life-threatening hazard. Over the past 20 years, however, freshwater flooding has become the leading cause of death related to hurricanes. This is due in part to the successful evacuation planning efforts in the United States, which significantly reduced the number of deaths (in the United States) related to storm surge. Hurricane Katrina tragically illustrated the danger of storm surge flooding in both Louisiana and Mississippi. However, it is also recognized that many coastal and inland residents do not recognize the risk associated with freshwater flooding, especially when driving. In response, a national program *"Turn Around, Don't Drown"* was implemented in 2002. The freshwater flooding associated with a hurricane may also inundate potential evacuation routes and prevent people from evacuating areas vulnerable to storm surge. Flooded roads and storm drains resulted in fatal accidents in the Bay Area in the 1982 No-Name Storm and in flooding in September 1988. Hillsborough County experienced excessive flooding in 1988 when I-4 near Plant City was cut off for several days and numerous residences were flooded.

Hurricanes can also produce **tornadoes** that add to the storm's destructive power. Tornadoes are most likely to occur in the right front quadrant of the hurricane, but they are also often found elsewhere embedded in the rain bands, well away from the center of the hurricane. Some hurricanes seem to produce no tornadoes, while others develop multiple ones. Studies have shown that more than half of the landfalling hurricanes produce at least

[3] *Hurricane Shelter Alternative Study*, Tampa Bay Regional Planning Council (TBRPC) and United States Army Corps of Engineers (USACOE), 1986

one tornado; Hurricane Buelah (1967) spawned 141 according to one study. According to the National Oceanic and Atmospheric Administration (NOAA), Hurricane Ivan (2004) spawned 117 tornadoes.

Like Murphy's Law, sometimes one emergency event can trigger another. Facilities that generate or store quantities of potentially hazardous materials, propane storage facilities, natural gas pipeline terminals, fuel storage facilities and tank farms all pose additional potential threats in a hurricane.

3. Storm Surge: The SLOSH Model

The principal tool utilized in this study for analyzing the expected hazards from potential hurricanes affecting the study area is the Sea, Lake and Overland Surges from Hurricane (SLOSH) numerical storm surge prediction model. The SLOSH computerized model predicts the tidal surge heights that result from hypothetical hurricanes with selected various combinations of pressure, size, forward speed, track and winds. Originally developed for use by the National Hurricane Center (NHC) as a tool to give geographically specific warnings of expected surge heights during the approach of hurricanes, the SLOSH model is utilized in regional studies for several key hazard and vulnerability analyses.

The SLOSH model must be developed for each specific geographic coastal area individually incorporating the unique local bay and river configuration, water depths, bridges, roads and other physical features. In addition to open coastline heights, one of the most valuable outputs of the SLOSH model for evacuation planning is its predictions of surge heights over land which predicts the degree of propagation or run-up of the surge into inland areas.

The Tampa Bay SLOSH model was completed in 1979 and represented the first application of SLOSH storm surge dynamics to a major coastal area of the United States. The model was developed by the Techniques Development Lab of the National Oceanic and Atmospheric Administration (NOAA) under the direction of the late Dr. Chester P. Jelesnianski. In December 1990 the National Hurricane Center introduced a major improvement to the model with the incorporation of wind speed degradation overland as the simulated storms moved inland. This duplicated the pressure "filling" and increases in the radii of maximum winds (RMW) as the hurricanes weaken after making landfall. The grid configuration provided more detail and additional information including storm surge projections. The model also included a tropical storm scenario.

The newest generation of SLOSH model, incorporated in the 2010 Statewide Regional Evacuation Study Program, reflects major improvements, including higher resolution basin data and grid configurations. Faster computer speeds allowed numerous hypothetical storms to be run to create the MOMs (maximum potential storm surge) values for each category of storm. Storm tracks were run in ten different directions. For each set of tracks in a specific direction storms were run at forward speeds of 5, 15 and 25 mph. And, for each direction, at each speed, storms were run at two different sizes (30 statute miles radius of maximum winds and 45 statute miles radius of maximum winds). Finally, each scenario was run at both mean tide and high tide. Both tide levels are now referenced to the North American Vertical Datum of 1988 (NAVD88), as opposed to the National Geodetic Vertical Datum of 1929 (NGVD29).

The proficiency of the Sea, Lake and Overland Surges from Hurricane (SLOSH) model has been evaluated (Jarvinin and Lawrence, 1985) through a comparative analysis of modeled and observed surges at 523 sites during 10 hurricanes. The mean absolute error in surge height calculations by SLOSH was 1.4 feet. Although the error range was from -7.1 feet to +8.8 feet, the standard deviation was only 2.0 feet and 79 percent of the errors lay within one standard deviation of the mean error, -0.3 feet. On average, modeled values were slightly less than observed.

a. Hypothetical Storm Simulations

Surge height partly depends on the distance between the location of a particular site and the storm's center. The SLOSH model was used to develop data for various combinations of hurricane strength, wind speed, and direction of movement. Storm strength was modeled using the central pressure (defined as the difference between the ambient sea level pressure and the minimum value in the storm's center), the storm eye size and the radius of maximum winds using the five categories of hurricane intensity as depicted in the Saffir-Simpson Hurricane Scale (see Table II-2), plus a hypothetical tropical storm intensity.

The modeling for each hurricane category was conducted using the mid-range pressure difference ($\triangle$p, millibars) for that category. The model also simulates the storm filling (weakening upon landfall) and radius of maximum winds (RMW) increase.

SLOSH modeling for South Florida includes two separate basins: Biscayne Bay (for Miami-Dade and Broward) and Florida Bay (for Monroe).

Ten storm track headings (E, ENE, NE, NNE, N, NNW, NW, WNW, W, and WSW) were selected as being representative of storm behavior in the South Florida region, based on observations by forecasters at the National Hurricane Center. Additional inputs into the model included depths of water offshore, and the heights of the terrain and barriers onshore (all measurements were made relative to NAVD88). In total, 14,700 runs were made for Biscayne Bay Basin, and 13,620 runs were made for Florida Bay Basin, consisting of the different parameters shown in Tables II-3a and II-3b.

Table II-3a
Biscayne Bay Basin Hypothetical Storm Parameters

Direction	Speeds (mph)	Size (Radius of Maximum winds)	Intensity	Tides	Tracks	Runs
E	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	28	1,680
ENE	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	27	1,620
NE	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	22	1,320
NNE	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	19	1,140
N	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	21	1,260
NNW	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	23	1,380
NW	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	28	1,680
WNW	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	25	1,500
W	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	26	1,560
WSW	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	26	1,560
TOTAL						14,700

Table II-3b
Florida Bay Basin Hypothetical Storm Parameters

Direction	Speeds (mph)	Size (Radius of Maximum winds)	Intensity	Tides	Tracks	Runs
E	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	21	1,260
ENE	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	21	1,260
NE	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	24	1,440
NNE	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	27	1,620
N	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	28	1,680
NNW	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	24	1,440
NW	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	22	1,320
WNW	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	21	1,260
W	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	21	1,260
WSW	5, 15, 25 mph	30-mile, 45-mile	1 through 5	Mean/High	18	1,080
TOTAL						13,620

b. The Grids for SLOSH Models for Biscayne Bay and Florida Bay

Figure II-1a illustrates the area covered by the grid for the Biscayne Bay Sea, Lake and Overland Surges from Hurricane (SLOSH) Model. To determine the surge values the SLOSH model uses a telescoping elliptical grid as its unit of analysis with 124 arc lengths (1< I < 124) and 189 radials (1< J < 189). Use of the grid configuration allows for individual calculations per grid square, which is beneficial in two ways: (1) it provides increased resolution of the storm surge at the coastline and inside the harbors, bays and rivers, while decreasing the resolution in the deep water where detail is not as important; and (2) it allows economy in computation. The grid size for the Biscayne Bay Model varies from approximately 0.02 square mile or 19 acres closest to the pole (i = 1) to the grids on the outer edges where each grid is approximately 4.83 square miles.

Figure II-1a
SLOSH Grid – Biscayne Bay

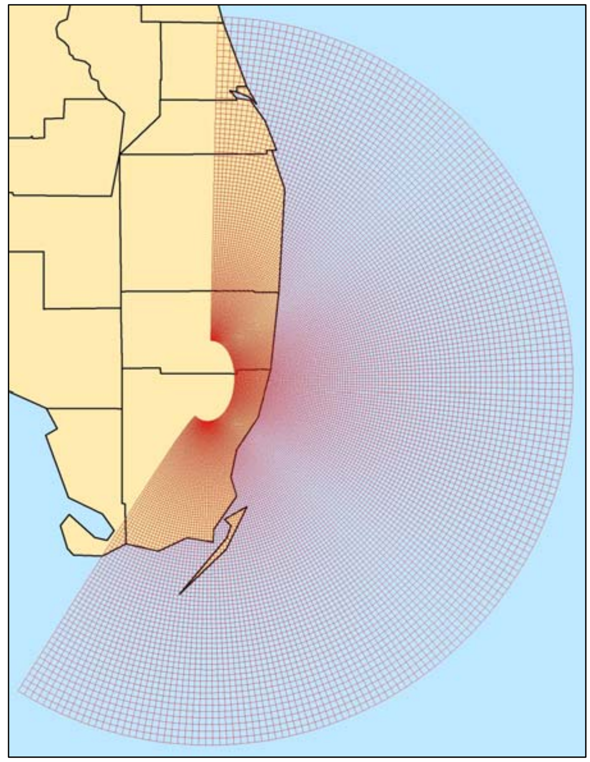


Figure II-1b illustrates the area covered by the grid for the Florida Bay SLOSH Model. The telescoping elliptical grid for Florida Bay had 169 arc lengths (1< I < 169) and 199 radials (1< J < 199). The grid size for the Florida Bay Model varies from approximately 0.03 square mile or 19 acres closest to the pole (i = 1) to the grids on the outer edges where each grid is approximately 2.85 square miles.

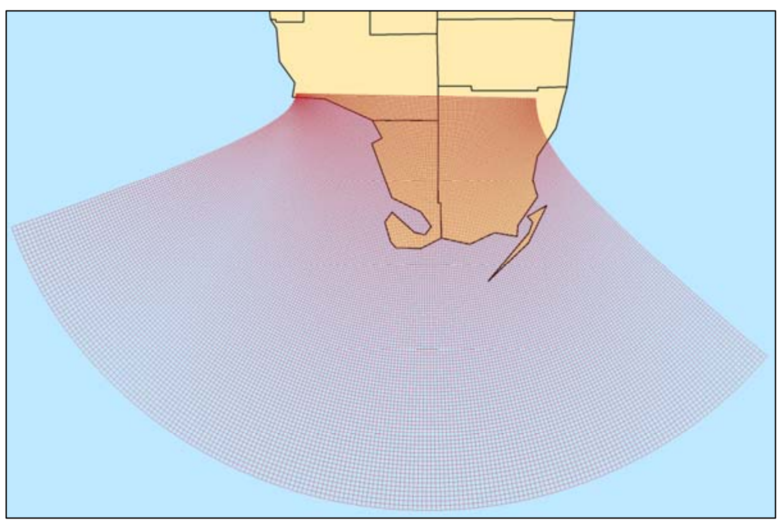


Figure II-1b
SLOSH Grid – Florida Bay

c. Storm Scenario Determinations

As indicated, the SLOSH model is the basis for the "hazard analysis" portion of coastal hurricane evacuation plans. Thousands of hypothetical hurricanes are simulated with various Saffir-Simpson Wind categories, forward speeds, landfall directions, and landfall locations. An envelope of high water containing the maximum value a grid cell attains is generated at the end of each model run. These envelopes are combined by the NHC into various composites which depict the possible flooding. One useful composite is the MEOW (Maximum Envelopes of Water), which incorporates all the envelopes for a particular category, speed and landfall direction. Once surge heights have been determined for the appropriate grids, the maximum surge heights are plotted by storm track and tropical storm/hurricane category. These plots of maximum surge heights for a given storm category and track are referred to as Maximum Envelopes of Water (MEOWs). The MEOWs, or Reference Hurricanes, can be used in evacuation decision-making when and if sufficient forecast information is available to project storm track or type of storm (different landfalling, paralleling or exiting storms).

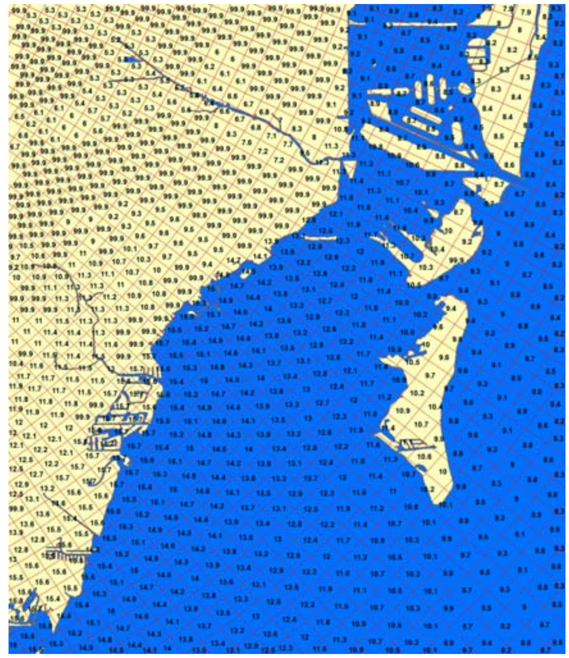


Figure II-2a: Biscayne Bay SLOSH Grid with surge values

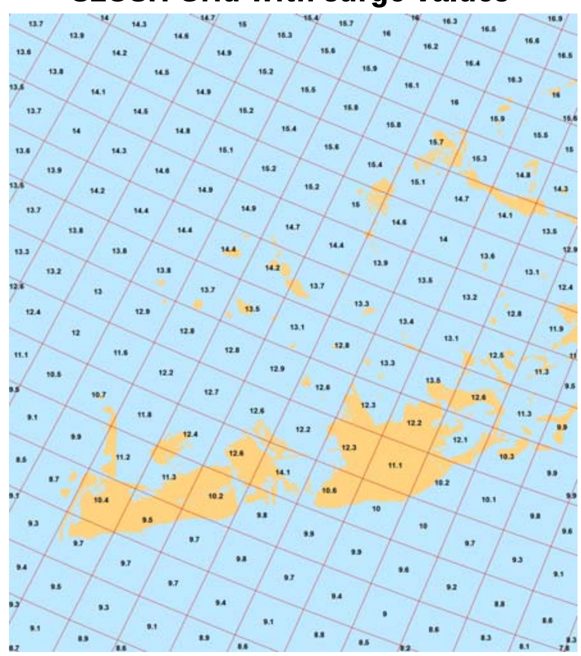


Figure II-2b: Florida Bay SLOSH Grid with surge values

The MEOWs provide information to the emergency managers in evacuation decision-making. However, in order to determine a scenario which may confront the county in a hurricane threat 24-48 hours before a storm is expected, a further compositing of the MEOWs into Maximums of the Maximums (MOMs) is usually required.

The MOM (Maximum of the MEOWs) combine all the MEOWs of a particular category. The MOMs represent the maximum surge expected to occur at any given location, regardless of the specific storm track/direction of the hurricane. The only variable is the intensity of the hurricane represented by category strength (Category 1-5).

The MOM surge heights, which were furnished by the National Hurricane Center, have two values, mean tide and high tide. Mean tide has 0' tide correction. High tide has a 1' tide correction added to it. All elevations are now referenced to the NAVD88 datum. These surge heights were provided within the SLOSH grid system as illustrated on Figure II-2a for the Biscayne Bay Basin, and in Figure II-2b for the Florida Bay Basin. The range of maximum surge heights for each county in the region based upon the model is provided for each category of storm in Table II-4. It should be noted again that these surge heights represent the maximum surge height recorded in the county, including inland and back bay areas where the surge can be magnified dependent upon storm parameters.

Table II-4
Potential Tide Height by County**
(in feet above NAVD88)

*Storm Strength	Broward	Miami-Dade	Monroe
Category 1	Up to 3.1'	Up to 5.0'	Up to 7.9'
Category 2	Up to 4.7'	Up to 8.2'	Up to 12.2'
Category 3	Up to 6.2'	Up to 11.4'	Up to 16.4'
Category 4	Up to 8.3'	Up to 14.2'	Up to 20.0'
Category 5	Up to 9.5'	Up to 16.5'	Up to 23.3'

** Based on the category of storm on the Saffir-Simpson Hurricane Wind Scale*
*** Surge heights represent the maximum values from SLOSH MOMs*

d. Determining Storm Surge Height and Flooding Depth

SLOSH and SLOSH-related products reference storm surge heights relative to the model vertical datum, in this case NAVD88. In order to determine the inundation depth of surge flooding at a particular location, the ground elevation (relative to NAVD88) at that location must be subtracted from the potential surge height. It is important to note that one must use a consistent vertical datum when post-processing SLOSH storm surge values.

Surge elevation, or water height, is the output of the SLOSH model. At each SLOSH grid point, the water height is the maximum value that was computed at that point. With the new SLOSH Model, water height is calculated relative to mean sea level data in NAVD88.

Within the SLOSH model an average elevation is assumed within each grid square. Height of water above terrain was not calculated using the SLOSH average grid elevation because terrain height may vary significantly within a SLOSH grid square. For example, the altitude of a 1-mile grid square may be assigned a value of 1.8 meters (6 feet), but this value represents an average of land heights that may include values ranging from 0.9 to 2.7 meters (3 to 9 feet). In this case, a surge value of 2.5 meters

(8 feet) in this square would imply a 0.7 meters (2 feet) average depth of water over the grid's terrain. However, in reality within the grid area, a portion of the grid would be "dry" and other parts could experience as much as 1.5 meters (5 feet) of inundation. Therefore, in order to determine the storm tide limits, the depth of surge flooding above the terrain at a specific site in the grid square is the result of subtracting the terrain height determined by remote sensing from the model-generated storm surge height in that grid square. [4]

As part of the Statewide Regional Evacuation Study Program, all coastal areas, as well as areas surrounding Lake Okeechobee, were mapped using laser terrain mapping (LIDAR[5]), providing the most comprehensive, accurate and precise topographic data for this analysis. As a general rule, the vertical accuracy of the laser mapping is within a 15 centimeter tolerance. However, it should be noted that the accuracy of these elevations is limited to the precision and tolerance in which the horizontal accuracy for any given point is recorded. Other factors such as artifact removal algorithms (that remove buildings and trees) can affect the recorded elevation in a particular location. For the purposes of this study, the horizontal accuracy cannot be assumed to be greater than that of a standard United States Geological Survey (USGS) 7.5-minute quadrangle map, or a scale of 1:24,000.

The storm tide limits based on the SLOSH MOMs have been determined using the methodology described above, mapped and published in Volume 7 – Storm Tide Atlas.

e. Variations to Consider

Variations between modeled versus actual measured storm surge elevations are typical of current technology in coastal storm surge modeling. In interpreting the data, emergency planners should recognize the uncertainties characteristic of mathematical models and severe weather systems such as hurricanes. The storm surge elevations presented in the Storm Tide Atlas should be used as guideline information for planning purposes.

(1) Storm Surge and Wave Height

Regarding interpretation of the data, it is important to understand that the configuration and depth (bathymetry) of the ocean bottom will have a bearing on surge and wave heights. A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water in close proximity to the shoreline, tends to produce a lower surge but a higher and more powerful wave. Other areas, like the Gulf Coast of Florida, that have a gently sloping shelf and shallower normal water depths, can expect a higher surge but smaller waves. The reason this occurs is because a surge in deeper water can be dispersed down and out away from the hurricane. However, once that surge reaches a shallow, gently sloping shelf it can no longer be dispersed away from the hurricane; consequently water "piles up" as it is driven ashore by the wind stresses of the hurricane. <u>Wave height is NOT</u>

[4] Note: This represents the regional post-processing procedure. When users view SLOSH output within the SLOSH Display Program, the system still uses average grid cell height when subtracting land.
[5] Light Imaging Detection and Ranging

calculated by the Sea, Lake and Overland Surges from Hurricane (SLOSH) model and is not reflected within the storm tide delineations.

(2) Forward Speed

Under actual storm conditions, it may be expected that a hurricane moving at a slower speed could have higher coastal storm surges than those depicted from model results. At the same time, a fast-moving hurricane would have less time to move storm surge water up river courses to more inland areas. As an example, a minimal hurricane or a storm further off the coast such as Hurricane Elena (1985), which stalled 90 miles off the Tampa Bay coast for several tidal cycles, could cause extensive beach erosion and move large quantities of water into interior lowland areas. In the newest version of the SLOSH model, for each set of tracks in a specific direction, storms were run at forward speeds of 5, 15 and 25 mph.

(3) Radius of Maximum Winds

As indicated previously, the size of the storm or radius of maximum winds (RMW) can have a significant impact on storm surge especially in bay areas and along the Gulf of Mexico. All of the hypothetical storms were run at two different sizes, 30 statute mile radius of maximum winds and 45 statute mile radius of maximum winds.

(4) Astronomical Tides

Surge heights were provided for both mean tide and high tide. Both tide levels are referenced to North American Vertical Datum of 1988 (NAVD88).

f. Storm Tide Atlas

The surge inundation limits (MOM surge heights minus the ground elevations) are provided as GIS shape files and graphically displayed on maps in the hurricane *Storm Tide Atlas* for the South Florida region. The *Atlas* was prepared by the South Florida Regional Planning Council under contract to the State of Florida, Division of Emergency Management, as part of this study effort. The maps prepared for the *Atlas* consist of base maps (1:24000) including topographic, hydrographic and highway files (updated using 2008 county and state highway data). Detailed shoreline and storm tide limits for each category of storm were determined using the region's geographic information system (GIS). Figure II-3 presents a compilation of the *Storm Tide Atlas* for the region.

g. Factors Influencing Model Accuracy

The purpose of the maps contained in this *Atlas* is to reflect a “worst probable” scenario of the hurricane storm surge inundation and to provide a basis for the hurricane evacuation zones and study analyses. While the storm tide delineations include the addition of an astronomical mean high tide and tidal anomaly, it should be noted that the data reflects only stillwater saltwater flooding. Local processes such as waves, rainfall and flooding from overflowing rivers, are usually included in observations of storm surge height, but are not surge and are not calculated by the SLOSH model. It is incumbent upon local emergency management officials and planners to estimate the degree and extent of freshwater flooding, as well as to determine the magnitude of the waves that will accompany the surge.

Figure II-3a
South Florida Region Storm Tide Map
Biscayne Bay Basin

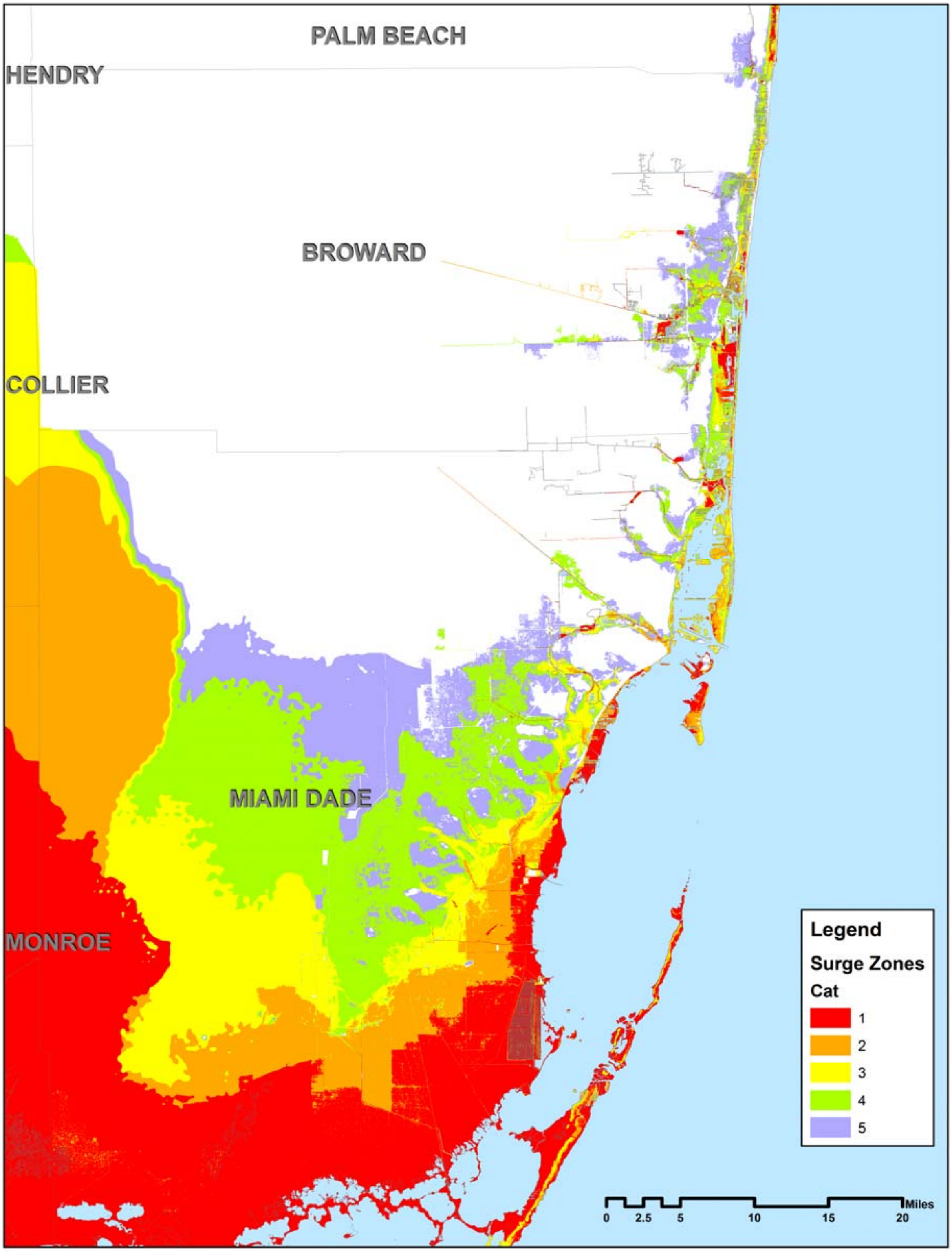
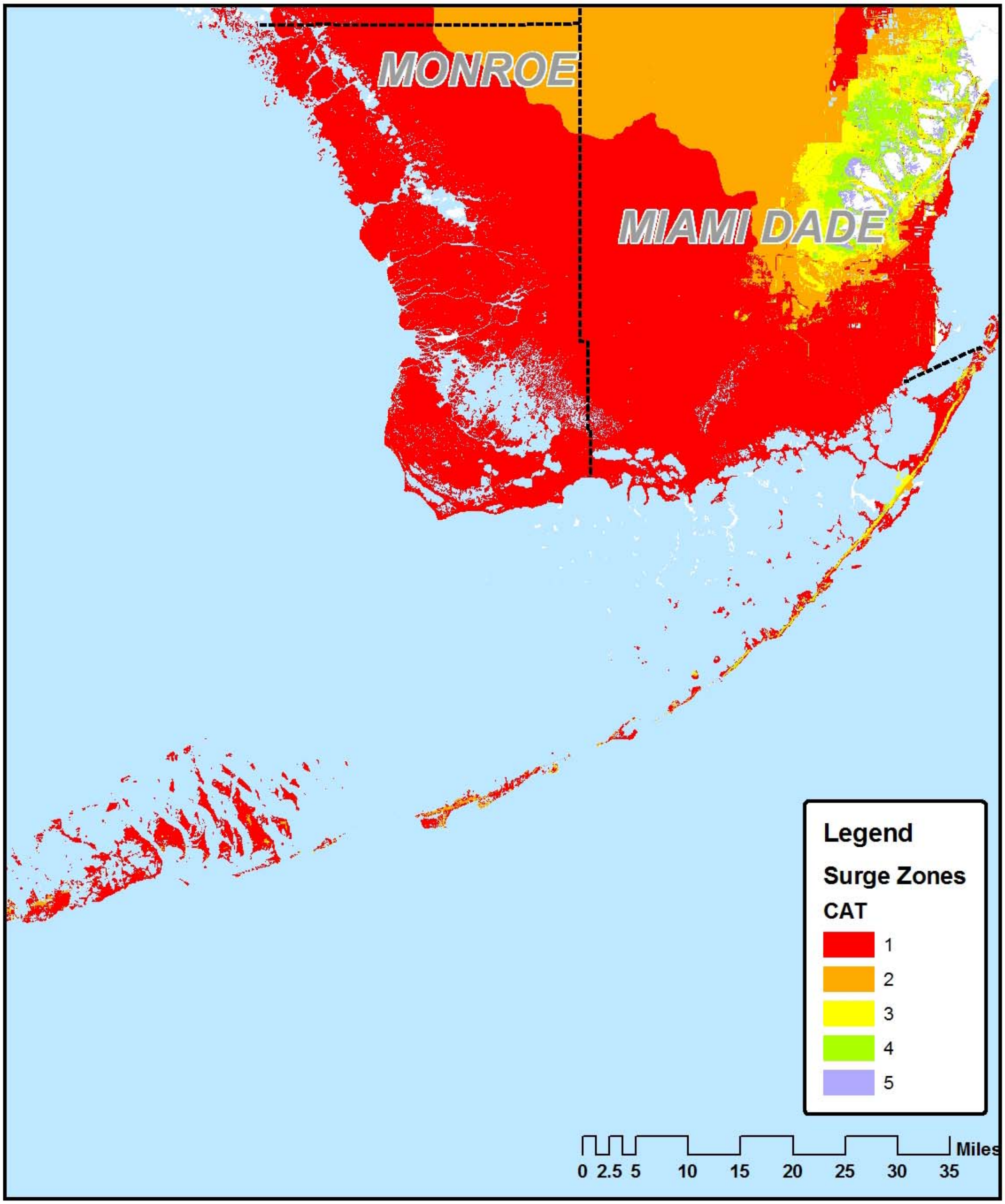


FIGURE II-3b
SOUTH FLORIDA REGION STORM TIDE MAP
Florida Bay Basin



4. Hurricane Wind Analysis

As discussed previously, hurricane winds are a devastating element of the hurricane hazard. Based on the Saffir-Simpson Hurricane Wind Scale (see Table II-2), hurricane force winds range from sustained winds of 74 mph to more than 155 mph.

The intensity of a landfalling hurricane is expressed in terms of categories that relate wind speeds and potential damage. According to the Saffir-Simpson Hurricane Wind Scale, a category 1 hurricane has lighter winds compared to storms in higher categories. **A category 4 hurricane** would have winds between 131 and 155 mph and, on average, would usually be expected to **cause 100 times the damage of the category 1 storm.** Depending on circumstances, less intense storms may still be strong enough to produce damage, particularly in areas that have not prepared in advance.

Tropical storm force winds are strong enough to be dangerous to those caught in them. For this reason emergency managers plan on having their evacuations complete and their personnel sheltered **before the onset of tropical storm force winds**, not hurricane force winds.

Hurricane force winds can easily destroy poorly constructed buildings and mobile homes. Debris such as signs, roofing material, and small items left outside become flying missiles in hurricanes. Extensive damage to trees, towers, water and underground utility lines (from uprooted trees), and fallen poles cause considerable disruption.

High-rise buildings are also vulnerable to hurricane force winds, particularly at the higher levels, since wind speed tends to increase with height. Recent research suggests you should stay below the tenth floor, but still above any floors at risk for flooding. It is not uncommon for high-rise buildings to suffer a great deal of damage due to windows being blown out. Consequently, the areas around these buildings can be very dangerous.

The strongest winds usually occur in the right side of the eyewall of the hurricane. Wind speed usually decreases significantly within 12 hours after landfall. Nonetheless, **winds can stay above hurricane strength well inland.** Hurricane Hugo (1989), for example, battered Charlotte, North Carolina (which is 175 miles inland) with gusts to nearly 100 mph. Tropical Storm Fay turned northeastward on August 19, 2008, making landfall early that day on the southwestern coast of the Florida peninsula at Cape Romano with maximum winds of 60 mph. Even after moving inland, Fay strengthened, exhibiting what resembled a classical eye in radar and satellite imagery, and it reached its peak intensity of about 65 mph as it passed over the western shores of Lake Okeechobee. During August 20-23 however, Fay continued interaction with the landmass of northern Florida causing the cyclone to weaken slightly. Fay's maximum winds remained 50-60 mph during most of that period.

Several key factors should be remembered about wind speeds. First, there is evidence that gusts rather than sustained winds cause the majority of damage associated with severe weather. The methodology described above does not specifically address wind gusts and does not address building codes/standards or construction practices.

a. Wind Risk Assessment: Inland Wind Model

The **Inland High Wind Model** can be used by emergency managers to estimate how far inland strong winds extend. The inland wind estimates can only be made shortly before landfall when the windfield forecast errors are relatively small. This information is most useful in the decision-making process to decide which people might be most vulnerable to high winds at inland locations.

Onshore winds at the coast will decrease as the storm system moves across the land as a result of friction characteristics. The National Hurricane Center has developed adjustment ratios to account for this effect. In addition, as the wind path continues around the storm, further reduction in wind speed occurs until equilibrium is reached or the wind path again crosses the coast to an open water area. The onshore and offshore winds are assumed to reach equilibrium after being over any underlying friction surface a distance of 10 nautical miles.

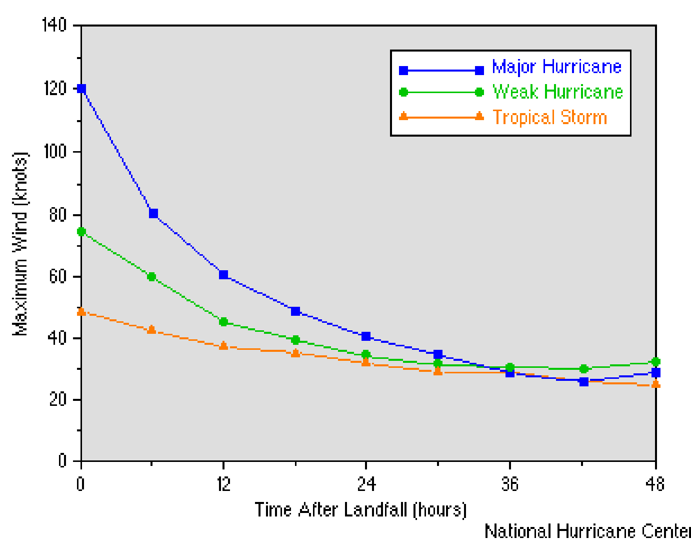
There are four friction categories defined as follows:

1. Open water
2. Awash – normally dry ground with tree or shrub growth, hills or dunes (non-inundated from storm surge)
3. Land – relatively flat non-inundated terrain or buildings
4. Rough terrain – major urban areas, dense forests, etc.

The graph below (Figure II-4) shows how wind speed rapidly decreases once a tropical cyclone reaches land. Part of the reason for this is that the roughness of the terrain increases friction, slowing the air. Another reason is that, once the storm is over land, it is usually cut off from the heat and moisture sources that sustain it. However, wind gusts (as opposed to the sustained winds shown in the graph) may actually increase because the greater turbulence over land mixes faster air to the surface in short bursts.

The graph shows that the sustained winds in a hurricane will decrease at a relatively constant rate (approximately half the wind speed in the first 24 hours). Therefore, the faster the forward speed of a landfalling hurricane, the further the inland penetration of hurricane force winds.

Figure II-4: Inland Wind Decay



Source:
www.nhc.noaa.gov/HAW2/english/wind/wind_decay.shtml

The inland wind model was developed by Mark DeMaria (NOAA/NWS/TPC) and John Kaplan (NOAA/AOML/HRD).[6] The model applies a simple two parameter decay equation to the hurricane wind field at landfall to estimate the maximum sustained surface wind as a storm moves inland. This model can be used for operational forecasting of the maximum winds of landfalling tropical cyclones. It can also be used to estimate the maximum inland penetration of hurricane force winds (or any wind threshold) for a given initial storm intensity and forward storm motion.

A model wind field, which illustrates the combined wind profiles from hurricanes striking the coast at different locations, has been developed for each category of hurricane and forward speed of the storm system. It demonstrates the potential wind speeds at different locations based upon a *"maximum of wind"* analysis.[7] Figures II-8 and II-9 illustrate the Maximum Inland Extent of Winds for Hurricanes Approaching the Gulf and East Coasts, respectively, from any direction. Looking at the results down the table by hurricane category, the increase in winds is highlighted. By reviewing the results across the table, the dramatic impact of the forward speed on the wind is apparent. (Map source: www.nhc.noaa.gov/aboutmeow.shtml.)

[6] Kaplan, J., DeMaria, M., 1995: *A Simple Empirical Model for Predicting the Decay of Tropical Cyclone Winds After Landfall*. J. App. Meteor., 34, No. 11, 2499-2512.

[7] One storm alone will not produce the following inland winds. This is the **combination** of multiple storm tracks and is for planning purposes.

Figure II-5: Maximum Inland Extent of Winds for Hurricanes Approaching the Gulf Coast

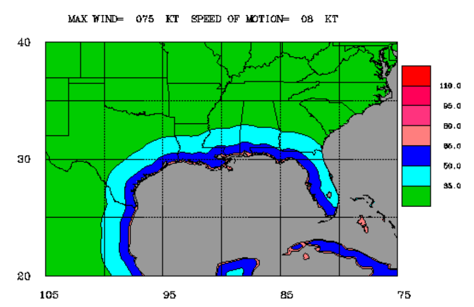
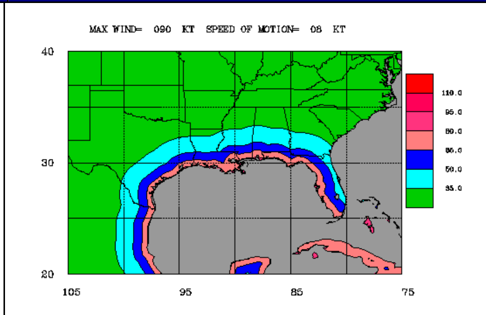
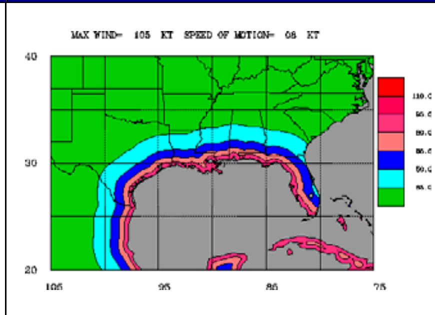
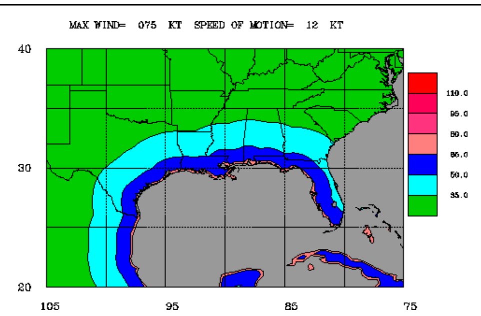
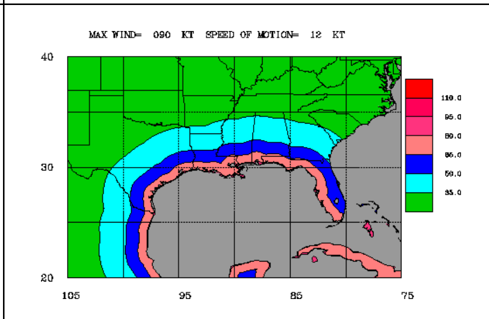
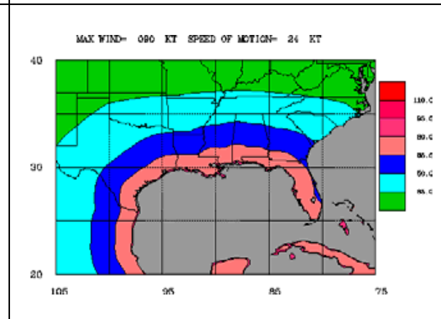
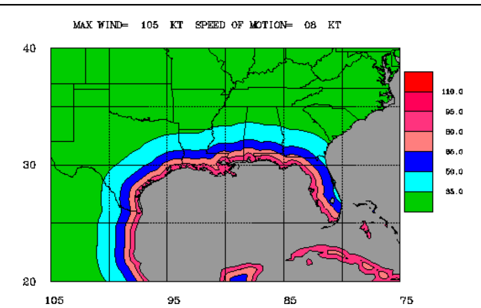
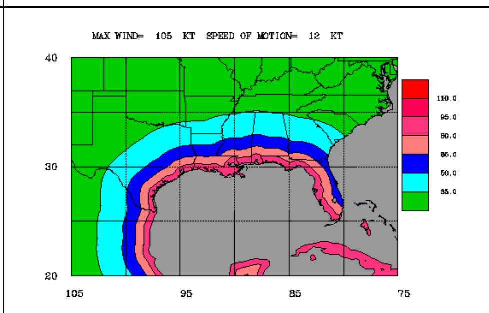
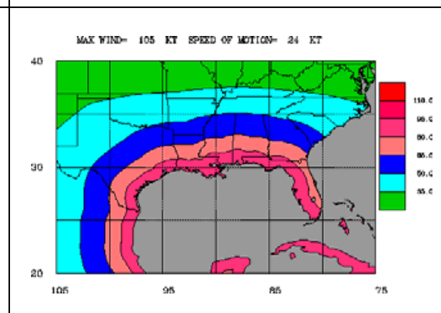
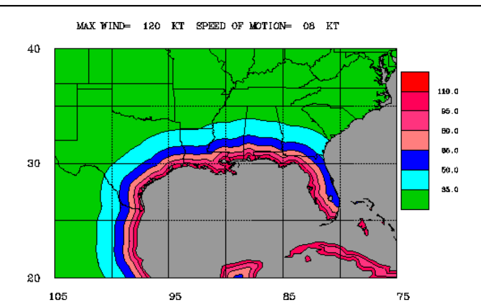
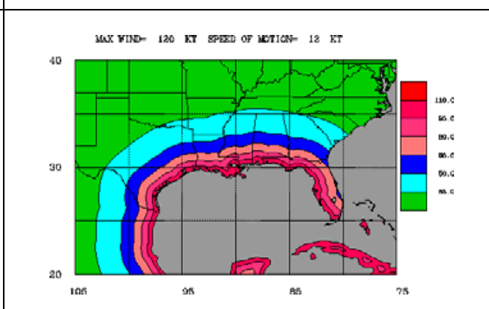
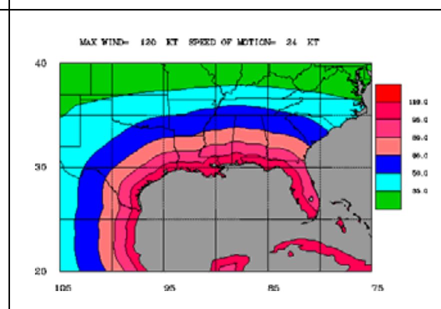
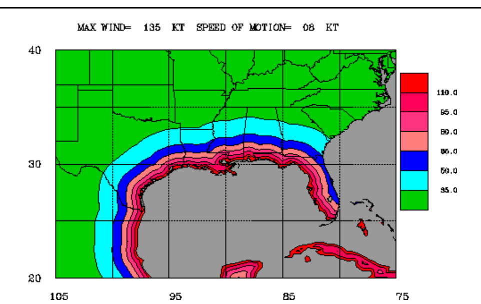
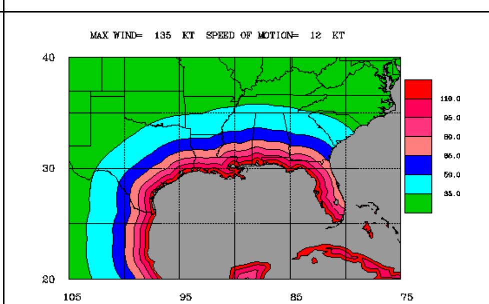
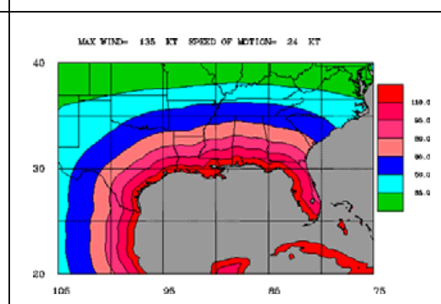
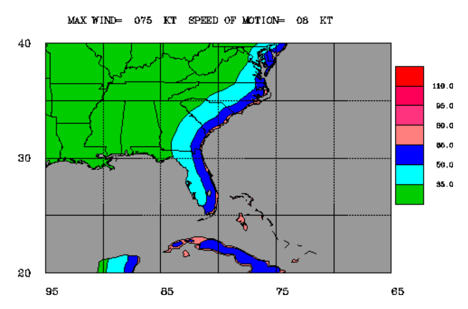
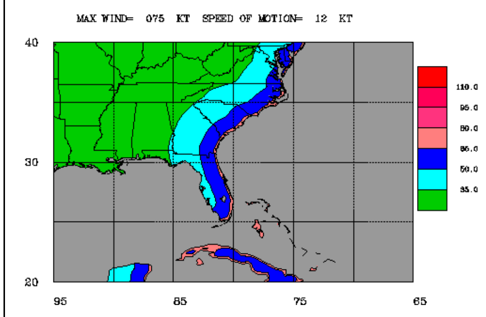
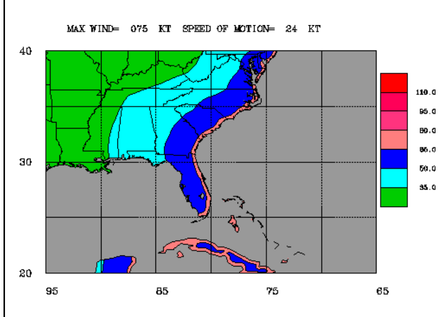
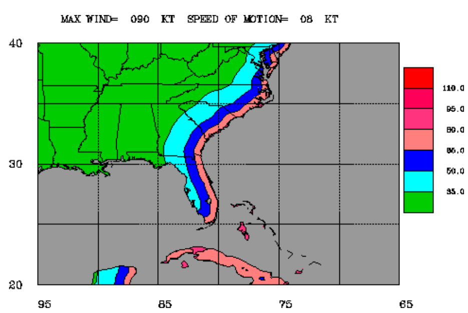
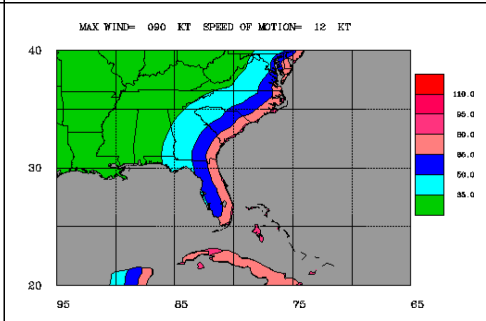
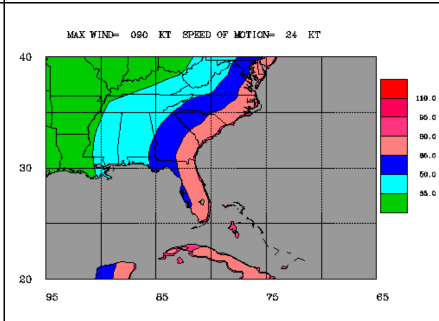
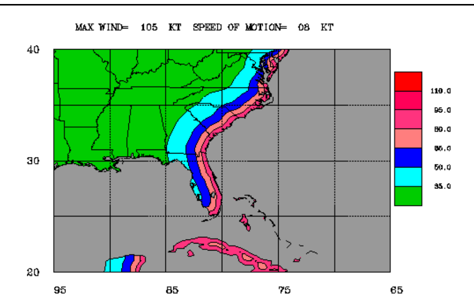
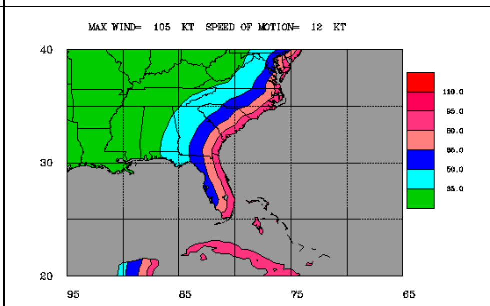
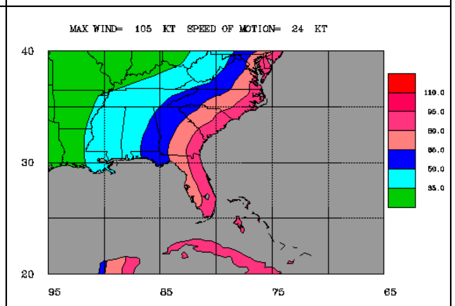
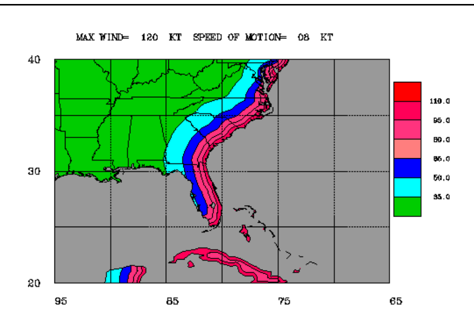
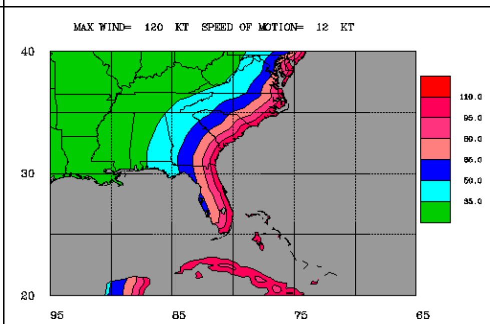
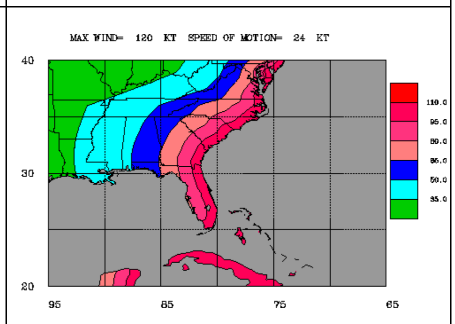
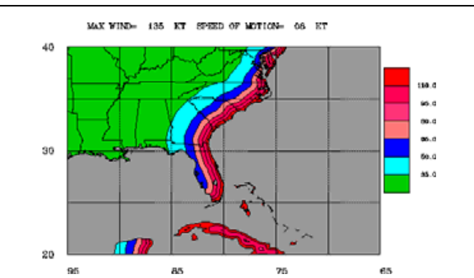
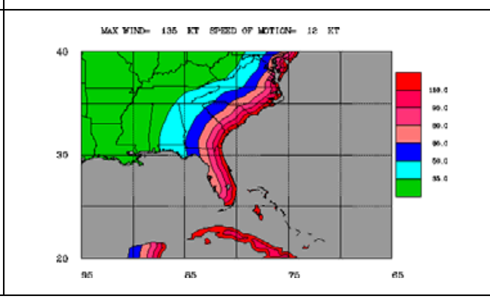
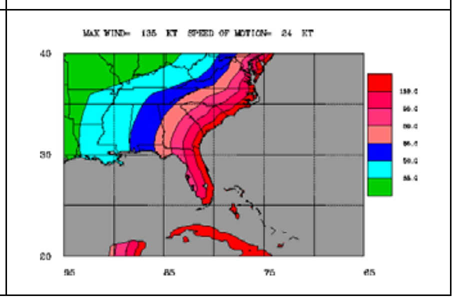
Cat	Forward Speed – 8 kts	Forward Speed – 12 kts	Forward Speed – 24 kts
1			
2			
3			
4			
5			

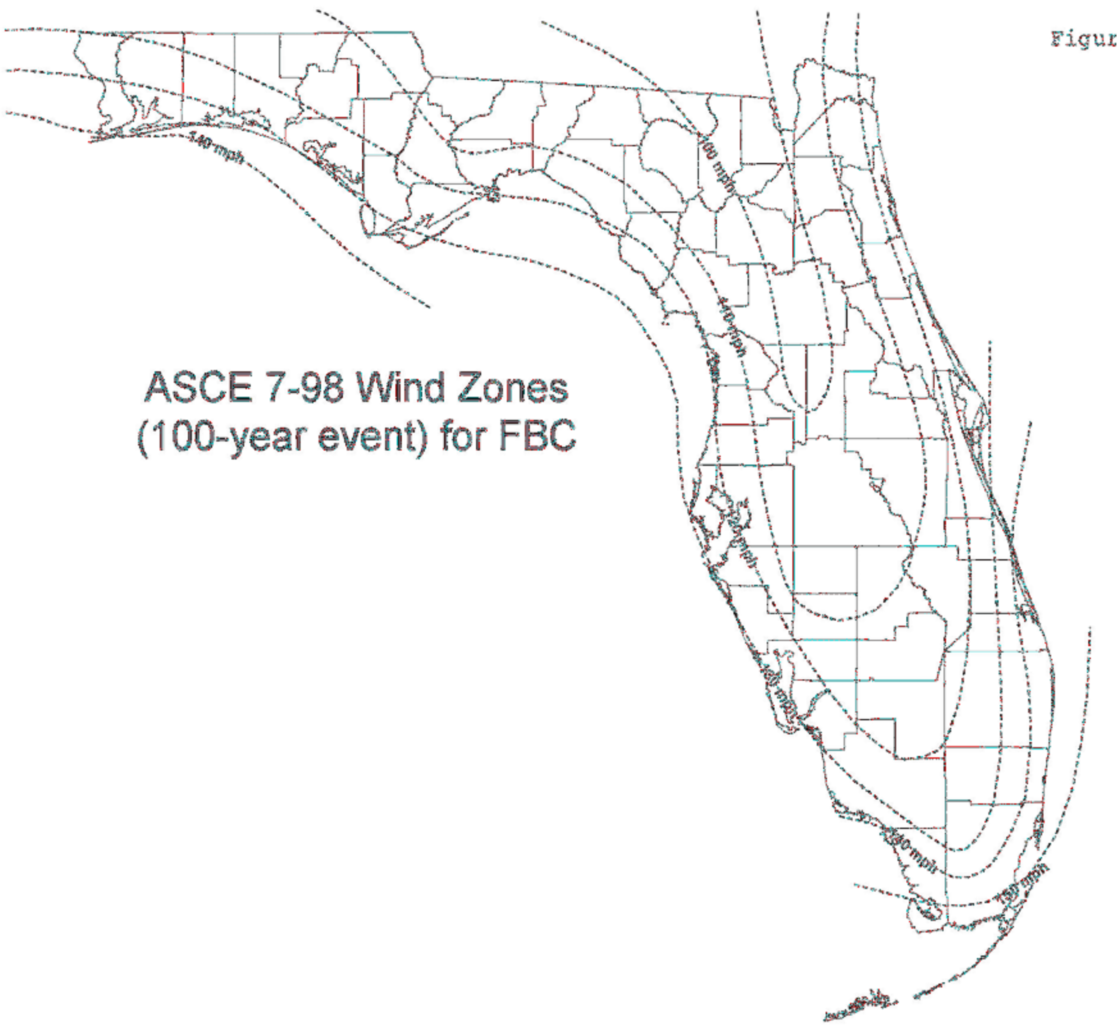
Figure II-6: Maximum Inland Extent of Winds for Hurricanes Approaching the East Coast

Cat	Forward Speed – 8 kts	Forward Speed – 12 kts	Forward Speed – 24 kts
1			
2			
3			
4			
5			

b. Wind Risk Assessment: Florida Building Code

In March of 2002, a Statewide Building Code was fully adopted and implemented in Florida. A critical element of that new building code was the adoption of stricter building standards based on wind hazard associated with hurricanes. To establish variable building standards for locales throughout Florida, the American Society of Civil Engineer's Standard 7 for 1998 (ASCE 7-98) was adopted. The ASCE 7-98 provides wind risk assessments for areas throughout Florida, along with associated building standards (see Figure II-7).

Figure II-7 ASCE 7-98 Wind Zones



Source:
FBC: Florida Building Code 2001, Chapters 2, 16, 17, & 22
ASCE 7-98: "Minimum Design Loads for Buildings and Other Structures", by American Society of Civil Engineers.

c. Wind Risk Assessment: Hazards US Multi-Hazard (HAZUS-MH)

HAZUS-MH also includes a vulnerability analysis incorporating other factors such as housing stock, vegetation and friction coefficients based on land cover. Figure II-8 provides a Level 1 wind risk assessment using this tool.

5. Tornadoes

In general, tornadoes associated with hurricanes are less intense than those that occur in the Great Plains (see the **Enhanced Fujita-Pearson Intensity Scale** below). Nonetheless, the effects of tornadoes, added to storm surge and inland flooding and the larger area of hurricane force winds, can produce substantial damage.

Sixty-nine percent of all tornadoes are weak tornadoes, EF0-EF2 sizes. Twenty-nine percent of all tornadoes are strong and can last 20 minutes or longer. Two percent of all tornadoes fall into the EF-4 and EF-5 categories. The most powerful tornadoes are spawned by what are called supercell thunderstorms. These are storms that, under the right conditions, are affected by horizontal wind shears (winds moving in different directions at different altitudes.) These wind shears cause horizontal columns of air to begin to rotate the storm. This horizontal rotation can be tilted vertically by violent updrafts, and the rotation radius can shrink, forming a vertical column of very quickly swirling air. This rotating air can eventually reach the ground, forming a tornado. We have no way at present to predict exactly which storms will spawn tornadoes or where they will touch down. The Doppler radar systems have greatly improved the forecaster's warning capability, but the technology usually provides lead times from only a few minutes up to about 30 minutes. Consequently, early warning systems and preparedness actions are critical.

STATEWIDE REGIONAL EVACUATION STUDY PROGRAM

Wind Risk assessment Using HAZUS-MH

Figure II-8: 50 Year Return Peak Gusts

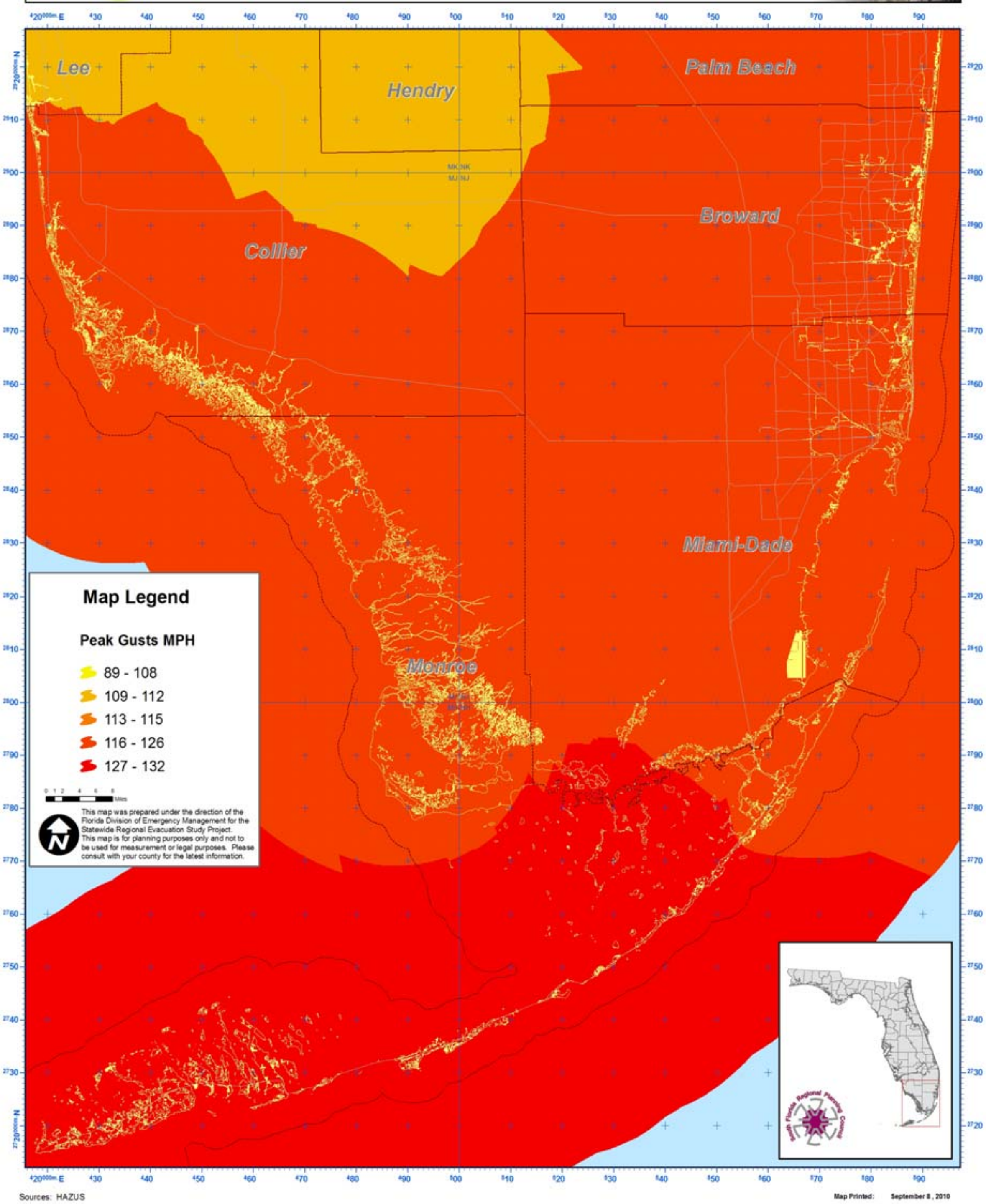


Table II-5
Enhanced Fujita-Pearson Tornado Intensity Scale

The Enhanced F-scale is a set of wind estimates (not measurements) based on damage. It uses three-second gusts estimated at the point of damage based on a judgment of 8 levels of damage (listed at www.spc.noaa.gov/faq/tornado/efscale.html). These estimates vary with height and exposure. **Important**: The 3-second gust is not the same wind as in standard surface observations. Standard measurements are taken by weather stations in open exposures, using a directly measured, "one minute mile" speed.

- **EF0 Gale Tornado** 65-85 mph
  Some damage to chimneys. Tree branches broken off. Shallow rooted trees uprooted.

- **EF1 Moderate Tornado** 86-110 mph
  Peels surface off roofs. Mobile homes overturned. Moving autos pushed off roads.

- **EF2 Significant Tornado** 111-135 mph
  Considerable damage. Roofs torn off frame houses. Large trees snapped or uprooted. Light-object missiles generated.

- **EF3 Severe Tornado** 126-165 mph
  Severe damage. Roofs and some walls torn off well-constructed homes. Trains overturned. Most trees in forests uprooted. Heavy cars lifted off ground.

- **EF4 Devastating Tornado** 166-200 mph
  Well-constructed houses leveled. Structures with weak foundations blown off some distance. Cars thrown and large missiles generated.

- **EF5 Incredible Tornado** over 200 mph
  Strong frame houses lifted off foundations and disintegrated. Automobile-sized missiles fly through the air in excess of 100 mph. Trees debarked.

Damage f scale	Little Damage	Minor Damage	Roof Gone	Walls Collapse	Blown Down	Blown Away
	f0	f1	f2	f3	f4	f5

	17 m/s	32	50	70	92	116	142
Windspeed F scale	F0	F1	F2	F3	F4	F5	
	40 mph	73	113	158	207	261	319

To convert f scale into F scale, add the appropriate number

Weak Outbuilding	-3	f3	f4	f5	f5	f5	f5
Strong Outbuilding	-2	f2	f3	f4	f5	f5	f5
Weak Framehouse	-1	f1	f2	f3	f4	f5	f5
Strong Framehouse	0	F0	F1	F2	F3	F4	F5
Brick Structure	+1	-	f0	f1	f2	f3	f4
Concrete Building	+2	-	-	f0	f1	f2	f3

Fig. 2.4-1 The Fujita tornado scale (F scale) pegged to damage-causing windspeeds. The extent of damage expressed by the damage scale (f scale) varies with both windspeed and the strength of structures.

6. Hazardous Materials

Like Murphy's Law, sometimes one emergency event can trigger another. Facilities that generate or store quantities of potentially hazardous materials, propane storage facilities, natural gas pipeline terminals, fuel storage facilities and tank farms all pose an additional potential threat in a hurricane. Identifying the location of these facilities is important to (1) provide additional information to facility managers to secure their operation and protect the employees, facility and inventory before the storm, and (2) assist emergency responders in safe re-entry into areas after the storm has passed. It may also serve to identify where mitigation strategies should be implemented to reduce the risk to resident and the environment.

The Hazard Materials Information System (HMIS) database was accessed to identify the current Extremely Hazardous Substances (EHS) facilities – also known as Section 302 facilities – in the South Florida Region. The geo-coded inventory of the Section 302 facilities is included in the **Critical Facility Inventory Data Base**. A regional Map that illustrates the vulnerability of all Section 302 facilities is included on Figure II-18. The inventory and vulnerability assessments are considered For Official Use Only (FOUO) and are not available to the public for security reasons.

Evacuation for Hazardous Material incidents will be discussed later in the chapter.

7. Freshwater Flooding and the Inundation of Evacuation Routes

Inland riverine and freshwater flooding often becomes a significant factor as a result of tropical storms and hurricanes. Typically the rainfall associated with, and in advance of, a hurricane does not in itself necessitate the emergency evacuation of residents during the passage of a hurricane, unlike storm surge. Following a storm however, the coastal flooding and rainfall – particularly from slow-moving storms – necessitates an evacuation of flooded inland residents days after, as swollen rivers and streams breach their bank or levees.

As noted previously, *due to Tropical Storm Fay's very slow motion, total storm rainfall amounts in some areas were staggering, including a few locations in east-central Florida that received more than two feet of rain. Fay's rain-induced floods caused significant damage and were directly responsible for numerous deaths in the Dominican Republic, Haiti and Florida* (www.nhc.noaa.gov).

Inland flooding will be discussed later in the chapter as a separate hazard. For hurricane evacuation, however, rainfall may cause the early inundation of roadways used as evacuation routes by vehicles attempting to escape from areas vulnerable to the approaching storm surge. In addition, given Florida climatology and the normal summer weather, flooding may occur as a disassociated event prior to the hurricane, flooding evacuation routes and saturating the ground.

Those roadways known historically to be vulnerable from freshwater flooding have been identified by the county and municipal emergency management, law enforcement and emergency response personnel. In South Florida, US 41, connecting Miami-Dade County to Collier County, and Card Sound Road, one of two routes connecting the Florida Keys to the mainland, are both subject to flooding during storm events. These routes, including those which were inundated or forced to close during recent flooding events, are presented on maps in Appendices IV-A, IV-B and IV-C.

Contingency plans including rerouting, sandbagging and pumping will be coordinated with local and state law enforcement and the Florida Department of Transportation. The impacts of road closures, rain and ambient conditions on evacuation times are addressed in the transportation analysis.

Rainwater inundation of evacuation routes must be addressed in an evacuation plan. The planning strategy to address this problem is to plan for the passage of all vehicles over such roadways before substantial rainfall from the hurricane was expected to arrive. Hourly records of rainfall rates and accumulation for past hurricanes indicate that rates high enough to surpass drainage capabilities normally parallel in time the arrival of sustained tropical storm force winds. Using this as an assumption of the timing of freshwater roadway inundation, the pre-landfall hazards time quantification for sustained tropical storm force winds will also compensate for early rainfall inundation of evacuation routes.

8. History of Hurricanes in the South Florida Region

Hurricanes are a natural yet very dangerous phenomenon, one for which the South Florida Region must always be prepared. Packing 74-200 mph winds and a storm surge that can exceed 23 feet in the South Florida Region, hurricanes represent a serious threat to the safety of residents and visitors and the economic health of this metropolitan region.

Emergency management and atmospheric scientists agree that global weather patterns have moved back into a period of increased tropical storm activity and of increased frequency of major hurricanes, a category 3 or higher on the Saffir-Simpson Hurricane Scale (see Table II-2), particularly in the state of Florida. An analysis of hurricane activity since the 1920s demonstrates that hurricane activity appears cyclical and that, after a period of relative inactivity since the early 1960's, the state of Florida and the South Florida Region are in a more active period.

Until the 1840s, Florida hurricanes were only experienced in the cities and ports along the east coast, the northwest panhandle and the Florida Keys. But the new settlements along the southwest coast soon began to confront devastating hurricanes. In 1848, the "small village" of Tampa was hit by a major hurricane causing the tide in the bay to rise fifteen feet above normal. The massive flood completely inundated Fort Brooke as well as the stores and homes along Tampa Bay.

During the period 1875-1997, 77 hurricanes struck the state of Florida. Historians identify a flurry of major hurricane activity in the late 20s, the 1930s and 1940s. The 1920s were forever marked with tragedy. There was the devastating hurricane in 1926 that made landfall in Miami and the 1928 storm, which caused the banks of Lake Okeechobee to rise 15 feet and drown 1,200 people. The September 1926 hurricane is the most costly hurricane in U.S. history. The hurricane of September 1928 remains Florida's "single greatest tragedy," with an official death toll of 2,500 (Barnes, 1998 and Blake, 2007).

Florida and the Gulf coast states were hit hard in the 1930s by both the Great Depression and hurricanes. Many seniors still remember the horrifying storm of 1935 that swept across the Florida Keys killing 400 people.

In the 1940s, Florida was the target of seven major hurricanes. The October 18-19, 1944 hurricane, later known as the Havana-Florida hurricane, tracked over the Dry Tortugas after destroying entire villages in Cuba and Grand Cayman Island. Warnings from the new weather forecast office, which later would become the National Hurricane Center, helped to evacuate low-lying areas along the coast, and were credited with saving many lives. The storm was extremely large and felt over much of the state as it moved up the Gulf coast and inland near Sarasota. Tampa and Orlando reported wind gusts over 100 mph and Miami experienced winds of 65 mph.

While not a major hurricane when it made landfall on the Florida coast near Bradenton, the hurricane of October 7, 1946, caused significant damage (approximately $5 million), especially to Florida's citrus crop. In 1950, Hurricane Easy parked itself over the west coast of Florida, drenching residents with record-breaking rains. *"Its remarkable double-loop* *track caused it to strike the same region of the Florida coast (Tampa Bay) twice in the same day!"* According to an Associated Press report, *"Tides from six and a half to eight feet above normal swept the pretty resort area from Clearwater to Sarasota, washing out roads, toppling beachfront houses, sinking a few small boats, putting a tug in distress and piling sea water like lakes around homes and hotels."* (Barnes, 1999)

In the 1950s, the pattern shifted with hurricanes directing their fury on the eastern Atlantic coast. Hurricane Donna (1960) was the only major hurricane to make landfall in Florida in a decade. The brunt of the hurricane was felt in the Keys, Collier and Lee counties; however, gusts were recorded at 120 mph in Manatee County.

In the 1960s and 1970s, hurricane activity was decreased and concentrated along the western Gulf coast of Texas, Louisiana and Mississippi. Even with hurricanes David (a glancing blow along the east coast) and Frederic (the most costly hurricane up to that time) – both of which made landfall in 1979 – the 1970s still had the lowest number of hurricanes (12) and the lowest number of major hurricanes (4) to make landfall in the United States of any decade in the twentieth century (Barnes, 1999). Meanwhile the state and the region were experiencing explosive population growth along the coast.

In the 1980s, the state of Florida was spared the direct hit of a major hurricane, although 1985 had the most named storms to hit the U.S. since 1916 – a total of six hurricanes and two tropical storms. *"During the 1985 season, at one time or another, some portion of every coastal state from Texas to Maine was placed under a hurricane warning."* (Barnes, 1999).

On **Labor Day weekend 1985, Hurricane Elena** threatened the Tampa Bay region and approached within 80 miles of the coast. Evacuations in Louisiana, Mississippi, Alabama and Florida were of unprecedented proportions. Almost a million residents and visitors were affected in the initial evacuation orders in the Florida panhandle and coastal region of Alabama, Mississippi and Louisiana. Then, as the storm turned and the warnings shifted, ten additional Florida counties including those in Tampa Bay were ordered to evacuate. The threat of Elena initiated an evacuation that forced over 500,000 to leave vulnerable areas in the Tampa Bay region and seek shelter. Many sought shelter in the homes of friends and relatives in inland areas of Florida and Georgia. Others went to hotels and motels, filling every room (and lobby) in the state, particularly along the I-75 and I-4 corridors. More than 300,000 sought public shelter in the Tampa Bay Region alone, one of the largest evacuations and shelter operations in U.S. history. After stalling off the coast for two days, Hurricane Elena turned toward the Florida Panhandle again, forcing the evacuation of thousands of coastal residents just returning after the earlier round of evacuations, ultimately making landfall near Biloxi, Mississippi.

Although Hurricane Elena remained more than 80 miles offshore, Elena did produce gusty winds up to 80 mph and constant rainfall. While sustained hurricane-force winds (>74 mph) were not experienced in the region, over $118 million in damage was caused in Pinellas County, mostly by the 6-7 foot storm surge, which hammered the coastal areas along the Gulf and Tampa Bay.

In the 1985 season, Hurricane Kate, a rare landfalling November storm, was considered the first direct hit of a hurricane in Florida in ten years (Eloise, 1975).

The 1990's went down in history as an extremely costly and deadly decade of hurricane activity. The last decade of the millennium brought several flooding events, including Tropical Storm Josephine (1996) and the 1998 evacuation from Hurricane Georges. **Hurricane Andrew** struck the east coast near Homestead on August 24, 1992 and Hurricane Opal struck the panhandle in 1995, two costly storms. Hurricane Mitch (1998) made landfall in Honduras and killed tens of thousands.

Hurricane Andrew affected the entire state in many ways. Only two other hurricanes in history, both category 5 storms – the Labor Day storm of 1935 and Camille in 1969 – were stronger than Hurricane Andrew when they made landfall in the United States. It struck South Florida with a storm surge of over 16 feet and winds that gusted over 175 mph. The scale of the disaster was enormous and the massive recovery that ultimately ensued was of epic proportions. The damages were staggering, surpassing $50 billion, affecting emergency management policies and procedures, the insurance industry and land development regulations (including the statewide building code).

Hurricane forecasters and scientists had warned with Hurricane Hugo (1989) that the strengthening of *El Niño* and rainfall patterns in the African Sahel desert were signaling increased patterns of hurricane activity. The 1995 hurricane season certainly gave credence to those predictions. Two tropical storms and two hurricanes struck the state of Florida, the most since 1953 – Hurricanes Opal (October) and Erin (August) and Tropical Storms Jerry (August) and Allison (June).

Hurricane activity has indeed increased but it has been in the last five years that the deadly predictions have come to fruition. The experiences in other parts of Florida as well as the other states have resulted in a greater awareness of the challenges and obstacles facing this metropolitan region.

a. The 2004 Hurricane Season

In 2004, the State of Florida was hit by an unprecedented four (4) hurricanes: Charley, Frances, Ivan, and Jeanne.

August 9-14, 2004 – *Hurricane Charley* *strengthened rapidly just before striking the southwestern coast of Florida as a Category 4 hurricane on the Saffir-Simpson Hurricane Scale. Charley was the strongest hurricane to hit the United States since Andrew in 1992 and, although small in size, it caused catastrophic wind damage in Charlotte County, Florida. Serious damage occurred well inland over the Florida peninsula. In the Tampa Bay Region, dead center for the 24 hour forecast track, evacuations were ordered in all four counties. Charley was directly responsible for ten deaths – primarily from flying debris and fallen trees. There were an additional 20 indirect deaths* (www.nhc.noaa.gov).

August 25-Sept. 8, 2004 – *Hurricane Frances* *was a Cape Verde type hurricane that reached a peak intensity of category 4 on the Saffir-Simpson Hurricane Scale. It* *affected the Bahamas as a category 3 hurricane and the Florida east coast as a category 2 hurricane. The Tampa Bay Region experienced tropical storm and minimal hurricane force winds, with some coastal and more extensive inland flooding caused by more than 10 inches of rainfall. Frances was directly responsible for seven deaths – five in Florida, one in the Bahamas, and one in Ohio. Three deaths were caused by wind, two by storm surge, one by freshwater flooding, and one by lightning. The hurricane was indirectly responsible for 42 deaths – 32 in Florida, 8 in Georgia, 1 in the Bahamas, and 1 in Ohio* (www.nhc.noaa.gov).

September 2-24, 2004 – *Hurricane Ivan* *was a classical, long-lived Cape Verde hurricane that reached category 5 strength on the Saffir-Simpson Hurricane Scale (SSHS) three times. It was also the strongest hurricane on record that far southeast of the Lesser Antilles. Ivan caused considerable damage and loss of life as it passed through the Caribbean Sea. Despite the unfavorable environmental conditions, the presence of cooler shelf water just offshore and eyewall replacement cycles, Ivan weakened only slowly and made landfall as a 105-knot hurricane (category 3 on the SSHS) on September 16th, just west of Gulf Shores, Alabama. By this time, the eye diameter had increased to 40-50 nautical miles, which resulted in some of the strongest winds occurring over a narrow area near the southern Alabama-western Florida panhandle border. The forces of Ivan were directly responsible for 92 deaths. In the United States, 14 occurred in Florida, 8 in North Carolina, 2 in Georgia, and 1 in Mississippi. The breakdown of U.S. deaths by cause is as follows: tornado (7), storm surge (5), freshwater floods (4), mud slides (4), wind (3), and surf (2). Ivan was also indirectly responsible for 32 deaths in the United States.*

Ivan caused extensive damage to coastal and inland areas of the United States. Portions of the Interstate 10 bridge system across Pensacola Bay, Florida, were severely damaged in several locations as a result of severe wave action on top of the 10-15 ft storm surge. As much as a quarter-mile of the bridge collapsed into the bay. The U.S Highway 90 Causeway across the northern part of the bay was also heavily damaged. To the south of Pensacola, Florida, Perdido Key bore the brunt of Ivan's fury and was essentially leveled. In addition, extensive beach erosion caused severe damage to or the destruction of numerous beachfront homes, as well as apartment and condominium buildings. Thousands of homes in the three-county coastal area of Baldwin, Escambia, and Santa Rosa were damaged or destroyed. Cleanup efforts alone in Escambia County resulted in debris piles that were more than three-quarters of a mile long and 70 feet high. In all, Ivan was the most destructive hurricane to affect this area in more than 100 years. Strong winds also spread well inland, damaging homes and downing trees and power lines. At one point, more than 1.8 million people were without power in nine states (www.nhc.noaa.gov).

September 13–28, 2004 – *Hurricane Jeanne* *produced heavy rain over Guadeloupe, Puerto Rico and the Dominican Republic and caused an estimated 3,000 or more deaths in Haiti, from torrential rainfall flooding. Finally, Jeanne hit the northern Bahamas and then the central Florida east coast as a category three hurricane. Jeanne moved across central Florida while weakening and began to recurve around the western periphery of the migratory ridge. The hurricane weakened to a tropical storm while centered about 30 nautical miles north of Tampa September 26th and then weakened to a tropical depression about 24 hours later while moving northward across central*

Georgia, accompanied by heavy rain. Winds were somewhat higher in the Tampa Bay Region for Hurricane Jeanne than Hurricane Frances, resulting in wind damage and minimal coastal flooding. Areas still flooded from Frances (three weeks before) received additional flood waters (www.nhc.noaa.gov).

b. The 2005 Hurricane Season

The impact of the 2005 Atlantic hurricane season and the resulting death, injury, destruction, and population displacement, were unprecedented in U.S. history. During 2005, 15 tropical storms became hurricanes. For the first time, four major hurricanes made landfall in the United States; three of those reached category 5 intensity.

The worst effects were felt from Hurricanes Katrina and Rita. These storms did not seriously impact the state of Florida; however, they have had a significant impact on emergency management and hurricane planning at the national, state and local levels.

On August 29, Hurricane Katrina struck the U.S. Gulf Coast, causing severe damage from a two-story storm surge, powerful winds, and heavy rains. Approximately 80% of New Orleans was flooded after the surge from the Gulf of Mexico forced breaks in a levee, releasing water from Lake Pontchartrain into the city. Katrina became the deadliest U.S. hurricane since 1928, and likely the costliest natural disaster on record in the United States. On September 24, response and recovery activities in the wake of Katrina were interrupted when Hurricane Rita struck the Gulf Coast. Rita rendered more homes uninhabitable and thousands more seeking shelter elsewhere. More than 200,000 persons were displaced by the hurricanes and dispersed to evacuee shelters in 18 states. The economic and health consequences of Hurricanes Katrina and Rita extended far beyond the Gulf region and ultimately affected states and communities throughout the US (www.cdc.gov/mmwr/mguide_nd.html).

Hurricane Katrina – August 23-30, 2005 Katrina was a large and intense hurricane that struck a portion of the United States coastline along the northern Gulf of Mexico that is particularly vulnerable to storm surge, leading to loss of life and property damage of immense proportions. The scope of human suffering inflicted by Hurricane Katrina in the United States has been greater than that of any hurricane to strike this country in several generations.

The total number of fatalities known, as of this writing, to be either directly or indirectly related to Katrina is 1,336, based on reports to date from state and local officials in five states: 1,090 fatalities in Louisiana, 228 in Mississippi, 14 in Florida, 2 in Georgia, and 2 in Alabama. The number of direct fatalities is highly uncertain and the true number might not ever be known, especially for Louisiana and Mississippi.

Presumably, most of the deaths in Louisiana were directly caused by the widespread storm surge-induced flooding and its miserable aftermath in the New Orleans area. The vast majority of the fatalities in Mississippi were probably directly caused by the storm surge in the three coastal counties. In Florida three of the direct fatalities were caused by downed trees in Broward County and the three others were due to drowning in Miami-Dade County. Two deaths were also reported in Georgia, with one directly caused by a tornado, and the other occurring in a car accident indirectly related to the storm. Alabama reported two indirect fatalities in a car accident during the storm. Despite the fact that inland freshwater floods produced the majority of fatalities due to tropical cyclones during the past few decades, <u>Katrina provides a grim reminder that storm surge poses the greatest potential cause for large loss of life in a single hurricane in this country</u> (emphasis added).

Where Katrina ranks among the deadliest hurricanes on record in the United States is somewhat uncertain, due to the unknown number of fatalities caused directly by this hurricane and by some others in the past. Katrina is surpassed by the Galveston, Texas hurricane in 1900 that claimed at least 8,000 lives, and it appears to be surpassed by the 1928 Lake Okeechobee, Florida hurricane with over 2,500 fatalities. If the assumption is correct that most of the Katrina-related fatalities were caused directly by the storm, then Katrina ranks as the third deadliest hurricane in the United States since 1900, and the deadliest in 77 years. However, two hurricanes in 1893 might each have been directly responsible for more fatalities in the United States than Katrina. One of these struck the southeastern Louisiana barrier island of Cheniere Caminanda and killed about 2,000 people, while another struck Georgia and South Carolina and claimed somewhere between 1,000 and 2,000 lives. As a result, Katrina ranks fourth or fifth on the list of the deadliest hurricanes on record in the United States.

The extent, magnitude, and impacts of the damage caused by Katrina are staggering and are well beyond the scope of this report to fully describe. Thousands of homes and businesses throughout entire neighborhoods in the New Orleans metropolitan area were destroyed by flood. Strong winds also caused damage in the New Orleans area, including downtown where windows in some high rise buildings were blown out and the roof of the Louisiana Superdome was partially peeled away. The storm surge of Katrina struck the Mississippi coastline with such ferocity that entire coastal communities were obliterated, some left with little more than the foundations on which homes, businesses, government facilities, and other historical buildings once stood. Despite being more distant from the eye of Katrina, the storm surge over Dauphin Island, Alabama destroyed or damaged dozens of beachfront homes and cut a new canal through the island's western end. Many of the most severely impacted areas along the northern Gulf coast could take years to completely rebuild. Katrina's heavy rains in southern Florida flooded some neighborhoods, primarily in Miami-Dade County. Many other structures from Florida and Georgia westward to Louisiana that avoided surge or freshwater floods, including some areas well inland, were damaged by strong winds and tornadoes. Considerable damage to some homes and agricultural facilities was caused by several tornadoes in Georgia. Strong winds caused significant tree damage throughout much of Mississippi and Alabama. Combining all of the areas it impacted, Katrina left about three million people without electricity, some for several weeks.

The economic and environmental ramifications of Katrina have been widespread and could in some respects be long-lasting, due to impacts on large population and tourism centers, the oil and gas industry, and transportation. The hurricane severely impacted or destroyed workplaces in New Orleans and other heavily populated areas of the northern Gulf coast, resulting in thousands of lost jobs and millions of dollars in lost tax revenues for the impacted communities and states. Along the Mississippi coast, several large casinos on floating barges were damaged or destroyed when the surge pushed them onshore. Large numbers of evacuees have not returned home, producing a shortage of workers for those businesses that have reopened. Major beach erosion occurred along the tourism-dependent Mississippi and Alabama coasts. A significant percentage of United States oil refining capacity was disrupted after the storm due to flooded refineries, crippled pipelines, and several oil rigs and platforms damaged, adrift or capsized. An oil rig under construction along the Mobile River in Alabama was dislodged, floated 1.5 miles northward, and struck the Cochrane Bridge just north of downtown Mobile. An offshore oil rig washed up near the beach of Dauphin Island, Alabama. Several million gallons of oil were spilled from damaged facilities scattered throughout southeastern Louisiana. While several facilities have since resumed operations, as of this writing oil and natural gas production and refining capacity in the northern Gulf of Mexico region remains less than that prior to Katrina. Key transportation arteries were disrupted or cut off by the hurricane. Traffic along the Mississippi River was below normal capacity for at least two weeks following the storm. Major highways into and through New Orleans were blocked by floods. Major bridges along the northern Gulf coast were destroyed, including several in Mississippi and the Interstate 10 Twin Span Bridge connecting New Orleans and Slidell, Louisiana.

Estimates of the insured property losses caused by Katrina vary considerably and range between about $20 billion and $60 billion. The American Insurance Services Group (AISG) estimates that Katrina is responsible for $38.1 billion of insured losses in the United States. A preliminary estimate of the total damage cost of Katrina is assumed to be roughly twice the insured losses (using the AISG estimate), or about $75 billion. This figure would make Katrina the costliest hurricane in United States history by far. Even after adjusting for inflation, the estimated total damage cost of Katrina is roughly double that of Hurricane Andrew (1992). Normalizing for inflation and for increases in population and wealth, only the 1926 hurricane that struck southern Florida surpasses Katrina in terms of damage cost. However, this would not be the case if the values on the higher end of the range of Katrina estimates are later found to be the most accurate. The Insurance Information Institute reports that, mostly due to Katrina, but combined with significant impacts from the other hurricanes striking the United States this year, 2005 was by a large margin the costliest year ever for insured catastrophic losses in this country.

Data provided by the Federal Emergency Management Agency (FEMA) indicate that over 1.2 million people along the northern Gulf coast from southeastern Louisiana to Alabama were under some type of evacuation order, but it is not clear how many people actually evacuated. Media reports indicate that many displaced residents have moved either temporarily or permanently to other areas in the United States. A large number of these people might never return to live in their pre-Katrina homes or cities. Thousands of people are still living in hotels and temporary shelters (www.nhc.noaa.gov).

Hurricane Rita, September 18-26, 2005 *Rita was an intense hurricane that reached category 5 strength (on the Saffir-Simpson Hurricane Scale) over the central Gulf of Mexico, where it had the fourth-lowest central pressure on record in the Atlantic* *basin. Although it weakened prior to making landfall as a category 3 hurricane near the Texas/Louisiana border, Rita produced significant storm surge that devastated coastal communities in southwestern Louisiana, and its winds, rain, and tornadoes caused fatalities and a wide swath of damage from eastern Texas to Alabama. Rita also caused floods due to storm surge in portions of the Florida Keys.*

The approach of Rita provoked one the largest evacuations in U. S. history. Just weeks after the country watched in horror the devastation of Hurricane Katrina, media reports indicate that the number of evacuees in Texas could have exceeded two million. Additional evacuations involving smaller numbers took place in Louisiana (www.nhc.noaa.gov).

Hurricane Wilma – October 15-25, 2005 *Wilma formed and became an extremely intense hurricane over the northwestern Caribbean Sea. It had the all-time lowest central pressure for an Atlantic basin hurricane, and it devastated the northeastern Yucatan Peninsula as a category 4 hurricane. Wilma also inflicted extensive damage over southern Florida.*

Despite the strong shear in its surroundings, Wilma strengthened over the southeastern Gulf of Mexico and its winds reached about 110 knots as it approached Florida. Maximum sustained winds were estimated to be near 105 knots (category 3 intensity) when landfall of the center occurred in southwestern Florida near Cape Romano October 24th. Continuing to accelerate and now moving at a forward speed of 20 to 25 knots, the hurricane crossed the southern Florida peninsula in 4.5 hours, with the center emerging into the Atlantic just southeast of Jupiter. Maximum winds had decreased to near 95 knots (category 2) during the crossing of Florida. Twenty-two deaths have been directly attributed to Wilma: 12 in Haiti, 1 in Jamaica, 4 in Mexico, and 5 in Florida.

Damage was reported to have been very severe in portions of the northeastern Yucatan Peninsula, where Wilma dealt a major blow to the tourist industry in that area. In southern Florida, damage was unusually widespread, including numerous downed trees, substantial crop losses, downed power lines and poles, broken windows, extensive roof damage, and destruction of mobile homes. Wilma caused the largest disruption to electrical service ever experienced in Florida. A preliminary amount of total insured damage compiled by the Property Claims Service is $6.1 billion. Using a doubling of insured losses to obtain the total damage gives a current estimate of Wilma's U.S. damage to be $12.2 billion (www.nhc.noaa.gov).

c. The 2006, 2007 and 2008 Seasons

The 2006 Hurricane season was a much quieter season for the state of Florida, with only one hurricane affecting the state, Hurricane Ernesto, which was actually a tropical storm when it impacted Florida. Tropical Storm Alberto also crossed the eastern Florida panhandle. The 2007 hurricane season was also a relatively quite season, with no hurricanes directly affecting the State of Florida.

The 2008 Atlantic hurricane season marked the end of a season that produced a record number of consecutive storms to strike the United States and ranks as one of the more active seasons in the 64 years since comprehensive records began. Overall, the season is tied as the fourth most active in terms of named storms (16) and major hurricanes (5), and is tied as the fifth most active in terms of hurricanes (8) since 1944, which was the first year aircraft missions flew into tropical storms and hurricanes.

For the first time on record, six consecutive tropical cyclones (Dolly, Edouard, Fay, Gustav, Hanna and Ike) made landfall on the U.S. mainland, and a record three major hurricanes (Gustav, Ike and Paloma) struck Cuba. This is also the first Atlantic season to have a major hurricane (Category 3) form in five consecutive months (July: Bertha, August: Gustav, September: Ike, October: Omar, November: Paloma).

The National Hurricane Center attributes the 2008 above-normal season to conditions that include:

- An ongoing multi-decadal signal. This combination of ocean and atmospheric conditions has spawned increased hurricane activity since 1995.
- Lingering La Niña effects. Although the La Niña that began in the Fall of 2007 ended in June, its influence of light wind shear lingered.
- Warmer tropical Atlantic Ocean temperatures. On average, the tropical Atlantic was about 1.0 degree Fahrenheit above normal during the peak of the season.

In 2008, Tropical Storm Fay made history as the only storm on record to make landfall four times in the state of Florida, and to prompt tropical storm and hurricane watches and warnings for the state's entire coastline (at various times during its August lifespan).

Though Florida was spared a direct hit from a major hurricane, Floridians saw major flooding throughout the State from Tropical Storm Fay. Fay came ashore in the Florida Keys August 18 and continued northward up the Florida Peninsula. Fay made records as the first storm to make four landfalls in one state, impacting the Florida Keys, South Florida, exiting off the east coast and coming back inland near Flagler Beach and exiting off the Gulf Coast and making landfall again near Carrabelle. The slow-moving storm also caused record rainfall and flooding throughout the state, with some areas getting as much as 25 inches of rain. Millions of dollars in damage and 15 deaths were caused in Florida by Fay (www.noaa.nhc.gov).

Hurricane Gustav brought tropical storm force winds to the Florida Keys and storm surge and severe thunderstorms to the Florida Panhandle. As Gustav headed for the Louisiana coast, many residents evacuated to Florida to escape the storm. Many Florida counties, in conjunction with the American Red Cross, opened shelters throughout the state for evacuees (www.noaa.nhc.gov).

9. Probability of Future Hurricane Events

Table II-6 provides the number of direct hits on the mainland United States coastline (1900-1996) for individual states. Florida is divided into four sections. The South Florida Region is located in the Southeast area, while the Florida Keys are included in the Southwest area.

Table II-6
U.S. Mainland Hurricane Strikes by State, 1851-2006

Area	Category					All (1-5)	Major (3-5)
	1	2	3	4	5		
U.S. (Texas to Maine)	110	73	75	18	3	279	96
Texas	23	18	12	7	0	60	19
Louisiana	18	14	15	4	1	52	20
Mississippi	2	5	8	0	1	16	9
Alabama	16	4	6	0	0	26	6
Florida	43	33	29	6	2	113	37
(Northwest)	26	17	14	0	0	57	14
(Northeast)	12	8	1	0	0	21	1
(Southwest)	18	10	8	4	1	41	13
(Southeast)	13	13	11	3	1	41	15
Georgia	15	5	2	1	0	23	3
South Carolina	18	6	4	2	0	30	6
North Carolina	24	14	11	1	0	50	12
Virginia	7	2	1	0	0	10	1
Maryland	1	1	0	0	0	2	0
Delaware	2	0	0	0	0	2	0
New Jersey	2	0	0	0	0	2	0
Pennsylvania	1	0	0	0	0	1	0
New York	6	1	5	0	0	12	5
Connecticut	5	3	3	0	0	11	3
Rhode Island	3	2	4	0	0	9	4
Massachusetts	6	2	3	0	0	11	3
New Hampshire	1	1	0	0	0	2	0
Maine	5	1	0	0	0	6	0

Notes: State totals will not necessarily equal U.S. totals, and Florida totals will not necessarily equal sum of sectional totals.

Table II-7 provides the total of major hurricane direct hits on the mainland (1900-1996) by month. Most major hurricanes occur in the later part of the hurricane season in September, October and November. Category one and two hurricanes tend to “spring up” in the Caribbean affecting the southwest Florida area in the early part of the season.

Table II-7
Major Hurricane Direct Hits on the U.S. Coastline, 1851-2006, by Month

	Jun	Jul	Aug	Sep	Oct	Nov
U.S. (Texas to Maine)	2	4	30	44	16	96
Texas	1	1	10	7	0	19
(North)	1	1	3	2	0	7
(Central)	0	0	2	2	0	4
(South)	0	0	5	3	0	8
Louisiana	2	0	7	8	3	20
Mississippi	0	1	4	4	0	9
Alabama	0	1	1	4	0	6
Florida	0	2	6	19	10	37
(Northwest)	0	2	1	7	3	13
(Northeast)	0	0	0	1	0	1
(Southwest)	0	0	2	5	6	13
(Southeast)	0	0	4	8	3	15
Georgia	0	0	1	1	1	3
South Carolina	0	0	2	2	2	6
North Carolina	0	0	4	8	1	13
Virginia	0	0	0	1	0	1
Maryland	0	0	0	0	0	0
Delaware	0	0	0	0	0	0
New Jersey	0	0	0	0	0	0
Pennsylvania	0	0	0	0	0	0
New York	0	0	1	4	0	5
Connecticut	0	0	1	2	0	3
Rhode Island	0	0	1	3	0	4
Massachusetts	0	0	0	3	0	3
New Hampshire	0	0	0	0	0	0
Maine	0	0	0	0	0	0

Taken from The Deadliest, Costliest, and Most Intense United States Hurricanes of this Century [NOAA Technical Memorandum NWS TPC-5], updated in 2007 (http://www.nhc.noaa.gov/pdf/NWS-TPC-5.pdf). Storms can affect more than one area in the state. Therefore, the total number of storms affecting Florida is less than the total number affecting all regions.

a. Monthly Zones of Origin and Hurricane Tracks

The figures below (Figures II-9 to II-14) show the zones of origin and tracks for different months during the hurricane season. These figures only depict average conditions and hurricanes can originate in different locations and travel much different paths from the average. Nonetheless, having a sense of the general pattern can give you a better picture of the average hurricane season for your area.

Figure II-9: Prevailing Tracks - June

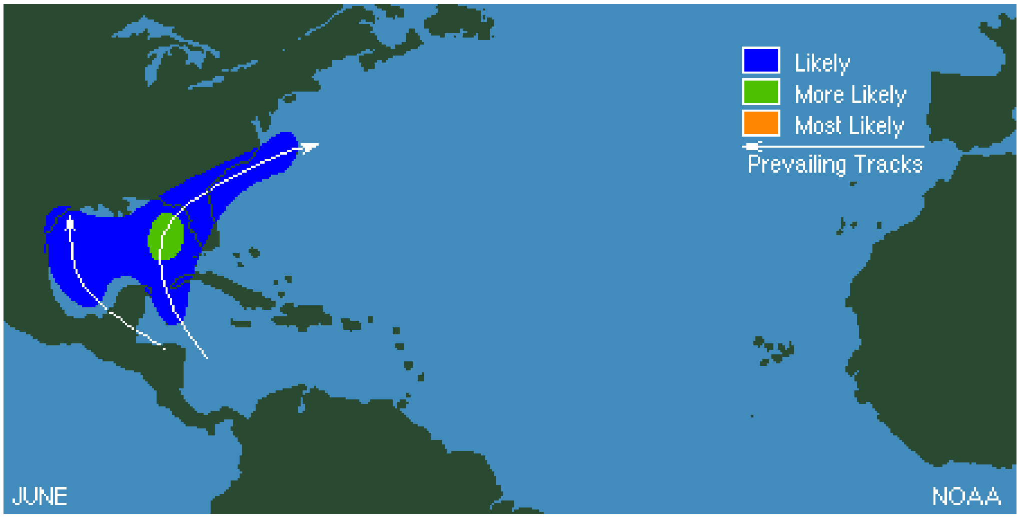


Figure II-10: Prevailing Tracks - July

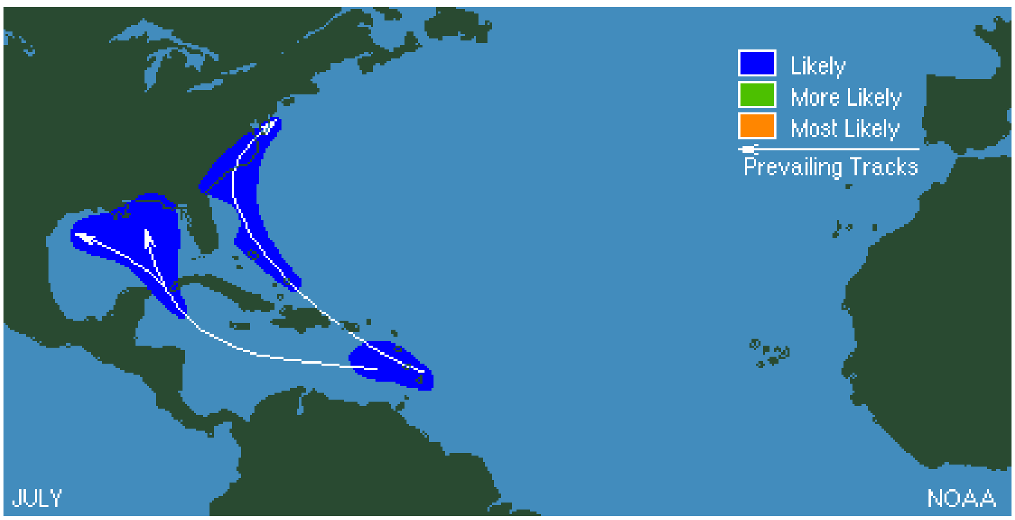


Figure II-11: Prevailing Tracks - August

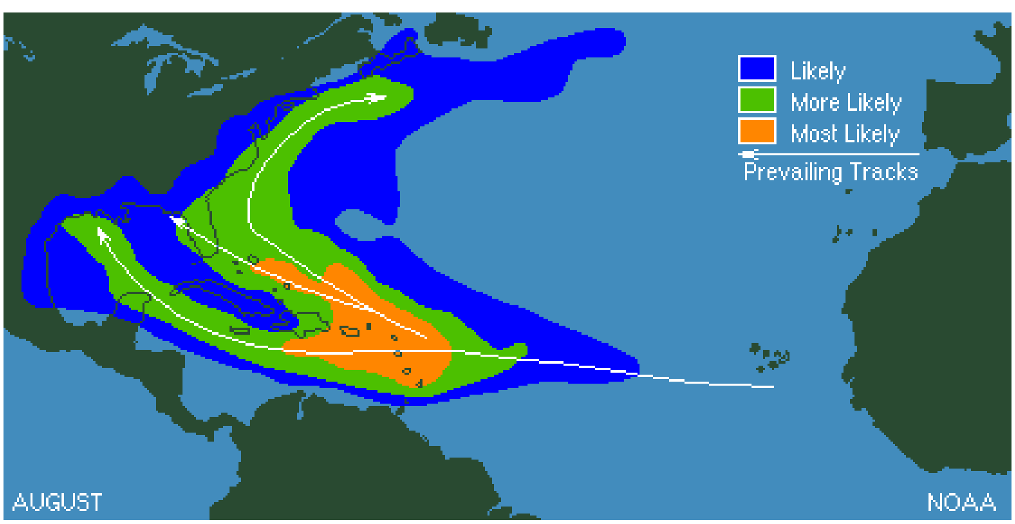


Figure II-12: Prevailing Tracks - September

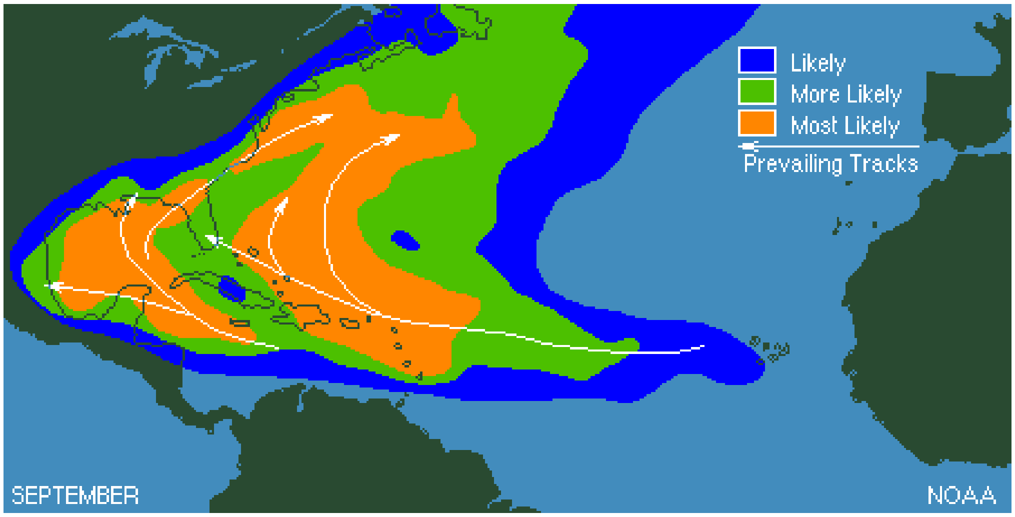


Figure II-13: Prevailing Tracks - October

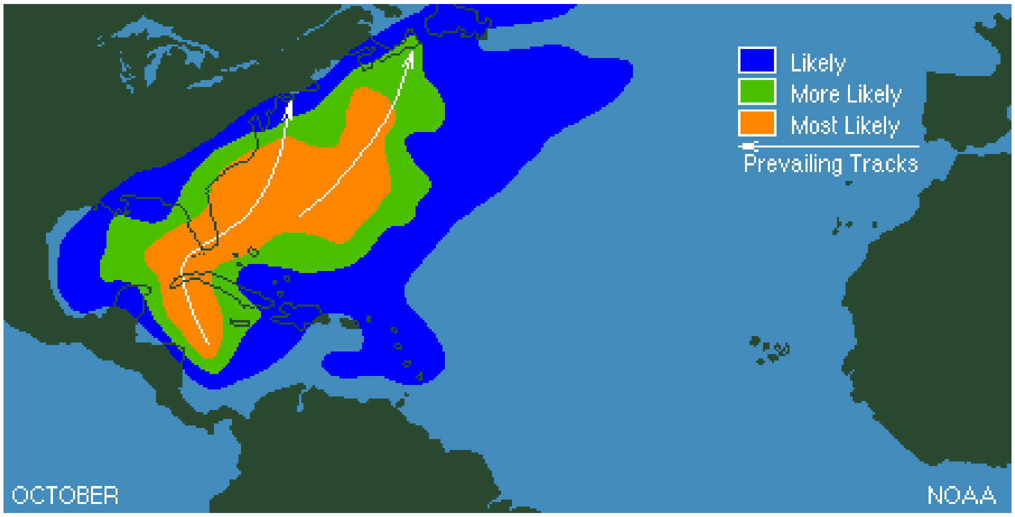
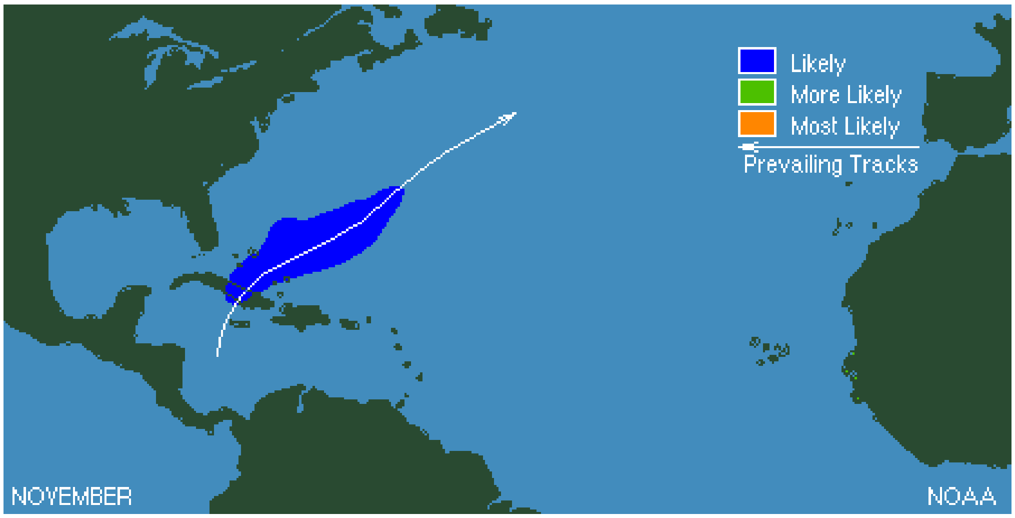


Figure II-14: Prevailing Tracks - November



b. National Oceanographic and Atmospheric Administration Historical Analysis for the Region

In the tables below, the National Hurricane Center provides a list of all the tropical storms and hurricanes that have passed within 100 nautical miles of five selected points in the South Florida Region: Key West (Table II-8a), Islamorada (Table II-8b), Flamingo (Table II-8c), Miami Beach (Table II-8d) and Fort Lauderdale (Table II-8e). Using an historical analysis, return intervals were developed for the South Florida Region and presented in Tables II-9a and II-9b.

Table II-8a: Key West

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF KEY WEST, FL 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	NOT NAMED	1870	OCT	9	6	90(90)	28 (SSE)	063/ 2.1
2	NOT NAMED	1870	OCT	20	9	80(80)	58 (WNW)	034/14.0
3	NOT NAMED	1871	JUN	1	1	40(40)	27 (S)	271/10.1
4	NOT NAMED	1873	OCT	6	5	100(100)	98 (NW)	043/20.8
5	NOT NAMED	1875	SEP	14	3	67(60)	78 (SSW)	294/15.2
6	NOT NAMED	1876	SEP	16	2	60(58)	95 (E)	006/16.0
7	NOT NAMED	1876	OCT	20	5	97(90)	11 (WNW)	022/12.9
8	NOT NAMED	1878	JUL	2	1	40(40)	86 (NNW)	080/13.2
9	NOT NAMED	1878	SEP	7	5	60(55)	44 (E)	353/ 7.1
10	NOT NAMED	1878	OCT	21	11	85(72)	40 (ESE)	032/14.0
11	NOT NAMED	1881	AUG	17	4	40(40)	29 (SSE)	067/12.9
12	NOT NAMED	1885	OCT	10	8	43(40)	78 (WSW)	340/ 8.5
13	NOT NAMED	1886	AUG	18	5	72(67)	39 (SSW)	294/12.9
14	NOT NAMED	1888	SEP	4	4	87(82)	92 (S)	266/10.1
15	NOT NAMED	1888	SEP	23	6	35(35)	44 (ESE)	034/14.0
16	NOT NAMED	1889	OCT	5	9	40(38)	32 (ESE)	016/16.6
17	NOT NAMED	1891	AUG	24	3	70(52)	76 (NNE)	292/ 8.7
18	NOT NAMED	1891	OCT	7	7	45(43)	7 (ESE)	023/11.9
19	NOT NAMED	1891	OCT	9	8	39(36)	78 (WNW)	029/16.3
20	NOT NAMED	1892	JUN	10	1	40(40)	46 (NNW)	062/11.8
21	NOT NAMED	1894	SEP	25	4	88(75)	14 (W)	360/10.0
22	NOT NAMED	1895	OCT	1	3	50(50)	24 (SSE)	075/ 9.4
23	NOT NAMED	1895	OCT	16	6	35(35)	58 (NNW)	075/15.0
24	NOT NAMED	1897	SEP	10	2	72(60)	12 (SSW)	295/ 9.5
25	NOT NAMED	1897	SEP	20	3	57(50)	86 (WNW)	029/11.6
26	NOT NAMED	1898	SEP	25	8	39(35)	5 (NNW)	064/16.1
27	NOT NAMED	1898	OCT	11	9	60(53)	62 (SSE)	056/ 8.9
28	NOT NAMED	1898	OCT	23	10	40(37)	57 (SSE)	057/13.0
29	NOT NAMED	1899	JUL	30	2	42(35)	59 (NE)	310/10.7
30	NOT NAMED	1900	SEP	5	1	68(59)	40 (SW)	310/ 9.5
31	NOT NAMED	1902	JUN	13	1	50(48)	73 (W)	350/11.2
32	NOT NAMED	1904	OCT	20	3	70(35)	52 (N)	094/ 5.6
33	NOT NAMED	1906	JUN	16	2	75(68)	23 (ESE)	023/ 5.3
34	NOT NAMED	1906	OCT	18	8	105(105)	24 (ESE)	[illegible]
35	NOT NAMED	1909	OCT	11	10	105(102)	12 (SSE)	064/20.8
36	NOT NAMED	1910	OCT	17	5	118(110)	45 (WNW)	027/12.3
37	NOT NAMED	1911	AUG	8	2	35(30)	70 (NW)	270/ .4
38	NOT NAMED	1916	MAY	14	1	39(33)	47 (ENE)	348/13.3
39	NOT NAMED	1916	AUG	25	7	40(40)	97 (ENE)	328/ 8.7
40	NOT NAMED	1916	NOV	15	15	55(53)	15 (NNW)	064/30.2
41	NOT NAMED	1919	SEP	9	2	130(128)	20 (SSW)	287/ 7.6
42	NOT NAMED	1924	SEP	13	4	60(60)	76 (WSW)	304/24.5
43	NOT NAMED	1924	OCT	20	7	96(87)	67 (NW)	055/ 7.6
44	NOT NAMED	1926	SEP	18	6	114(113)	93 (NNE)	299/12.4
45	NOT NAMED	1926	OCT	20	10	102(97)	52 (SE)	046/16.3
46	NOT NAMED	1926	NOV	16	11	34(33)	89 (SSE)	064/36.8
47	NOT NAMED	1928	AUG	13	2	51(48)	27 (ENE)	332/ 9.2
48	NOT NAMED	1929	SEP	28	2	110(89)	54 (NNE)	300/ 7.1
49	NOT NAMED	1932	AUG	30	3	55(53)	73 (NE)	305/ 8.8
50	NOT NAMED	1933	SEP	1	11	91(90)	46 (S)	280/13.1
51	NOT NAMED	1933	OCT	5	18	112(102)	36 (SE)	054/11.5
52	NOT NAMED	1934	MAY	27	1	40(40)	24 (NW)	040/11.6
53	NOT NAMED	1935	SEP	3	2	150(115)	46 (NE)	306/ 9.0
54	NOT NAMED	1935	SEP	28	4	100(100)	91 (ESE)	019/13.2
55	NOT NAMED	1935	NOV	5	6	82(70)	29 (NNW)	252/13.4
56	NOT NAMED	1936	JUN	15	1	40(40)	78 (N)	096/19.9
57	NOT NAMED	1936	JUL	29	5	55(53)	57 (NNE)	295/ 7.9
58	NOT NAMED	1941	OCT	6	5	105(103)	80 (NNE)	301/17.9
59	NOT NAMED	1941	OCT	18	6	40(40)	35 (SSW)	295/ 9.1
60	NOT NAMED	1944	OCT	18	11	107(105)	58 (W)	008/13.1

NOTES:
Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 24.55N 81.75W.

CHART 1A (Page 1)

Table II-8a: Key West (continued)

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF KEY WEST, FL 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
61	NOT NAMED	1945	SEP	4	7	35(35)	20 (W)	007/11.8
62	NOT NAMED	1945	SEP	16	9	115(110)	93 (NE)	317/12.6
63	NOT NAMED	1946	OCT	7	5	115(113)	88 (WNW)	012/17.4
64	NOT NAMED	1947	AUG	19	3	42(37)	27 (S)	268/ 7.3
65	NOT NAMED	1947	SEP	18	4	120(97)	92 (N)	274/ 5.4
66	NOT NAMED	1947	SEP	22	6	45(45)	99 (WSW)	343/ 9.5
67	NOT NAMED	1947	OCT	11	8	75(68)	7 (NW)	039/12.9
68	NOT NAMED	1948	SEP	21	7	100(100)	6 (ESE)	014/ 7.2
69	NOT NAMED	1948	OCT	5	8	115(100)	20 (SE)	042/16.2
70	EASY	1950	SEP	3	5	88(73)	27 (WSW)	342/12.5
71	NOT NAMED	1952	FEB	3	1	43(38)	10 (NW)	043/29.7
72	ALICE	1953	JUN	3	1	47(35)	57 (SW)	331/ 3.1
73	NOT NAMED	1953	AUG	29	3	45(45)	87 (N)	091/12.6
74	NOT NAMED	1953	OCT	4	10	35(34)	91 (ESE)	015/10.2
75	DONNA	1960	SEP	10	5	115(112)	48 (NE)	319/ 8.1
76	ISBELL	1964	OCT	14	11	110(102)	31 (NW)	037/13.7
77	BETSY	1965	SEP	8	3	110(107)	41 (N)	279/13.7
78	ALMA	1966	JUN	8	1	110(110)	36 (W)	357/15.2
79	INEZ	1966	OCT	5	9	84(78)	4 (N)	267/ 8.3
80	ABBY	1968	JUN	4	1	65(64)	90 (WNW)	028/ 7.9
81	GLADYS	1968	OCT	16	8	65(65)	86 (WSW)	349/12.8
82	JENNY	1969	OCT	2	13	40(33)	28 (W)	008/12.2
83	GRETA	1970	SEP	27	8	43(30)	4 (S)	282/14.0
84	DOTTIE	1976	AUG	19	5	35(29)	20 (NW)	042/ 2.7
85	DENNIS	1981	AUG	16	4	35(35)	25 (E)	360/ 4.0
86	ALBERTO	1982	JUN	6	1	72(20)	73 (NW)	090/ 1.1
87	ELENA	1985	AUG	29	5	54(52)	75 (SSW)	296/17.5
88	KATE	1985	NOV	19	11	84(81)	79 (SSW)	291/16.3
89	FLOYD	1987	OCT	12	7	65(65)	2 (NNW)	064/14.5
90	MARCO	1990	OCT	10	13	50(37)	28 (SW)	318/ 6.3
91	FABIAN	1991	OCT	16	6	40(40)	65 (ESE)	033/16.8
92	ANDREW	1992	AUG	24	2	145(115)	66 (N)	277/17.3
93	GORDON	1994	NOV	15	7	45(45)	3 (NE)	311/ 6.1
94	GEORGES	1998	SEP	25	7	90(90)	17 (SW)	307/12.3
95	MITCH	1998	NOV	5	13	53(52)	92 (NNW)	058/19.0
96	HARVEY	1999	SEP	21	8	50(50)	80 (N)	086/11.9
97	IRENE	1999	OCT	15	9	65(65)	3 (ESE)	033/ 8.4
98	CHARLEY	2004	AUG	13	3	125(100)	62 (W)	007/17.6
99	DENNIS	2005	JUL	9	4	92(77)	78 (SW)	316/12.2
100	KATRINA	2005	AUG	26	11	92(75)	36 (NNW)	248/ 6.4
101	RITA	2005	SEP	20	17	103(88)	37 (SSW)	282/10.3
102	WILMA	2005	OCT	24	22	110(110)	64 (NNW)	059/22.4
103	ERNESTO	2006	AUG	30	6	40(40)	67 (ENE)	329/ 7.0

NOTES:

Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 24.55N 81.75W.

CHART 1A (Page 2)

Table II-8b: Islamorada

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF ISLAMORADA 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	NOT NAMED	1870	OCT	10	6	90(90)	11 (SE)	053/ 3.4
2	NOT NAMED	1870	OCT	20	9	80(80)	93 (NW)	041/16.2
3	NOT NAMED	1871	JUN	1	1	40(40)	56 (SSW)	268/10.0
4	NOT NAMED	1876	SEP	16	2	60(60)	36 (ESE)	012/21.7
5	NOT NAMED	1876	OCT	20	5	90(90)	61 (WNW)	023/14.1
6	NOT NAMED	1878	JUL	2	1	40(33)	83 (NNW)	065/13.4
7	NOT NAMED	1878	SEP	7	5	60(58)	23 (W)	353/ 7.1
8	NOT NAMED	1878	OCT	21	11	77(70)	2 (SE)	041/18.8
9	NOT NAMED	1881	AUG	17	4	40(40)	26 (SSE)	065/16.8
10	NOT NAMED	1885	AUG	23	2	70(63)	78 (ENE)	340/10.6
11	NOT NAMED	1886	AUG	17	5	66(64)	90 (SSW)	299/13.0
12	NOT NAMED	1886	AUG	23	6	83(81)	86 (E)	003/17.3
13	NOT NAMED	1888	AUG	16	3	110(110)	57 (NNE)	299/10.3
14	NOT NAMED	1888	SEP	23	6	39(35)	2 (ESE)	032/14.0
15	NOT NAMED	1889	OCT	6	9	40(40)	23 (WNW)	017/19.4
16	NOT NAMED	1891	AUG	24	3	76(70)	32 (NNE)	284/ 8.4
17	NOT NAMED	1891	OCT	7	7	45(43)	44 (WNW)	020/12.8
18	NOT NAMED	1892	JUN	11	1	40(35)	56 (NNW)	060/12.0
19	NOT NAMED	1894	SEP	25	4	87(80)	78 (W)	360/11.5
20	NOT NAMED	1895	OCT	2	3	50(50)	20 (SSE)	061/ 8.3
21	NOT NAMED	1895	OCT	22	5	90(88)	70 (ESE)	027/15.8
22	NOT NAMED	1895	OCT	16	6	35(34)	59 (NNW)	059/14.9
23	NOT NAMED	1897	SEP	10	2	62(55)	62 (SSW)	294/ 9.4
24	NOT NAMED	1898	SEP	26	8	40(38)	11 (NNW)	065/14.0
25	NOT NAMED	1898	OCT	11	9	60(60)	41 (SE)	040/12.9
26	NOT NAMED	1898	OCT	23	10	40(39)	43 (SSE)	058/15.1
27	NOT NAMED	1899	JUL	30	2	40(36)	2 (SW)	312/14.8
28	NOT NAMED	1899	OCT	29	8	72(70)	97 (ESE)	013/16.4
29	NOT NAMED	1900	SEP	5	1	57(57)	100 (SW)	309/ 9.5
30	NOT NAMED	1901	AUG	10	4	40(40)	84 (NNE)	293/ 7.8
31	NOT NAMED	1903	SEP	11	3	75(75)	73 (NNE)	297/ 7.0
32	NOT NAMED	1904	OCT	17	3	70(70)	25 (NE)	318/ 8.1
33	NOT NAMED	1906	JUN	17	2	75(75)	16 (NW)	037/ 8.9
34	NOT NAMED	1906	OCT	18	8	105(105)	18 (NW)	034/16.1
35	NOT NAMED	1909	JUN	28	3	45(45)	59 (ENE)	327/ 9.7
36	NOT NAMED	1909	AUG	29	7	44(41)	93 (N)	278/ 8.1
37	NOT NAMED	1909	OCT	11	10	103(98)	0 (W)	057/23.0
38	NOT NAMED	1910	OCT	18	5	108(105)	94 (WNW)	017/11.2
39	NOT NAMED	1916	MAY	14	1	40(34)	21 (WSW)	348/13.3
40	NOT NAMED	1916	AUG	25	7	40(40)	30 (NE)	323/10.1
41	NOT NAMED	1916	NOV	15	15	53(51)	21 (NNW)	064/30.1
42	NOT NAMED	1919	SEP	9	2	130(121)	57 (S)	275/ 7.4
43	NOT NAMED	1924	OCT	21	7	83(59)	67 (NNW)	074/ 7.5
44	NOT NAMED	1926	SEP	18	6	120(115)	41 (NNE)	298/11.1
45	NOT NAMED	1926	SEP	16	7	35(30)	10 (SE)	234/ 6.8
46	NOT NAMED	1926	OCT	21	10	98(95)	17 (ESE)	034/15.9
47	NOT NAMED	1928	AUG	13	2	50(47)	41 (WSW)	332/ 9.2
48	NOT NAMED	1929	SEP	28	2	118(110)	6 (NNE)	290/ 5.8
49	NOT NAMED	1932	AUG	30	3	55(55)	21 (NNE)	296/ 9.1
50	NOT NAMED	1933	SEP	1	11	89(87)	83 (SSW)	283/14.1
51	NOT NAMED	1933	OCT	5	18	118(110)	21 (SSE)	060/15.8
52	NOT NAMED	1934	MAY	27	1	40(40)	68 (WNW)	027/12.1
53	NOT NAMED	1935	SEP	3	2	150(148)	9 (SSW)	302/ 7.5
54	NOT NAMED	1935	SEP	28	4	100(100)	40 (ESE)	024/13.2
55	NOT NAMED	1935	NOV	4	6	85(77)	33 (NW)	238/ 8.7
56	NOT NAMED	1936	JUN	15	1	40(36)	47 (N)	095/19.9
57	NOT NAMED	1936	JUL	29	5	55(50)	12 (NNE)	287/ 7.5
58	NOT NAMED	1937	SEP	26	8	35(35)	92 (E)	011/12.4
59	NOT NAMED	1941	OCT	6	5	105(103)	31 (NNE)	290/16.2
60	NOT NAMED	1941	OCT	17	6	40(40)	76 (S)	279/ 7.9

NOTES:

Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 24.95N 80.57W.

CHART 1A (Page 1)

Table II-8b: Islamorada (continued)

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF ISLAMORADA 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
61	NOT NAMED	1945	SEP	4	7	35(35)	82 (W)	001/10.0
62	NOT NAMED	1945	SEP	15	9	115(115)	31 (NE)	312/12.1
63	NOT NAMED	1946	SEP	12	4	59(53)	71 (ESE)	019/11.6
64	NOT NAMED	1946	NOV	1	6	40(40)	85 (NE)	318/13.5
65	NOT NAMED	1947	AUG	18	3	38(35)	54 (S)	274/13.7
66	NOT NAMED	1947	SEP	17	4	135(123)	76 (NNW)	254/ 7.5
67	NOT NAMED	1947	OCT	12	8	75(73)	38 (NW)	047/10.1
68	NOT NAMED	1948	SEP	21	7	100(100)	49 (WNW)	020/ 6.7
69	NOT NAMED	1948	OCT	5	8	105(96)	11 (NW)	042/17.6
70	EASY	1950	SEP	3	5	75(73)	96 (WSW)	342/12.5
71	KING	1950	OCT	18	11	110(108)	38 (ENE)	338/11.9
72	NOT NAMED	1952	FEB	3	1	45(42)	42 (NW)	041/29.7
73	FOX	1952	OCT	25	7	88(85)	74 (SE)	044/ 8.3
74	NOT NAMED	1953	AUG	29	3	45(35)	64 (N)	087/12.7
75	NOT NAMED	1953	OCT	4	10	35(35)	36 (ESE)	020/10.7
76	DONNA	1960	SEP	10	5	115(115)	16 (SW)	315/ 8.1
77	CLEO	1964	AUG	27	5	90(90)	45 (ENE)	343/ 9.4
78	ISBELL	1964	OCT	14	11	103(100)	63 (NW)	045/18.1
79	BETSY	1965	SEP	8	3	110(110)	8 (N)	275/10.9
80	INEZ	1966	OCT	4	9	80(75)	1 (NNW)	248/ 7.9
81	JENNY	1969	OCT	2	13	40(37)	88 (W)	009/12.1
82	GRETA	1970	SEP	27	8	45(35)	41 (SSW)	282/14.0
83	SUBTROP	1974	OCT	6	11	43(40)	85 (ENE)	331/ 9.9
84	DOTTIE	1976	AUG	19	5	35(35)	41 (NW)	048/21.8
85	DAVID	1979	SEP	3	4	85(82)	79 (ENE)	337/11.0
86	DENNIS	1981	AUG	17	4	35(35)	37 (WNW)	012/ 3.1
87	ISIDORE	1984	SEP	27	10	50(50)	90 (NE)	316/ 8.8
88	BOB	1985	JUL	23	2	40(40)	92 (NNW)	077/10.7
89	FLOYD	1987	OCT	12	7	65(63)	5 (NNW)	068/15.7
90	MARCO	1990	OCT	10	13	38(33)	92 (SW)	318/ 8.1
91	FABIAN	1991	OCT	16	6	40(40)	25 (SE)	035/15.9
92	ANDREW	1992	AUG	24	2	145(130)	34 (N)	279/17.3
93	GORDON	1994	NOV	15	7	45(45)	57 (SW)	310/ 9.5
94	JERRY	1995	AUG	23	10	35(30)	76 (ENE)	344/11.7
95	GEORGES	1998	SEP	25	7	90(89)	74 (SSW)	297/11.3
96	HARVEY	1999	SEP	21	8	50(48)	66 (NNW)	076/27.6
97	IRENE	1999	OCT	15	9	65(65)	38 (WNW)	033/11.8
98	KATRINA	2005	AUG	26	11	82(67)	43 (NNW)	241/10.3
99	RITA	2005	SEP	20	17	88(75)	72 (S)	280/12.1
100	WILMA	2005	OCT	24	22	110(105)	75 (NW)	057/22.4
101	ERNESTO	2006	AUG	30	6	40(40)	0 (NE)	328/ 7.0

NOTES:
Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 24.95N 80.57W.

CHART 1A (Page 2)

Table II-8c: Flamingo

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF FLAMINGO 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	NOT NAMED	1870	OCT	10	6	90(90)	32 (SSE)	059/ 2.1
2	NOT NAMED	1870	OCT	20	9	80(80)	71 (NW)	041/16.2
3	NOT NAMED	1871	JUN	1	1	40(40)	63 (S)	268/10.0
4	NOT NAMED	1876	SEP	16	2	60(60)	57 (ESE)	012/21.7
5	NOT NAMED	1876	OCT	20	5	90(90)	39 (WNW)	023/14.1
6	NOT NAMED	1878	JUL	2	1	40(37)	65 (NNW)	069/13.3
7	NOT NAMED	1878	SEP	8	5	60(58)	5 (W)	350/ 8.2
8	NOT NAMED	1878	OCT	21	11	77(70)	24 (SE)	041/18.8
9	NOT NAMED	1881	AUG	17	4	40(40)	45 (SSE)	067/12.9
10	NOT NAMED	1885	AUG	23	2	70(65)	93 (ENE)	341/10.6
11	NOT NAMED	1886	AUG	18	5	67(65)	91 (SSW)	297/13.0
12	NOT NAMED	1888	AUG	16	3	110(104)	56 (NNE)	300/10.3
13	NOT NAMED	1888	SEP	23	6	39(35)	25 (ESE)	032/14.0
14	NOT NAMED	1889	OCT	6	9	40(40)	1 (WNW)	017/19.4
15	NOT NAMED	1891	AUG	24	3	73(54)	26 (NNE)	290/ 8.7
16	NOT NAMED	1891	OCT	7	7	45(43)	22 (WNW)	020/12.8
17	NOT NAMED	1891	OCT	9	8	34(33)	93 (NW)	041/19.0
18	NOT NAMED	1892	JUN	10	1	40(40)	36 (NNW)	060/12.4
19	NOT NAMED	1894	SEP	25	4	90(82)	58 (W)	360/13.0
20	NOT NAMED	1895	OCT	2	3	50(50)	40 (SSE)	061/ 8.3
21	NOT NAMED	1895	OCT	22	5	90(88)	93 (ESE)	027/15.8
22	NOT NAMED	1895	OCT	16	6	35(35)	40 (NNW)	065/14.7
23	NOT NAMED	1896	OCT	9	5	50(48)	98 (NNW)	057/14.9
24	NOT NAMED	1897	SEP	10	2	63(58)	63 (SSW)	297/ 9.1
25	NOT NAMED	1898	SEP	26	8	40(37)	8 (SSE)	065/14.0
26	NOT NAMED	1898	OCT	11	9	60(59)	63 (SE)	046/ 9.5
27	NOT NAMED	1898	OCT	23	10	40(40)	63 (SSE)	058/14.0
28	NOT NAMED	1899	JUL	30	2	43(35)	3 (NE)	311/10.7
29	NOT NAMED	1900	SEP	5	1	61(58)	96 (SW)	310/ 9.5
30	NOT NAMED	1901	AUG	11	4	40(35)	81 (NNE)	292/ 8.2
31	NOT NAMED	1903	SEP	12	3	75(70)	72 (NNE)	299/ 8.2
32	NOT NAMED	1904	OCT	20	3	70(35)	22 (NNW)	073/ 5.6
33	NOT NAMED	1906	JUN	17	2	75(75)	6 (SE)	037/ 8.9
34	NOT NAMED	1906	OCT	18	8	105(105)	5 (SE)	034/16.1
35	NOT NAMED	1909	JUN	28	3	45(45)	68 (NE)	324/ 9.2
36	NOT NAMED	1909	AUG	29	7	44(38)	84 (N)	282/ 3.7
37	NOT NAMED	1909	OCT	11	10	103(98)	20 (SSE)	057/23.0
38	NOT NAMED	1910	OCT	18	5	112(105)	72 (WNW)	017/11.2
39	NOT NAMED	1916	MAY	14	1	40(35)	4 (WSW)	347/12.3
40	NOT NAMED	1916	AUG	25	7	40(40)	40 (ENE)	332/ 8.8
41	NOT NAMED	1916	NOV	15	15	53(51)	2 (NNW)	064/30.1
42	NOT NAMED	1919	SEP	9	2	130(124)	65 (S)	280/ 7.4
43	NOT NAMED	1924	OCT	21	7	90(67)	51 (NNW)	073/ 9.5
44	NOT NAMED	1926	SEP	18	6	120(114)	41 (NNE)	299/12.4
45	NOT NAMED	1926	SEP	16	7	35(30)	30 (SE)	234/ 6.8
46	NOT NAMED	1926	OCT	21	10	98(95)	40 (ESE)	034/15.9
47	NOT NAMED	1928	AUG	13	2	51(48)	29 (WSW)	331/ 9.2
48	NOT NAMED	1929	SEP	28	2	113(100)	2 (NNE)	293/ 7.0
49	NOT NAMED	1932	AUG	30	3	55(55)	20 (NNE)	298/ 8.9
50	NOT NAMED	1933	SEP	1	11	90(88)	89 (SSW)	282/14.1
51	NOT NAMED	1933	OCT	5	18	117(108)	41 (SSE)	060/15.8
52	NOT NAMED	1934	MAY	27	1	40(40)	45 (WNW)	027/12.1
53	NOT NAMED	1935	SEP	3	2	150(133)	8 (SSW)	304/ 5.4
54	NOT NAMED	1935	SEP	28	4	100(100)	63 (ESE)	024/13.2
55	NOT NAMED	1935	NOV	5	6	85(75)	13 (NNW)	243/11.1
56	NOT NAMED	1936	JUN	15	1	40(38)	38 (N)	096/19.9
57	NOT NAMED	1936	JUL	29	5	55(51)	7 (NNE)	288/ 7.8
58	NOT NAMED	1941	OCT	6	5	105(105)	28 (NNE)	297/17.1
59	NOT NAMED	1941	OCT	17	6	40(40)	83 (SSW)	284/ 8.5
60	NOT NAMED	1944	OCT	19	11	107(105)	96 (W)	009/14.2

NOTES:

Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 25.14N 80.93W.

CHART 1A (Page 1)

Table II-8c: Flamingo (continued)

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF FLAMINGO 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
61	NOT NAMED	1945	SEP	4	7	35(35)	62 (W)	359/10.0
62	NOT NAMED	1945	SEP	15	9	115(115)	36 (NE)	314/12.1
63	NOT NAMED	1946	SEP	12	4	56(53)	93 (ESE)	019/11.6
64	NOT NAMED	1946	NOV	1	6	40(40)	92 (NE)	318/13.4
65	NOT NAMED	1947	AUG	18	3	40(35)	64 (S)	274/13.7
66	NOT NAMED	1947	SEP	18	4	135(120)	59 (NNW)	257/ 6.4
67	NOT NAMED	1947	OCT	12	8	75(72)	16 (NW)	046/10.1
68	NOT NAMED	1948	SEP	21	7	100(100)	27 (WNW)	023/ 6.7
69	NOT NAMED	1948	OCT	5	8	108(96)	11 (SE)	042/17.6
70	EASY	1950	SEP	3	5	85(74)	81 (WSW)	342/12.5
71	KING	1950	OCT	18	11	110(108)	52 (ENE)	338/11.9
72	NOT NAMED	1952	FEB	3	1	45(42)	19 (NW)	041/29.7
73	FOX	1952	OCT	25	7	85(85)	96 (SE)	044/ 8.3
74	NOT NAMED	1953	AUG	29	3	45(35)	52 (N)	088/12.7
75	NOT NAMED	1953	OCT	4	10	35(35)	58 (ESE)	020/10.7
76	DONNA	1960	SEP	10	5	115(115)	9 (SW)	318/ 8.1
77	CLEO	1964	AUG	27	5	90(90)	60 (ENE)	342/ 8.9
78	ISBELL	1964	OCT	14	11	105(100)	41 (NW)	044/18.1
79	BETSY	1965	SEP	8	3	110(109)	1 (SSW)	278/13.7
80	ALMA	1966	JUN	8	1	110(106)	84 (W)	353/15.2
81	INEZ	1966	OCT	4	9	80(75)	17 (SSE)	248/ 7.9
82	JENNY	1969	OCT	2	13	40(38)	66 (W)	010/12.1
83	GRETA	1970	SEP	27	8	45(33)	48 (SSW)	282/14.0
84	SUBTROP	1974	OCT	6	11	42(41)	97 (ENE)	333/10.9
85	DOTTIE	1976	AUG	19	5	35(35)	20 (NW)	048/21.8
86	DAVID	1979	SEP	3	4	84(82)	93 (ENE)	337/11.0
87	DENNIS	1981	AUG	17	4	35(35)	15 (W)	012/ 3.1
88	ISIDORE	1984	SEP	27	10	50(50)	96 (NE)	317/ 8.8
89	BOB	1985	JUL	23	2	40(40)	76 (N)	077/10.7
90	FLOYD	1987	OCT	12	7	65(63)	12 (SSE)	068/15.7
91	MARCO	1990	OCT	10	13	49(43)	84 (W)	354/ 6.1
92	FABIAN	1991	OCT	16	6	40(40)	48 (SE)	035/15.9
93	ANDREW	1992	AUG	24	2	145(125)	25 (N)	278/17.3
94	GORDON	1994	NOV	15	7	45(45)	53 (SW)	311/ 7.8
95	JERRY	1995	AUG	23	10	34(32)	91 (ENE)	343/13.0
96	GEORGES	1998	SEP	25	7	90(90)	72 (SW)	308/12.4
97	MITCH	1998	NOV	5	13	55(53)	85 (NNW)	057/19.0
98	HARVEY	1999	SEP	21	8	50(48)	50 (N)	076/27.6
99	IRENE	1999	OCT	15	9	65(65)	16 (WNW)	033/11.8
100	CHARLEY	2004	AUG	13	3	125(120)	95 (WNW)	021/17.7
101	KATRINA	2005	AUG	26	11	86(66)	23 (NNW)	242/10.3
102	RITA	2005	SEP	20	17	90(80)	80 (S)	280/12.1
103	WILMA	2005	OCT	24	22	110(105)	55 (NNW)	057/22.4
104	ERNESTO	2006	AUG	30	6	40(40)	11 (ENE)	329/ 7.0

NOTES:
Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 25.14N 80.93W.

CHART 1A (Page 2)

Table II-8d: Miami Beach

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF MIAMI BEACH 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	NOT NAMED	1870	OCT	11	6	90(90)	37 (SE)	038/ 4.1
2	NOT NAMED	1870	OCT	21	9	80(70)	76 (NW)	045/16.7
3	NOT NAMED	1871	AUG	16	3	100(100)	67 (NNE)	295/ 2.9
4	NOT NAMED	1871	AUG	24	4	90(90)	76 (NE)	313/10.7
5	NOT NAMED	1873	JUN	1	1	40(40)	83 (E)	006/13.6
6	NOT NAMED	1876	SEP	16	2	62(60)	24 (ESE)	015/21.7
7	NOT NAMED	1876	OCT	20	5	90(88)	63 (WNW)	024/16.7
8	NOT NAMED	1878	JUL	2	1	40(32)	51 (NW)	054/15.9
9	NOT NAMED	1878	SEP	8	5	60(53)	56 (WSW)	346/ 8.2
10	NOT NAMED	1878	OCT	21	11	70(70)	13 (ESE)	029/18.4
11	NOT NAMED	1881	AUG	17	4	40(40)	55 (SE)	053/21.2
12	NOT NAMED	1885	AUG	24	2	73(70)	38 (ENE)	339/10.2
13	NOT NAMED	1886	AUG	23	6	85(83)	68 (E)	009/17.3
14	NOT NAMED	1888	AUG	16	3	110(110)	0 (NNE)	299/10.3
15	NOT NAMED	1888	SEP	7	5	45(45)	46 (NNE)	303/ 9.5
16	NOT NAMED	1888	SEP	23	6	40(37)	3 (ESE)	021/11.9
17	NOT NAMED	1889	OCT	6	9	40(40)	30 (WNW)	019/22.2
18	NOT NAMED	1891	AUG	24	3	78(70)	24 (SSW)	284/ 8.4
19	NOT NAMED	1891	OCT	7	7	45(40)	48 (WNW)	025/12.8
20	NOT NAMED	1892	JUN	11	1	40(35)	25 (NNW)	058/11.6
21	NOT NAMED	1893	AUG	26	6	105(105)	97 (NE)	320/12.1
22	NOT NAMED	1895	OCT	2	3	50(50)	54 (SSE)	065/ 7.0
23	NOT NAMED	1895	OCT	22	5	90(90)	72 (ESE)	027/15.8
24	NOT NAMED	1895	OCT	16	6	35(31)	31 (NW)	052/15.2
25	NOT NAMED	1896	OCT	9	5	45(40)	89 (NW)	055/13.7
26	NOT NAMED	1898	AUG	2	1	35(35)	73 (NNE)	291/17.1
27	NOT NAMED	1898	SEP	26	8	43(40)	24 (SSE)	059/10.8
28	NOT NAMED	1898	OCT	11	9	60(60)	41 (ESE)	021/17.1
29	NOT NAMED	1898	OCT	23	10	40(37)	73 (SSE)	058/15.0
30	NOT NAMED	1899	JUL	30	2	39(35)	56 (SW)	312/12.8
31	NOT NAMED	1899	AUG	13	3	105(105)	96 (ENE)	345/ 7.2
32	NOT NAMED	1899	OCT	30	8	82(75)	84 (ESE)	013/14.4
33	NOT NAMED	1901	AUG	10	4	40(40)	28 (NNE)	293/ 7.8
34	NOT NAMED	1903	SEP	11	3	75(75)	17 (NNE)	297/ 7.0
35	NOT NAMED	1904	OCT	20	3	70(31)	2 (SSE)	072/ 9.5
36	NOT NAMED	1906	JUN	17	2	75(75)	3 (NW)	045/15.4
37	NOT NAMED	1906	OCT	18	8	105(100)	5 (NW)	042/16.9
38	NOT NAMED	1909	JUN	28	3	45(44)	9 (NE)	322/ 8.8
39	NOT NAMED	1909	AUG	29	7	45(43)	39 (N)	277/ 8.1
40	NOT NAMED	1909	SEP	26	9	34(30)	62 (NW)	053/10.0
41	NOT NAMED	1909	OCT	11	10	100(95)	29 (SE)	056/23.0
42	NOT NAMED	1916	MAY	14	1	40(38)	56 (WSW)	346/11.3
43	NOT NAMED	1916	AUG	25	7	40(40)	16 (WSW)	340/ 8.9
44	NOT NAMED	1916	NOV	16	15	52(50)	14 (SSE)	064/31.3
45	NOT NAMED	1924	OCT	21	7	80(55)	24 (NNW)	072/ 8.6
46	NOT NAMED	1926	JUL	27	1	106(96)	57 (NE)	321/ 6.8
47	NOT NAMED	1926	SEP	18	6	120(115)	15 (SSW)	298/11.1
48	NOT NAMED	1926	SEP	16	7	35(35)	36 (SE)	231/10.7
49	NOT NAMED	1926	OCT	21	10	98(95)	25 (SE)	038/18.2
50	NOT NAMED	1928	AUG	7	1	85(85)	52 (NE)	326/ 6.2
51	NOT NAMED	1928	AUG	13	2	50(49)	87 (WSW)	329/ 9.2
52	NOT NAMED	1928	SEP	17	4	130(130)	47 (NNE)	304/10.8
53	NOT NAMED	1929	SEP	28	2	117(110)	50 (SSW)	290/ 5.8
54	NOT NAMED	1932	AUG	30	3	55(55)	35 (SSW)	296/ 9.1
55	NOT NAMED	1933	JUL	30	5	75(71)	92 (NNE)	284/ 4.6
56	NOT NAMED	1933	SEP	4	12	118(115)	56 (NNE)	299/16.4
57	NOT NAMED	1933	OCT	5	18	122(115)	53 (SSE)	058/17.1
58	NOT NAMED	1934	MAY	28	1	40(38)	66 (WNW)	027/15.7
59	NOT NAMED	1935	SEP	3	2	150(150)	65 (SSW)	302/ 6.5
60	NOT NAMED	1935	SEP	29	4	100(100)	42 (ESE)	031/ 9.8

NOTES:
Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 25.80N 80.12W.

CHART 1A (Page 1)

Table II-8d: Miami Beach (continued)

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF MIAMI BEACH 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
61	NOT NAMED	1935	NOV	4	6	85(83)	4 (NNW)	244/16.0
62	NOT NAMED	1936	JUN	15	1	40(35)	6 (S)	093/20.9
63	NOT NAMED	1936	JUL	29	5	55(50)	43 (SSW)	286/ 7.5
64	NOT NAMED	1937	AUG	29	3	45(40)	92 (ENE)	340/ 5.7
65	NOT NAMED	1937	SEP	27	8	35(35)	79 (ESE)	019/15.6
66	NOT NAMED	1939	AUG	11	2	70(68)	77 (NNE)	299/10.2
67	NOT NAMED	1941	OCT	6	5	105(103)	25 (SSW)	290/16.2
68	NOT NAMED	1945	SEP	15	9	115(115)	23 (SW)	314/12.1
69	NOT NAMED	1946	SEP	12	4	63(58)	67 (ESE)	026/ 7.9
70	NOT NAMED	1946	NOV	1	6	40(40)	33 (NE)	318/13.4
71	NOT NAMED	1947	SEP	17	4	140(133)	33 (NNW)	255/ 8.3
72	NOT NAMED	1947	OCT	12	8	75(75)	19 (NW)	039/10.9
73	NOT NAMED	1948	SEP	22	7	100(85)	39 (NW)	037/ 7.5
74	NOT NAMED	1948	OCT	6	8	100(90)	5 (SE)	044/17.2
75	NOT NAMED	1949	AUG	26	2	120(118)	49 (NE)	305/12.1
76	KING	1950	OCT	18	11	110(110)	4 (WSW)	337/12.5
77	HOW	1951	OCT	2	8	59(58)	88 (NNW)	057/15.9
78	NOT NAMED	1952	FEB	3	1	45(45)	27 (NW)	040/29.4
79	FOX	1952	OCT	25	7	85(85)	98 (SSE)	056/ 8.9
80	NOT NAMED	1953	AUG	29	3	45(35)	15 (N)	085/12.6
81	NOT NAMED	1953	OCT	5	10	36(35)	33 (ESE)	026/13.6
82	JUDITH	1959	OCT	18	11	43(40)	73 (N)	083/23.4
83	DONNA	1960	SEP	10	5	115(112)	68 (SW)	319/ 8.1
84	CLEO	1964	AUG	27	5	90(90)	6 (ENE)	342/ 8.5
85	ISBELL	1964	OCT	15	11	100(85)	44 (NW)	045/19.1
86	BETSY	1965	SEP	8	3	110(110)	44 (S)	270/10.9
87	INEZ	1966	OCT	4	9	76(75)	36 (SSE)	248/ 7.8
88	JENNY	1969	OCT	3	13	40(34)	97 (WNW)	027/11.4
89	GRETA	1970	SEP	27	8	43(38)	96 (SSW)	282/14.0
90	SUBTROP	1974	OCT	6	11	45(42)	39 (ENE)	334/11.0
91	DOTTIE	1976	AUG	19	5	38(35)	24 (NW)	038/21.8
92	DAVID	1979	SEP	3	4	85(83)	38 (ENE)	341/11.2
93	DENNIS	1981	AUG	17	4	35(35)	58 (W)	360/ 5.0
94	ISIDORE	1984	SEP	27	10	50(50)	37 (NE)	317/ 8.8
95	BOB	1985	JUL	23	2	42(40)	55 (NW)	054/11.7
96	FLOYD	1987	OCT	13	7	65(60)	32 (SSE)	067/15.9
97	FABIAN	1991	OCT	16	6	40(40)	36 (SE)	040/17.6
98	ANDREW	1992	AUG	24	2	145(145)	20 (S)	278/17.3
99	ERIN	1995	AUG	2	5	75(75)	88 (NNE)	303/14.8
100	JERRY	1995	AUG	23	10	35(33)	37 (ENE)	338/12.8
101	MITCH	1998	NOV	5	13	55(53)	68 (NNW)	076/28.5
102	HARVEY	1999	SEP	21	8	50(47)	25 (NNW)	070/27.9
103	IRENE	1999	OCT	16	9	65(65)	32 (WNW)	031/10.7
104	FRANCES	2004	SEP	5	6	95(93)	79 (NNE)	283/ 7.4
105	JEANNE	2004	SEP	26	10	105(105)	84 (N)	281/10.9
106	KATRINA	2005	AUG	25	11	72(68)	10 (NNW)	241/ 7.0
107	TAMMY	2005	OCT	5	20	35(35)	93 (NNE)	338/11.0
108	WILMA	2005	OCT	24	22	110(101)	49 (NW)	049/26.6
109	ERNESTO	2006	AUG	30	6	40(38)	46 (WSW)	343/ 8.3

NOTES:

Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 25.80N 80.12W.

CHART 1A (Page 2)

Table II-8e: Fort Lauderdale

TROP STORMS AND HURRICANES PASSING WITHIN 100 NMi of FT. LAUDERDALE 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
1	NOT NAMED	1870	OCT	11	6	90(90)	50 (SE)	048/ 4.7
2	NOT NAMED	1870	OCT	21	9	80(68)	62 (NW)	045/17.4
3	NOT NAMED	1871	AUG	16	3	100(100)	49 (NNE)	296/ 2.9
4	NOT NAMED	1871	AUG	24	4	90(90)	61 (NE)	311/10.7
5	NOT NAMED	1873	JUN	1	1	40(40)	83 (E)	004/13.0
6	NOT NAMED	1873	OCT	7	5	96(92)	92 (NW)	046/27.3
7	NOT NAMED	1876	SEP	16	2	63(60)	28 (ESE)	016/21.7
8	NOT NAMED	1876	OCT	20	5	90(87)	56 (WNW)	024/16.7
9	NOT NAMED	1878	JUL	2	1	40(33)	37 (NW)	049/16.1
10	NOT NAMED	1878	SEP	8	5	60(50)	62 (WSW)	345/ 7.9
11	NOT NAMED	1878	OCT	22	11	72(70)	20 (ESE)	018/14.7
12	NOT NAMED	1881	AUG	17	4	42(40)	70 (SE)	051/21.3
13	NOT NAMED	1885	AUG	24	2	75(70)	29 (ENE)	338/ 9.7
14	NOT NAMED	1886	AUG	23	6	85(83)	71 (ESE)	012/17.3
15	NOT NAMED	1888	AUG	16	3	110(110)	17 (SSW)	300/10.3
16	NOT NAMED	1888	SEP	7	5	45(45)	29 (NNE)	303/ 9.5
17	NOT NAMED	1888	SEP	23	6	40(38)	9 (ESE)	021/11.9
18	NOT NAMED	1889	OCT	6	9	41(40)	25 (WNW)	020/22.2
19	NOT NAMED	1891	AUG	24	3	76(70)	43 (SSW)	284/ 8.4
20	NOT NAMED	1891	OCT	7	7	44(40)	41 (WNW)	027/12.8
21	NOT NAMED	1892	JUN	11	1	40(35)	8 (NNW)	058/11.6
22	NOT NAMED	1893	AUG	27	6	105(105)	83 (NE)	320/12.5
23	NOT NAMED	1895	OCT	2	3	50(50)	71 (SSE)	066/ 7.0
24	NOT NAMED	1895	OCT	22	5	90(90)	80 (ESE)	027/15.8
25	NOT NAMED	1895	OCT	16	6	35(30)	16 (NW)	052/16.9
26	NOT NAMED	1896	OCT	9	5	48(39)	74 (NW)	054/12.6
27	NOT NAMED	1898	AUG	2	1	35(35)	54 (NNE)	291/17.1
28	NOT NAMED	1898	SEP	26	8	44(40)	40 (SSE)	055/10.9
29	NOT NAMED	1898	OCT	11	9	60(60)	47 (ESE)	023/16.9
30	NOT NAMED	1898	OCT	23	10	38(36)	89 (SSE)	058/15.0
31	NOT NAMED	1899	JUL	30	2	38(35)	72 (SW)	311/10.7
32	NOT NAMED	1899	AUG	13	3	105(105)	90 (ENE)	348/ 8.2
33	NOT NAMED	1899	OCT	30	8	83(78)	87 (ESE)	013/12.3
34	NOT NAMED	1901	AUG	10	4	40(40)	9 (NNE)	293/ 7.8
35	NOT NAMED	1903	SEP	11	3	75(75)	1 (SSW)	298/ 7.0
36	NOT NAMED	1904	OCT	20	3	70(30)	21 (SSE)	071/ 9.5
37	NOT NAMED	1906	JUN	17	2	76(75)	11 (SE)	050/15.4
38	NOT NAMED	1906	OCT	18	8	105(100)	7 (SE)	042/16.9
39	NOT NAMED	1909	JUN	28	3	45(43)	4 (SW)	322/ 8.8
40	NOT NAMED	1909	AUG	29	7	45(43)	19 (N)	277/ 8.1
41	NOT NAMED	1909	SEP	26	9	35(30)	47 (NW)	053/10.0
42	NOT NAMED	1909	OCT	11	10	100(93)	45 (SE)	055/23.0
43	NOT NAMED	1916	MAY	14	1	40(38)	62 (WSW)	346/11.3
44	NOT NAMED	1916	AUG	25	7	40(40)	23 (WSW)	345/ 9.0
45	NOT NAMED	1916	NOV	16	15	52(49)	32 (SSE)	063/32.5
46	NOT NAMED	1924	OCT	21	7	80(55)	6 (NNW)	072/ 8.6
47	NOT NAMED	1926	JUL	27	1	105(94)	43 (NE)	321/ 7.5
48	NOT NAMED	1926	SEP	18	6	120(115)	33 (SSW)	298/11.1
49	NOT NAMED	1926	SEP	16	7	35(35)	50 (SE)	228/10.8
50	NOT NAMED	1926	OCT	21	10	98(96)	37 (SE)	041/20.6
51	NOT NAMED	1928	AUG	7	1	85(85)	39 (NE)	319/ 5.4
52	NOT NAMED	1928	AUG	13	2	50(50)	99 (WSW)	327/ 9.4
53	NOT NAMED	1928	SEP	17	4	130(130)	30 (NNE)	304/10.8
54	NOT NAMED	1929	SEP	28	2	113(110)	69 (SSW)	290/ 5.8
55	NOT NAMED	1932	AUG	30	3	55(55)	54 (SSW)	296/ 9.1
56	NOT NAMED	1933	JUL	30	5	75(70)	72 (NNE)	286/ 3.7
57	NOT NAMED	1933	SEP	4	12	118(115)	38 (NNE)	299/16.4
58	NOT NAMED	1933	OCT	5	18	122(115)	70 (SSE)	058/17.1
59	NOT NAMED	1934	MAY	28	1	40(37)	57 (WNW)	027/15.7
60	NOT NAMED	1935	SEP	3	2	150(138)	83 (SSW)	303/ 5.4

NOTES:
Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 26.13N 80.10W.

CHART 1A (Page 1)

Table II-8e: Fort Lauderdale (continued)

TROP STORMS AND HURRICANES PASSING WITHIN 100 NMi of FT. LAUDERDALE 1870-2007

1 STORM INDEX NUMBER	2 STORM NAME	3 YEAR	4 MONTH	5 DAY	6 STORM NUMBER FOR YEAR	7 MAX WIND AT STORM CENTER (SEE NOTES)	8 CPA (CLOSEST POINT OF APPROACH)	9 DDD/SS.S DDD=HEADING SS.S=FORWARD SPEED AT CPA
61	NOT NAMED	1935	SEP	29	4	100(100)	52 (ESE)	033/ 9.7
62	NOT NAMED	1935	NOV	4	6	85(83)	13 (SSE)	244/16.0
63	NOT NAMED	1936	JUN	15	1	40(35)	26 (S)	093/20.9
64	NOT NAMED	1936	JUL	29	5	55(50)	63 (SSW)	286/ 7.5
65	NOT NAMED	1937	AUG	29	3	46(43)	84 (ENE)	340/ 6.5
66	NOT NAMED	1937	SEP	27	8	35(35)	84 (ESE)	019/15.6
67	NOT NAMED	1938	OCT	20	6	38(37)	94 (ENE)	330/14.0
68	NOT NAMED	1939	AUG	11	2	70(68)	59 (NNE)	299/10.2
69	NOT NAMED	1941	OCT	6	5	105(104)	44 (SSW)	293/16.2
70	NOT NAMED	1945	SEP	16	9	115(110)	37 (SW)	317/12.6
71	NOT NAMED	1946	SEP	12	4	63(59)	76 (ESE)	034/ 7.8
72	NOT NAMED	1946	NOV	1	6	40(40)	19 (NE)	318/13.4
73	NOT NAMED	1947	SEP	17	4	140(135)	14 (NNW)	255/ 8.3
74	NOT NAMED	1947	OCT	12	8	75(75)	8 (NW)	039/10.8
75	NOT NAMED	1948	SEP	22	7	100(82)	28 (NW)	037/ 7.5
76	NOT NAMED	1948	OCT	6	8	98(89)	18 (SE)	049/16.9
77	NOT NAMED	1949	AUG	26	2	120(117)	32 (NE)	305/12.1
78	KING	1950	OCT	18	11	110(104)	13 (WSW)	337/13.2
79	HOW	1951	OCT	2	8	60(58)	72 (NW)	057/15.9
80	NOT NAMED	1952	FEB	3	1	45(45)	15 (NW)	040/29.4
81	NOT NAMED	1953	AUG	29	3	45(35)	5 (S)	080/12.6
82	NOT NAMED	1953	OCT	5	10	37(35)	41 (ESE)	028/13.6
83	HAZEL	1953	OCT	9	12	57(55)	96 (NW)	054/22.0
84	JUDITH	1959	OCT	18	11	44(40)	54 (N)	083/23.4
85	DONNA	1960	SEP	10	5	115(105)	81 (WSW)	336/ 9.7
86	CLEO	1964	AUG	27	5	90(90)	2 (WSW)	341/ 8.4
87	ISBELL	1964	OCT	15	11	100(85)	30 (NW)	045/19.1
88	BETSY	1965	SEP	8	3	110(110)	64 (S)	270/10.9
89	INEZ	1966	OCT	4	9	75(75)	54 (SSE)	248/ 7.2
90	JENNY	1969	OCT	3	13	40(33)	88 (WNW)	030/11.3
91	SUBTROP	1974	OCT	6	11	45(43)	30 (ENE)	336/11.0
92	DOTTIE	1976	AUG	19	5	38(35)	14 (NW)	032/21.9
93	DAVID	1979	SEP	3	4	85(85)	28 (ENE)	332/10.7
94	DENNIS	1981	AUG	17	4	35(35)	59 (W)	360/ 4.0
95	ISIDORE	1984	SEP	27	10	50(50)	23 (NE)	319/ 9.8
96	BOB	1985	JUL	23	2	45(40)	41 (NW)	043/11.9
97	FLOYD	1987	OCT	13	7	63(58)	50 (SSE)	067/16.1
98	CHRIS	1988	AUG	27	3	37(30)	37 (ENE)	331/11.9
99	FABIAN	1991	OCT	16	6	40(40)	48 (SE)	043/17.5
100	ANDREW	1992	AUG	24	2	145(145)	40 (S)	278/17.3
101	GORDON	1994	NOV	16	7	52(47)	89 (NW)	053/15.4
102	ERIN	1995	AUG	2	5	75(75)	71 (NNE)	305/14.9
103	JERRY	1995	AUG	23	10	35(35)	27 (ENE)	329/10.1
104	MITCH	1998	NOV	5	13	55(53)	49 (NNW)	076/28.5
105	HARVEY	1999	SEP	21	8	50(45)	7 (NNW)	067/28.1
106	IRENE	1999	OCT	16	9	65(65)	23 (WNW)	029/ 9.6
107	FRANCES	2004	SEP	5	6	95(93)	60 (NNE)	283/ 7.4
108	JEANNE	2004	SEP	26	10	105(105)	64 (N)	281/10.9
109	KATRINA	2005	AUG	25	11	70(67)	7 (SSE)	242/ 7.0
110	TAMMY	2005	OCT	5	20	37(35)	73 (NNE)	338/11.0
111	WILMA	2005	OCT	24	22	110(101)	35 (NW)	049/26.6
112	ERNESTO	2006	AUG	30	6	40(35)	48 (W)	001/ 8.7

NOTES:
Datetimes are UTC, winds are in knots and distances are in nautical miles (nmi). Directions in column 8 refer to bearing of storm from site at the closest point of approach (CPA). Two winds are listed in column 7. First is the maximum wind anywhere within the 100 nmi scan radius. Second (in parenthesis) is the maximum wind at CPA. If this is <34 kts, it is treated as a weak tropical storm (34kts) in tables and charts. Site location (degs and degs/100) is 26.13N 80.10W.

CHART 1A (Page 2)

Table II-9a
Summary for Hurricanes and Tropical Storms, 1870-2007

	Key West	Islamorada	Flamingo	Miami Beach	Fort Lauderdale
Number of Years	138	138	138	138	138
Number of Hurricanes and Tropical Storms	103	101	104	109	112
Mean Number of Occurrences per Year	0.75	0.74	0.75	0.79	0.81
Mean Recurrence Interval (years)	1.34	1.37	1.33	1.27	1.23

Table II-9b
Summary for Hurricanes, 1870-2007

	Key West	Islamorada	Flamingo	Miami Beach	Fort Lauderdale
Number of Years	138	138	138	138	138
Number of Hurricanes	38	38	40	45	45
Mean Number of Occurrences per Year	0.28	0.28	0.29	0.33	0.33
Mean Recurrence Interval (years)	3.63	3.63	3.45	3.07	3.07

Figure II-15a
Hurricane Return Intervals for the South Florida Region - Key West

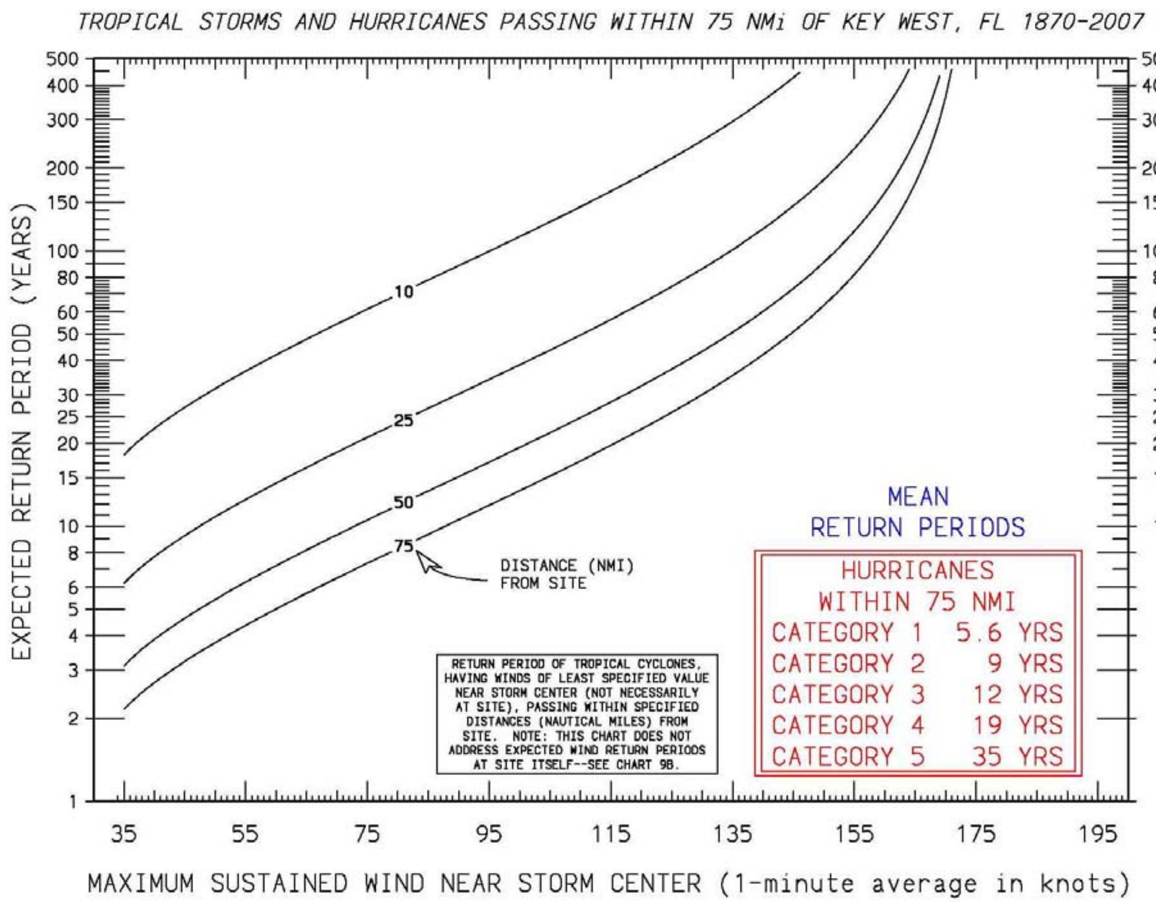


Figure II-15b
Hurricane Return Intervals for the South Florida Region - Islamorada

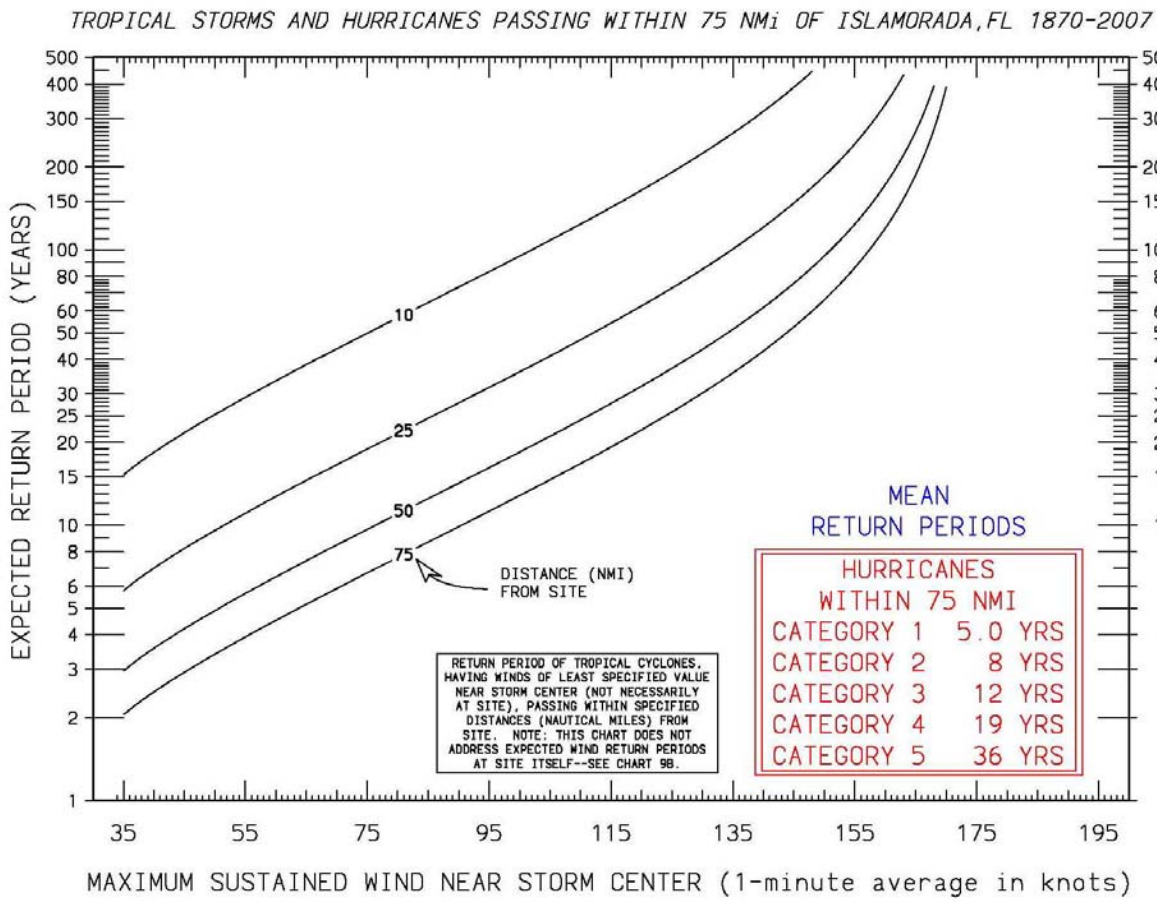


Figure II-15c
Hurricane Return Intervals for the South Florida Region - Flamingo

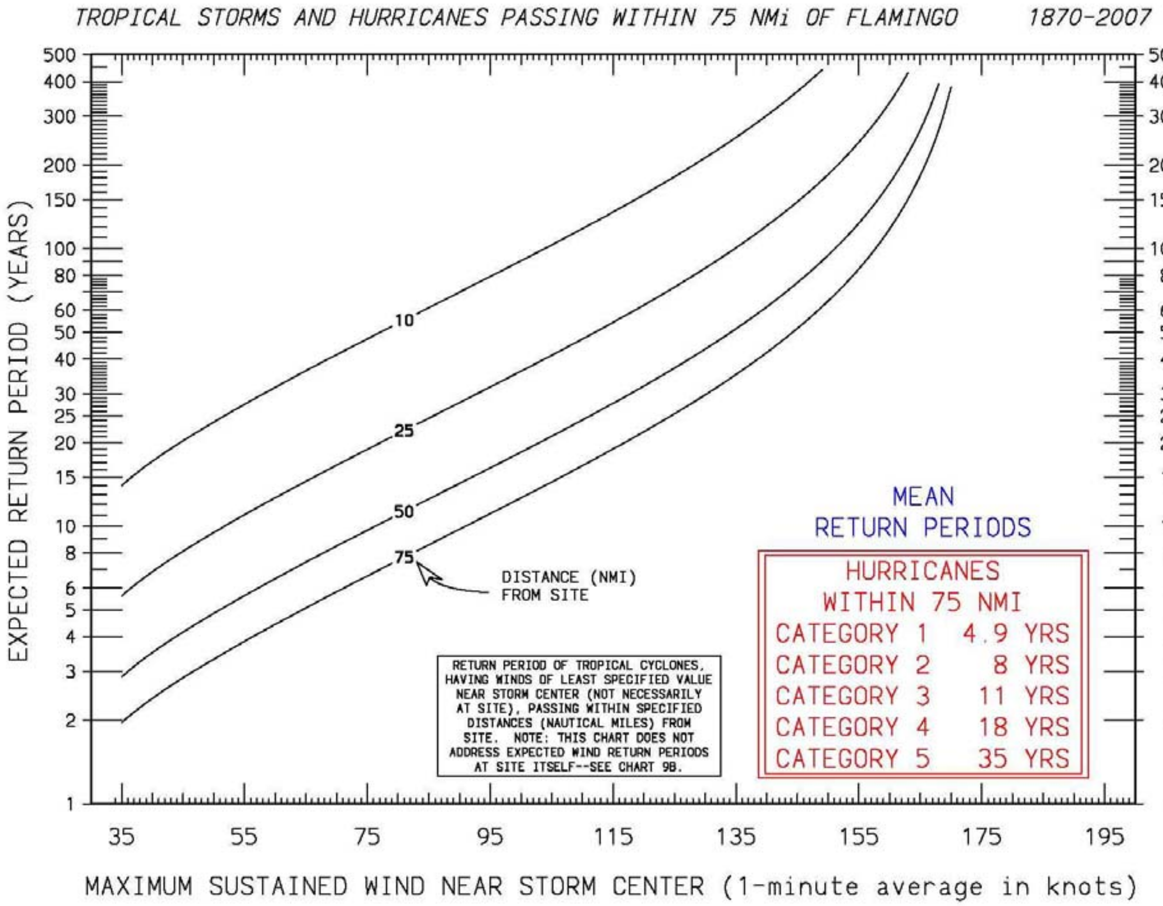


Figure II-15d
Hurricane Return Intervals for the South Florida Region – Miami Beach

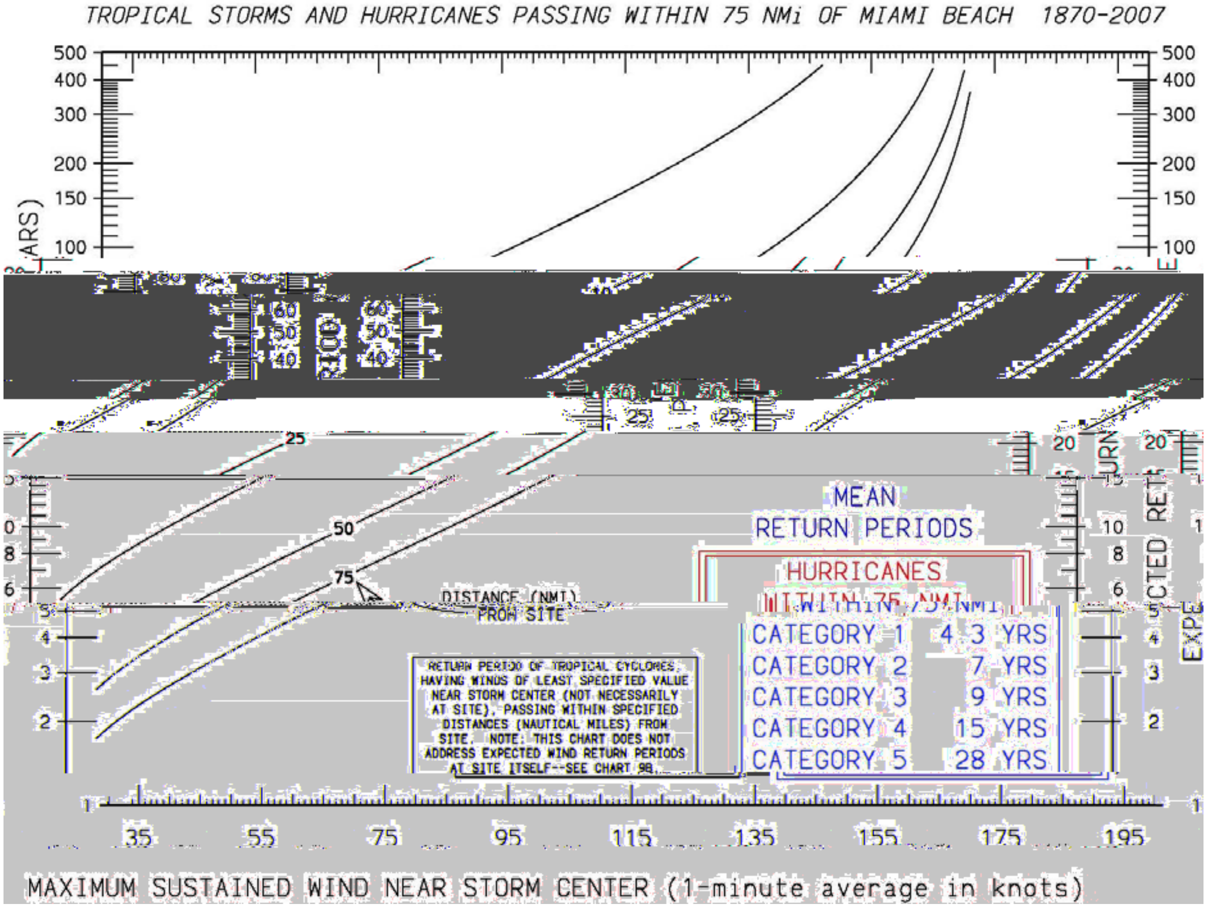
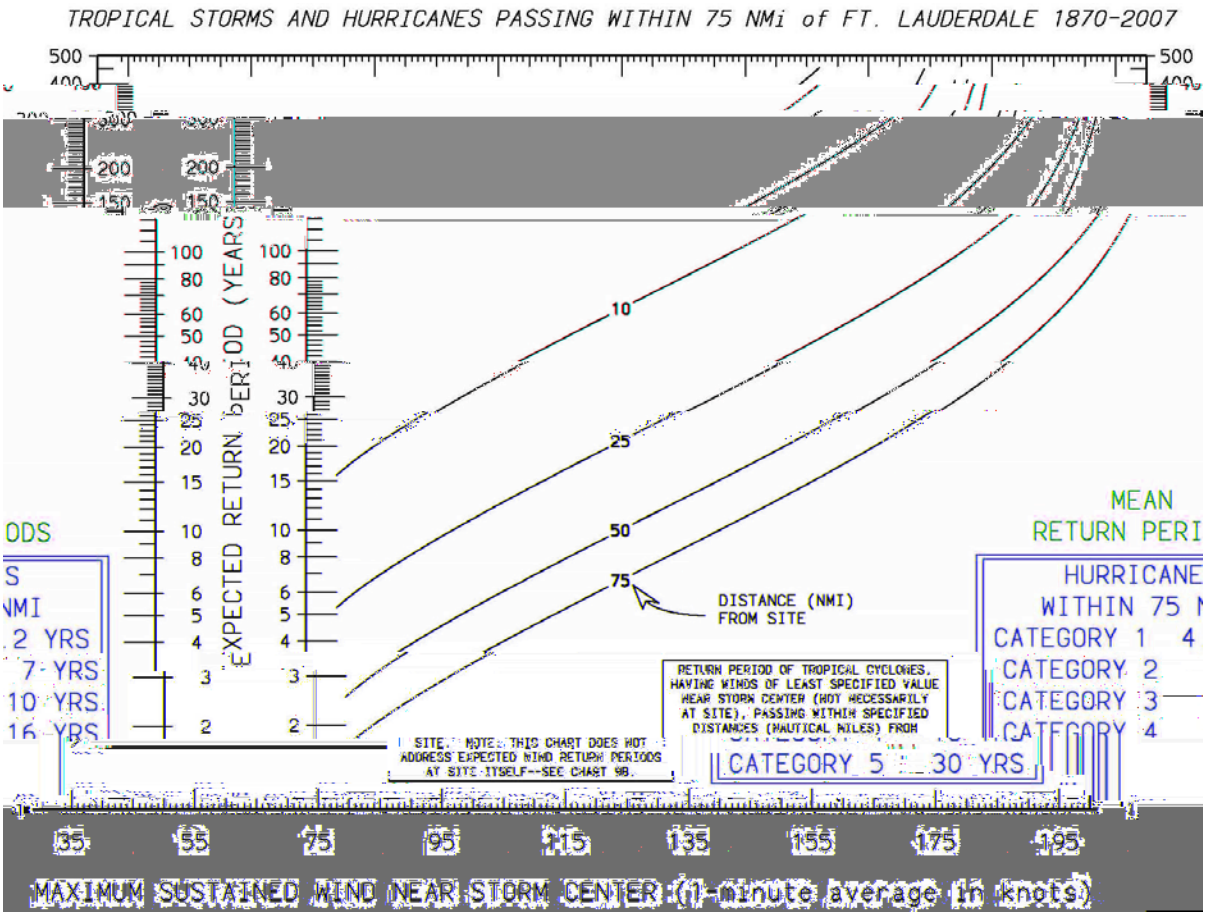


Figure II-15e
Hurricane Return Intervals for the South Florida Region – Miami Beach



C. Freshwater Flooding: The 100-Year Flood Plain

1. Inland / Riverine Flooding Profile

Flooding refers to the *general or temporary conditions of partial or complete inundation of normally dry land areas by surface water runoff from any source* (*Statewide Hazard Mitigation Plan*, 2009). The State of Florida and the South Florida Region are affected by a large number of weather systems that result in flooding.

Flooding can be divided into two major categories: Coastal and Riverine. As indicated previously, interrelated hazards, such as hurricanes and severe storms, can result in both types of flooding, sometimes in difference locations. Many areas of Florida are susceptible to flooding from both storm surge and watershed runoff.

Coastal flooding is usually the result of a severe weather system such as a tropical cyclone, hurricane, tropical storm or "northeaster," which contains the element of wind. The damaging effects of coastal floods are caused by a combination of higher water levels of the storm surge, the winds, rains, erosion and battering by debris. Loss of life and property damage are often more severe since it involves velocity wave action and accompanying winds.

Riverine flooding is associated with a river's watershed, which is the natural drainage basin that conveys water runoff from rain. Riverine flooding occurs when the flow of runoff is greater than the carrying capacities of the natural drainage systems. Rainwater that is not absorbed by soil or vegetation seeks surface drainage lines following natural topography lines. These lines merge to form a hierarchical system of rills, creeks, streams and rivers. Generally, floods can be slow or fast rising depending on the size of the river or stream. The rivers in north Florida drain portions of Alabama and Georgia, and excessive rainfall in those states often causes flood conditions in Florida.

Flash floods are much more dangerous and flow much faster than riverine floods. They can result from tropical storms, dam failures or excessive rain and snow. Flash floods pose more significant safety risks because of the rapid onset, the high water velocity, the potential for channel scour and the debris load.

The variations of flooding, including severe thunderstorms, hurricanes, seasonal rain and other weather related conditions, are a natural part of the earth's hydrologic system; however, when buildings and infrastructure are constructed within the natural drainage system, there are significant losses. Based on frequency, floods are the most destructive category of natural hazards in the United States. The loss of life, property, crops, business facilities, utilities and transportation are major impacts of flooding. Economic losses from impacts to major transportation routes and modes, public health and other environmental hazards are key factors in long-term recovery (*Statewide Hazard Mitigation Plan*, 2009).

2. Probability of Flooding: Flood Insurance Rate Maps (FIRMs)

The probability of freshwater flooding has been quantified by the Federal Emergency Management Agency (FEMA) through the National Flood Insurance Program. Areas subject to flooding, the Velocity Zone, 100-year flood plain and the 500-year floodplain, have been delineated on Flood Insurance Rate Maps (FIRMs) for every jurisdiction in the region. Moderate to low risk areas include zones B, C and X. High risk areas include zones A, AE, AH, AO, and AR. High risk coastal areas include the Velocity zones (Zones V, VE, V1-V30) and undetermined risk areas (Zone D).

Table II-10
Definitions of National Flood Insurance Program (NFIP) Zones

AE	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. In most instances base flood elevations (BFEs) derived from detailed analyses are shown at selected intervals within these zones.
X500	An area inundated by 500-year flooding; an area inundated by 100-year flooding with average depths of less than 1 foot or with drainage areas less than 1 square mile; or an area protected by levees from the 100-year flooding.
X	Areas outside the 1-percent annual chance floodplain, areas of 1% annual chance sheet flow flooding where average depths are less than 1 foot, areas of 1% annual chance stream flooding where the contributing drainage area is less than 1 square mile, or areas protected from the 1% annual chance flood by levees. No Base Flood Elevations or depths are shown within this zone. Insurance purchase is not required in these zones.
A	Flood zone area with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths of base flood elevations are shown within these zones.
ANI	An area that is located within a community or county that is not mapped on any published FIRM.
IN	An area designated as within a "Special Flood Hazard Area" (of SFHA) on a FIRM. This is an area inundated by 100-year flooding for which no BFEs or velocity may have been determined. No distinctions are made between the different flood hazard zones that may be included within the SFHA. These may include Zones A, AE, AO, AH, AR, A99, V, or VE.
VE	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.
UNDES	A body of open water, such as a pond, lake, ocean, etc., located within a community's jurisdictional limits, that has no defined flood hazard.
AO	River or stream flood hazard areas and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet.

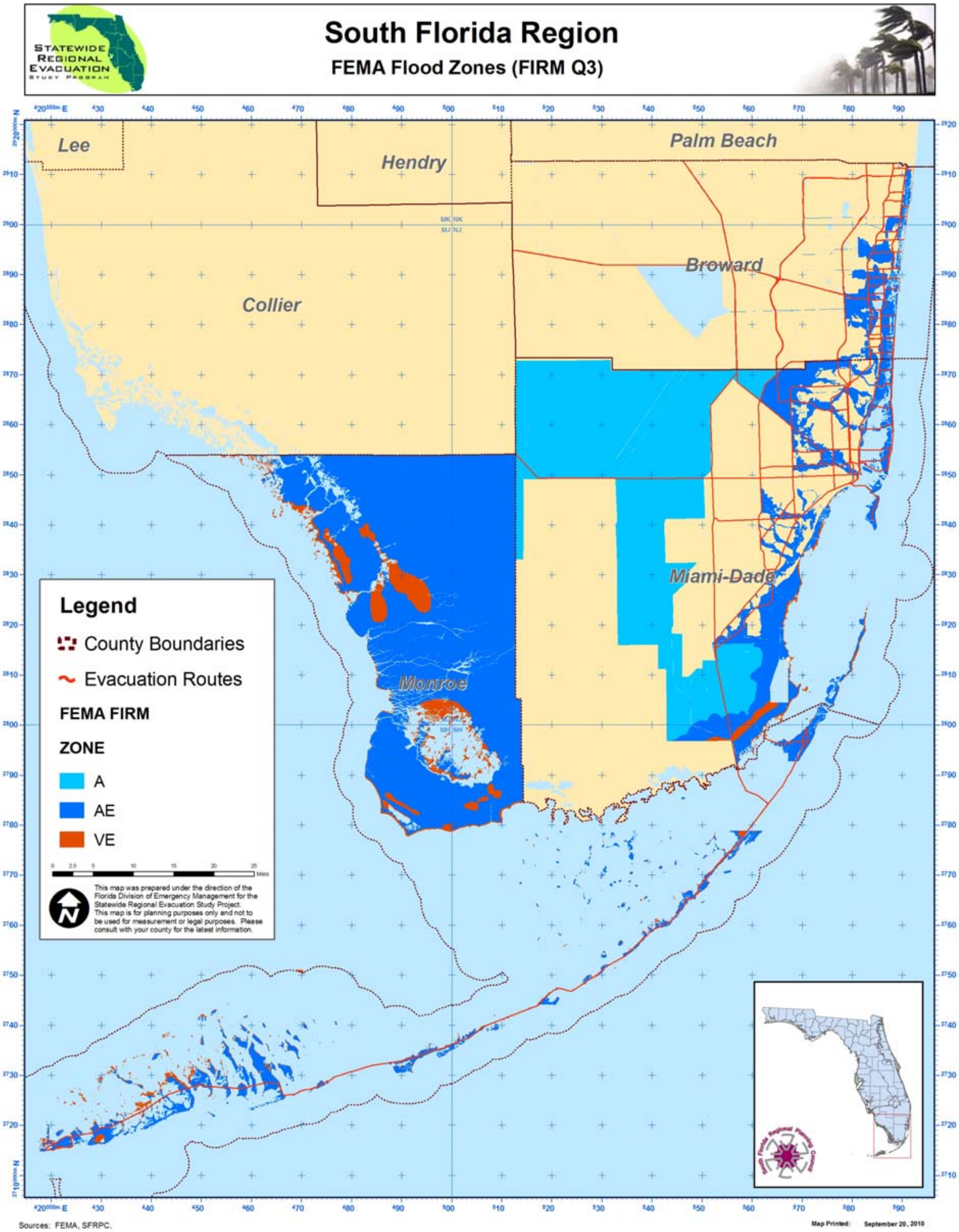
	These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.
D	Areas with possible but undetermined flood hazards. No flood hazard analysis has been conducted. Flood insurance rates are commensurate with the uncertainty of the flood risk.
AH	Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.
V	Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves. These areas have a 26% chance of flooding over the life of a 30-year mortgage. No base flood elevations are shown within these zones.
100IC	An area where the 100-year flooding is contained within the channel banks and the channel is too narrow to show to scale. An arbitrary channel width of 3 meters is shown. BFEs are not shown in this area, although they may be reflected on the corresponding profile.

The model used to determine the flood plain, like the Sea, Lake and Overland Surges from Hurricane (SLOSH) MEOWs or MOMs and the Inland Wind model, is a cumulative model. In other words, it is based on several storm events; no one storm will inundate all the areas within the flood zone. In addition, because there is a return interval (1% or greater chance of flooding in any given year) associated with the flood level, there is a basis for planning and cost-benefit analysis.

While the 6-12 inches of rain typically associated with a hurricane is not considered life-threatening, freshwater flooding along rivers and streams can and does cause significant property damage and has the potential of causing personal injury and deaths. Hurricane Floyd (September 1999) caused billions of dollars in property damage in North Carolina alone. Over the past two decades, freshwater flooding has become a leading cause of death in hurricane events with most of those deaths the result of driving or walking in flood waters.

In order to identify the potential magnitude of inland flooding, the 100-year flood plain was delineated using the Federal Emergency Management Agency's (FEMA) most recent digital files. County maps illustrating the 100-year flood plain are presented in the Maps section of Chapter IV Appendices. Within the flood zone, it is recognized that there are properties that have sustained repeated damage from flooding and are extremely susceptible to flood damage. These local neighborhoods should be warned prior to hurricane events that flooding is very probable.

Figure II-16


Statewide Regional Evacuation Study Program
South Florida Region
FEMA Flood Zones (FIRM Q3)
Lee
Hendry
Palm Beach
Collier
Broward
Miami-Dade
Monroe
Legend
County Boundaries
Evacuation Routes
FEMA FIRM
ZONE
A
AE
VE
0 2.5 5 10 15 20 25 Miles
N
This map was prepared under the direction of the Florida Division of Emergency Management for the Statewide Regional Evacuation Study Project.
This map is for planning purposes only and not to be used for measurement or legal purposes. Please consult with your county for the latest information.
Sources: FEMA, SFRPC.
Map Printed: September 20, 2010

The total acreage within the flood plain by county is presented below. It was calculated using the total acreage as determined by the Soil Conservation Service and the FEMA FIRM Maps as of 2009.

Table II-11
Flood Plain Acreage by County

Area	Total Acreage	Flood Plain Acreage	% in Flood Plain
Broward	775,946	43,081	5.55%
Miami-Dade	1,250,287	557,871	44.62%
Monroe	1,152,568	1,118,192	97.02%
South Florida Region	3,178,801	1,719,144	54.08%

Source: Soil Conservation Service (Total Acreage); FEMA (Digital Inventory of Flood Plain Acreage)

3. Dam Failure

A flood event may also trigger a dam failure. The dam impounds water in the reservoir, or upstream area. The amount of water impounded is measured in acre-feet.[8] *Dam failures are not routine but the results can be significant. Two factors influence the potential severity of a dam failure: (1) the amount of water impounded and (2) the density, type and value of the development downstream* (*Statewide Hazard Mitigation Plan*, 2009).

The "dam hazard" is a term indicating the potential hazard to the downstream area resulting from failure or mis-operation of the dam or facilities. According to the USGS National Inventory of Dams, there are 149 major dams in the State of Florida that have been identified by a hazard risk of low, significant and high.

- *Low hazard: A dam where failure or mis-operation results in no probable loss of human life and low economic and/or environmental loss. Losses are principally limited to the owner's property.*
- *Significant hazard: A dam where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities or impact other concerns. These dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.*
- *High hazard: A dam where failure or mis-operation will probably cause loss of human life* (*Statewide Hazard Mitigation Plan*, 2009).

[8] An acre-foot of water is the volume that covers an acre of land to the depth of one foot.

Table II-12
Dams in the South Florida Region

Dam Name	NIDID	Long.	Lat.	County	River	Hazard[9]	USNG
PUMPING STATION NO. 8	FL00343	-80.77	26.33	BROWARD	MIAMI CANAL (C-6)	L	17R NK 22953 12251
PUMPING STATION NO. 7	FL00345	-80.53	26.33	BROWARD	NORTH NEW RIVER CANAL	L	17R NK 46905 12315
STRUCTURE 11C	FL00347	-80.46	26.23	BROWARD	NONE	L	17R NK 53771 01224
STRUCTURE 11B	FL00348	-80.46	26.20	BROWARD	NONE	L	17R NJ 54422 97759
STRUCTURE 11A	FL00349	-80.45	26.18	BROWARD	NONE	L	17R NJ 54814 95364
STRUCTURE NO. 143 (CULVERT L-35B-1)	FL00350	-80.44	26.17	BROWARD	NORTH NEW RIVER CANAL	L	17R NJ 55963 94631
STRUCTURE NO. 34	FL00352	-80.44	26.15	BROWARD	NORTH NEW RIVER CANAL	L	17R NJ 55973 92416
STRUCTURE NO. 141 (SPILLWAY L-38E-1)	FL00353	-80.44	26.15	BROWARD	NORTH NEW RIVER CANAL	L	17R NJ 55973 92416
STRUCTURE 12A	FL00367	-80.82	25.76	MIAMI-DADE	SHARK RIVER SLOUGH	H	17R NJ 17938 49312
STRUCTURE 12B	FL00368	-80.77	25.76	MIAMI-DADE	SHARK RIVER SLOUGH	H	17R NJ 23114 49333
STRUCTURE 12C	FL00369	-80.73	25.76	MIAMI-DADE	SHARK RIVER SLOUGH	H	17R NJ 27384 49349
STRUCTURE 12D	FL00370	-80.68	25.76	MIAMI-DADE	SHARK RIVER SLOUGH	H	17R NJ 31909 49361
STRUCTURE NO. 31	FL00384	-80.45	25.96	MIAMI-DADE	MIAMI CANAL (C-6)	L	17R NJ 55062 71370
STRUCTURE 333	FL00681	-80.67	25.76	MIAMI-DADE	LEVEE 29 BORROW CANAL	L	17R NJ 33093 49147
STRUCTURE 336	FL00683	-80.49	25.76	MIAMI-DADE	TAMIAMI CANAL (C-4)	L	17R NJ 51143 49205
STRUCTURE 337	FL00693	-80.44	25.94	MIAMI-DADE	S-31 BYPASS CANAL	L	17R NJ 56072 69159

Source: US Army Corps of Engineers (2009)

4. History of Inland Flooding

Based on data collected by the National Climatic Data Center (NCDC), there were 993 flooding events in Florida between 1950 and 2009, for an average of 16.83 flooding events per year. Total property damages were estimated at $1.43 billion, with an additional $972 million in crop-related damages (www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms).

Below is a summary of the major flooding events in the South Florida Region from 1993-2008.

[9] Hazard Reference: H= High, S=Significant, L=Low

October 1999, Hurricane Irene: Widespread flooding from Hurricane Irene inundated most of the metropolitan areas of Miami-Dade, Broward and Palm Beach Counties. This flood was responsible for property damage of $205 million, as well as $290 million of crop damage.

October 2000: On October 2 and 3, 2000, a broad area of low pressure in the Gulf of Mexico off the southwest Florida coast moved northeast across central Florida and eventually became subtropical depression number one, then tropical storm Leslie, off of the northeast Florida coast. Some flood waters lingered for up to a week. Flood damage was particularly severe in the communities of Sweetwater, West Miami, Hialeah, Opa Locka and Pembroke Park. An estimated 93,000 houses with about 214,000 persons were isolated by floodwaters. Power was cut to 13,000 people. There were three indirect deaths, including two males who drove vehicles into canals and one man who fell from a roof while repairing a leak. Total property damage and crop damage estimates were $450 million and $500 million, respectively.

5. Structural Inventories, Economic Vulnerability and Repetitive Loss

The location of repetitive loss structures[10] helps to identify specific areas in the community where flooding continues to be a problem and where mitigation efforts should be concentrated. For many of these flood-prone areas, mitigation will involve significant property owner investment and will probably be delayed until redevelopment or reconstruction occurs. New construction or significant remodeling will require adherence to current floodplain management regulations. In regard to evacuation planning, these areas are important to consider, as they represent the most vulnerable areas subject to flooding from significant rainfall and minor tropical storm activity. In addition, these areas may not be coastal or reside in hurricane evacuation areas. Therefore, the residents in these areas may constitute additional evacuation impacts.

The repetitive loss properties and repetitive loss areas are addressed in the Local Mitigation Plans (LMSs). A breakdown of the properties by structure type is provided in Table II-13 below.

[10] A "repetitive-loss property" is one that has suffered two or more flood losses over 10 years with the cumulative cost of repairs equaling or exceeding 50 percent of the value of the structure. Increased Cost of Compliance for repetitive-loss structures is available only in communities that have repetitive-loss provisions in their floodplain-management ordinances and track repetitive-loss damages.

Table II-13
Repetitive Loss Properties

Community Name	Repetitive Loss Structures	SF	2-4 Family	Other Res	Condo Assoc.	Non-Res.
Broward County	0	0	0	0	0	0
Fort Lauderdale	209	142	13	14	2	38
Hallandale	397	248	49	39	6	55
Hollywood	459	395	16	14	4	30
Lauderhill	61	61	0	0	0	0
Oakland Park	116	81	0	7	0	28
Pembroke Park	36	0	0	4	0	32
Pembroke Pines	25	25	0	0	0	0
Weston	4	0	0	4	0	0
Wilton Manners	14	14	0	0	0	0
Davie	49	41	0	0	2	6
Deerfield	9	9	0	0	0	0
Hillsboro	2	0	0	0	0	2
Southwest Ranches	2	0	0	2	0	0
Cooper City	8	8	0	0	0	0
Coconut Creek	2	2	0	0	0	0
Coral Springs	22	22	0	0	0	0
Lauderdale By The Sea	3	3	0	0	0	0
Lauderdale Lakes	41	41	0	0	0	0
Lazy Lake	2	2	0	0	0	0
Lighthouse Point	4	4	0	0	0	0
Margate	22	22	0	0	0	0
Miramar	77	77	0	0	0	0
North Lauderdale	17	17	0	0	0	0
Parkland	2	2	0	0	0	0
Plantation	24	24	0	0	0	0
Pompano Beach	25	17	0	0	0	8
Sunrise	18	18	0	0	0	0
Tamarac	22	22	0	0	0	0
West Park	62	62	0	0	0	0
Dania	77	61	5	4	0	7
Miami-Dade County	5,649	0	5,649	0	0	0
Aventura	6	0	0	3	0	3
Biscayne	7	7	0	0	0	0
Coral Gables	4	4	0	0	0	0
Cutler Bay	57	57	0	0	0	0
Doral	122	18	0	35	11	58
El Portal	8	8	0	0	0	0
Hialeah Gardens	3	0	0	0	0	3
Hialeah	4	2	0	0	0	2
Key Biscayne	2	2	0	0	0	0
Medley	6	0	0	0	2	4
Metropolitan Dade County	12	2	0	0	3	7

Community Name	Repetitive Loss Structures	SF	2-4 Family	Other Res	Condo Assoc.	Non-Res.
Miami Beach	17	3	2	8	2	2
Miami Gardens	23	21	0	0	0	2
Miami Lakes	8	4	0	0	0	4
Miami Springs	19	15	0	0	0	4
City of Miami	515	322	62	57	20	54
Miami-Dade County	4,634	3,912	175	155	92	300
North Miami Beach	4	2	2	0	0	0
North Miami	4	2	2	0	0	0
Opa Locka	2	0	0	0	0	2
Palmetto Bay	18	16	0	0	0	2
Pinecrest	20	15	0	0	0	5
South Miami	17	12	0	0	0	5
Sunny Isles Beach	5	0	0	5	0	0
Sweetwater	150	118	32	0	0	0
Virginia Gardens	4	2	0	2	0	0
West Miami	44	44	0	0	0	0
Monroe County	4	2	0	0	0	2
Marathon	272	198	34	10	12	18
Big Pine Key	141	133	4	2	2	0
Summer Land Key	170	156	8	0	0	6
Islamorada	98	48	10	8	8	24
Cudjoe Key	154	146	3	0	2	2
Ramrod Key	33	31	2	0	0	0
Lower Matecumbe	5	0	2	3	0	0
Key Largo	203	173	6	5	9	10
Key Colony Beach	40	4	2	24	9	11
Grassy Key	18	4	0	2	6	6
Long Key	2	0	0	0	2	0
Marathon Shores	14	8	2	0	4	0
Plantation	7	2	0	0	3	2
Sugar Loaf Key	30	26	0	0	0	4
Big Coppitt Key	10	4	0	0	0	6
Stock Island	6	0	0	0	0	6
Tavernier	40	37	0	0	0	3
Little Torch Key	24	24	0	0	0	0
Key West	731	531	54	29	19	98
Big Torch Key	2	2	0	0	0	0
Dunnellon	2	2	0	0	0	0
Matecumbe	2	2	0	0	0	0
Sugar Loaf Shores	8	8	0	0	0	0

Source: *Local Mitigation Strategy* Plans for Broward, Miami-Dade and Monroe Counties; and Florida Division of Emergency Management, National Flood Insurance Program (numbers based on latest Repetitive Loss List, dated 06/30/09)

D. Wildfires and the Urban Interface

Florida is home to millions of residents who enjoy the state's beautiful scenery and warm climate. But few people realize that these qualities also create severe wildfire conditions. Each year, thousands of acres of wildland and many homes are destroyed by fires that can erupt at any time of the year from a variety of causes, including arson, lightning and debris burning. Adding to the fire hazard is the growing number of people living in new communities built in areas that were once wildland. This growth places even greater pressure on the state's wildland firefighters. As a result of this growth, fire protection becomes everyone's responsibility (Florida Division of Emergency Management, 2008 www.floridadisaster.org/bpr/EMTOOLS/wildfire/wildfire.htm)

1. Wildfire Hazard Profile

A wildfire is any fire occurring in the wildlands (i.e. grasslands, forest, brushland, etc). Wildfires have burned across the woodlands of Florida for centuries and are part of the natural management of much of Florida's ecosystems (Statewide Hazard Mitigation Plan, 2009). There are four types of forest fires:

- Surface fires are the most common type of wildfire burns along the floor of the forest, moving slowly killing or damaging trees.
- Ground fires (muck fires) are usually started by carelessness, burn on or below the forest floor. These fires are hard to detect and even harder to extinguish.
- Crown fires are spread rapidly by the wind and move fastest of all types of fires by jumping along the tops of trees.
- Wildland-Urban Interface (WUI) fires are in a geographical area where structures and other human development meet or intermingle with wildlands or vegetative fuels.

Florida's typical fire season is from January to May. During relatively dry months, the potential for wildfires increases dramatically. The driest months, combined with low humidity and high wind, have the highest number of fires reported (January, February and March). During these months, fine fuels (i.e. grass, leaves, pine needles) are in optimal burning condition. The largest number of fires caused by lightning occurs in July, coinciding with the peak of the thunderstorm season.

Each wildfire, especially near development, can threaten human life, structures and natural resources. Urban development has moved into wildland areas where the hazard is more severe and fire control is more difficult.

2. History of Wildfire in the State of Florida

Florida's typical forest fire season is the dry portion of the year between January and May. The largest number of naturally caused fires occurs in July due to lightning and coincides with the height of the thunderstorm season. However, lightning accounts for only 11.7% of the fires started during 1974-1990. Other sources are manmade, including arson, carelessness, debris/trash burning, and operating equipment that may emit sparks. Because so much of the State is comprised of timber lands, a major portion of the State is vulnerable to forest fires, although the threat to the population at large is not considered significant.

In the Spring of 1985 a drought that had been underway in the state since August 1984 created numerous spot fires around the state. On May 16, 1985, a wildfire was discovered west of the Palm Coast Development in Flagler County. Palm Coast is a 42,000 acre planned community situated in the coastal plain flat woods along the East Coast of Florida. A wildfire burned through Palm Coast and destroyed 100 homes, damaged 200 more and burned 13,000 acres. This disaster was a mixed wildland-urban interface fire associated with urban sprawl type development where the hydro-period is drastically altered and cuts the land into many unmanaged tracts of fire vulnerable wildlands.

In 1989, there were a record number of acres burned (645,326) as a result of 7,291 fires. A large percentage of the acres burned were located in the Everglades. A record number of wildfires occurred in 1981, with 14,042 fires that burned 587,400 acres as a result of a drought that started in July of 1980 and continued throughout 1981. In 1985, another drought stricken year, there were 8,261 fires that burned 443,811 acres.

From 1981 through 1996, an average of 6,080 wildfires occurred per year, burning 219,725 acres. Because of changing weather conditions, the yearly figures range from a low of 3,985 wildfires (86,944 acres burned) in 1991 to a record high of 14,042 wildfires (587,400 acres burned) in 1981. Florida experienced a record high (645,326 acres burned) in 1989 as a result of drought conditions around the state.

The beginning months of 1998 brought widespread flooding. After the rain stopped, severe drought conditions developed and lasted from April through June of 1998. As a result of the extreme drought conditions, high temperatures and buildup of flammable wildland fuels, the 1998 wildfires began. The first fire broke out on May 25 in the Apalachicola National Forest. In a two-month period, almost 500,000 acres of the state had burned in approximately 2,300 separate wildfires. The cost of this event reached over $160 million. The wildfires of 1998 damaged or destroyed over 300 homes and the value of lost timber exceeded $300 million.

Spring/Summer 2007 - The wildfires that put much of Florida in a several weeks-long smoky haze were started May 5 by a lightning strike on Bugaboo Island in Georgia's Okefenokee National Wildlife Refuge. Thick smoke from area wildfires forced officials to close stretches of I-75 and I-10 in northern Florida. A section of I-95 in Duval County, from Pecan Park to State Road A1A, was also closed due to smoke, as was a section of I-75 in Broward County, near fire-ravaged Collier County in southern Florida. The fires scorched at least 212,000 acres, according to the joint information center, a coalition of state and federal agencies. Of those acres, 101,000 were in Florida and about 111,000 were in Georgia. Interstate 75 was closed from Valdosta, Georgia, south to Lake City, Florida and Interstate 10 was closed from Sanderson, Florida, eastward to Live Oak.

3. Wildland-Urban Interface (WUI)

The Florida Division of Forestry (DOF) provides risk maps for wildfire. The web-based risk system produces maps for Level of Concern (LOC), Fuels, Wildland Fire Susceptibility Index (WFSI), and the likelihood of the number of fires per 1000 acres per year (FOA). Unfortunately, the website does not offer a vulnerability output in terms of dollars lost and the data was last updated in 2005. Data layers are in the process of being updated along with DOF's new web-based mapping risk assessment program, due out in late 2009 or early 2010.

The Wildland Fire Risk Assessment System (FRAS) combines indices of Wildland Fire Susceptibility and Fire Effects to generate a "Level of Concern" map. Data layers used to develop the Wildland Fire Susceptibility Index include: fuel and crown closure classifications and non-burnable areas from Landsat™ data, and topographic and fire weather data from existing data sets.

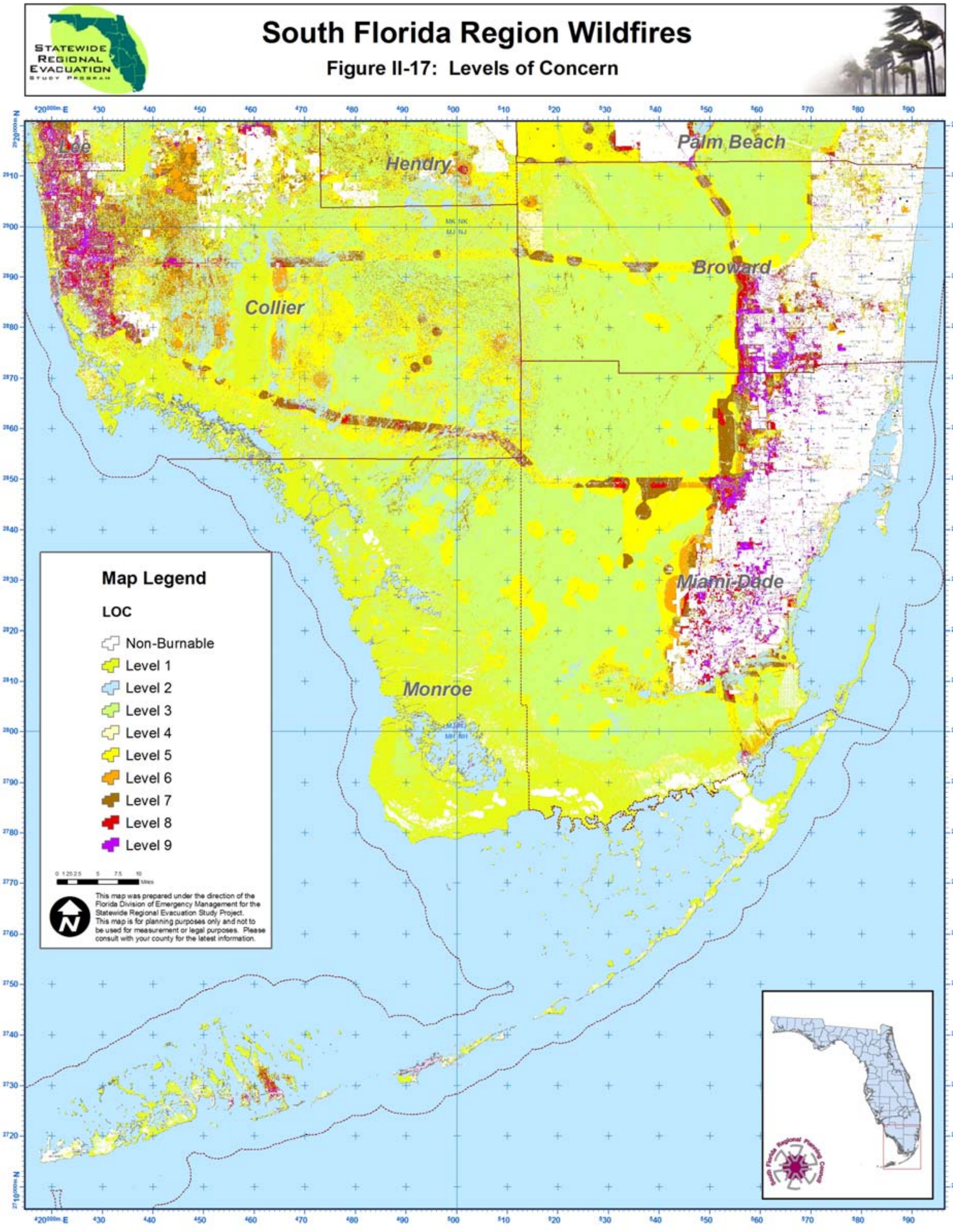
The Fire Effects Index uses data layers derived from a variety of existing data sets. These data included location of critical facilities, forest plantations, utility corridors, urban interface areas, roads, and firefighting resource locations; as well as, suppression cost--based on soil and fuel types.

The Levels of Concern (LOC) were computed by multiplying the Wildland Fire Susceptibility Indices by the Fire Effects Indices. The LOC values were then assigned to nine categories of risk and mapped for each Florida Division of Forestry District.

Another component of FRAS is the Fire Response Accessibility Index (FRAI). The FRAI is a relative measure of travel time from the nearest fire station to reach a particular mapped cell. Values are assigned into one of six categories of time ranging from class 1 (greater than 120 minutes) to class 6 (0-14 minutes). Accessibility is based on the location of roads and wildland firefighting resource dispatch stations. The Fire Response Accessibility Index is coupled with the Levels of Concern data on District maps.

The fire behavior model, FlamMap, is used in FRAS. FlamMap calculates the behavior of a fire occurring in each 30x30 meter cell under defined weather conditions given topographic, fuels, and crown closure data.

Figure II-17 illustrates the risk for wildfire within the region using the data provided by the Florida Division of Forestry.


STATEWIDE REGIONAL EVACUATION STUDY PROGRAM
South Florida Region Wildfires
Figure II-17: Levels of Concern
Lee
Hendry
Palm Beach
Broward
Collier
Miami-Dade
Monroe
Map Legend
LOC
Non-Burnable
Level 1
Level 2
Level 3
Level 4
Level 5
Level 6
Level 7
Level 8
Level 9
Miles
This map was prepared under the direction of the Florida Division of Emergency Management for the Statewide Regional Evacuation Study Project. This map is for planning purposes only and not to be used for measurement or legal purposes. Please consult with your county for the latest information.
Sources: Florida Division of Forestry, Florida Department of Agriculture and Consumer Services
Map Printed: September 9, 2010

E. Hazardous Materials Incidents

1. Overview

Hazardous Materials are part of everyday life in America. The good things chemicals bring into our lives have become vital to us. Although major chemical emergencies are extremely rare, there always remains a chance that one will occur. In the State of Florida, the county emergency management agencies plan for hazardous materials incidents and coordinate regionally for response through the Local Emergency Planning Committees (LEPCs).

2. History of the Local Emergency Planning Committees (LEPCs)

Public awareness of the potential danger from accidental releases of hazardous substances has increased over the years as serious chemical accidents have occurred around the world, including a significant release in Bhopal, India in 1984 that killed thousands, and a more localized event in Institute, West Virginia. In response to this public concern and the hazards that exist, the U.S. Environmental Protection Agency (EPA) began its Chemical Emergency Preparedness Program (CEPP) in 1985. CEPP was a voluntary program to encourage state and local authorities to identify hazards in their areas and to plan for potential chemical emergencies. This local planning complemented emergency response planning carried out at the national and regional levels by the National Response Team and Regional Response Teams organized by EPA, the U.S. Coast Guard, and the National Oceanic and Atmospheric Administration (NOAA).

The following year, Congress enacted many of the elements of CEPP in the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), also known as Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This law required states to establish State Emergency Response Commissions and Local Emergency Planning Committees to develop emergency response plans for each community. EPCRA also required facilities to make information available to the public on the hazardous chemicals they have on site. EPCRA's reporting requirements foster a valuable dialogue between industry and local communities on hazards to help citizens become more informed about the presence of hazardous chemicals that might affect public health and the environment. According to OSHA requirements, workers on site also have a right to know about the hazardous chemicals to which they could be exposed.

The South Florida LEPC (SoFlaLEPC) was created in 1988 to help the public and emergency responders address hazardous materials public safety issues. The focus of the committee is on planning, regional coordination, education and awareness. LEPCs can be found in every State. In Florida, the LEPCs are organized in conjunction with the eleven Regional Planning Councils, which provide staff support with funding from the Florida Division of Emergency

Management. District 11, which incorporates the counties of Broward, Miami-Dade and Monroe Counties, and their respective jurisdictions, meets quarterly beginning in February of each year. LEPC members are appointed by the State Emergency Response Commission for Hazardous Materials (SERC), a policy board appointed by the Governor, which administers the hazardous materials (HAZMAT) laws for the U.S. Environmental Protection Agency (EPA) at the Florida level; and at the local level, through the 11 LEPCs statewide. The Chairman of the SERC is the Secretary of the Department of Community Affairs and the Alternate Chairman is the Director of the Division of Emergency Management. Membership of the LEPC represents 15 occupational categories as follows: Elected State and Local Officials, Law Enforcement, Civil Defense/Emergency Management, Firefighting, First Aid, Health and Safety, Local Environmental, Hospital, Transportation, Broadcast and Print Media, Community Groups, Facility Owners and Operators, Non-Elected Local Officials, Water Management District and Interested Citizens.

3. South Florida LEPC Mission Statement

The mission of the SoFlaLEPC is to partner with citizens, facilities, and local emergency management officials to protect communities from the adverse effects of hazardous materials in District XI. To support this goal, the SoFlaLEPC is committed to the following objectives:

a. The SoFlaLEPC shall **prepare hazardous materials emergency plans** which indicate the facilities that store, use, or produce hazardous substances at or above established threshold amounts and that are located in District 11;

- Data collected for the plans is used in responding to and recovering from a release or spill of hazardous or toxic substances. These plans are reviewed and updated by the annually and are approved by the Florida Division of Emergency Management (FDEM) on behalf of the Commission.

b. The SoFlaLEPC shall serve as the **repository for District 11 reports** filed under EPCRA;

- FDEM has undertaken a restructuring of how facilities report their chemical inventories of both hazardous and extremely hazardous substances under Sections 311/312 of EPCRA in Florida. Online filing is now available via FloridaHMIS.org and the information is available for public review at the SoFlaLEPC office.

c. The SoFlaLEPC shall direct regional implementation activities and perform associated outreach functions to **increase awareness and understanding** of and compliance with the EPCRA as well as the RMP programs.

d. The SoFlaLEPC shall play an active role in **risk communication, public education, industry outreach, mitigation and emergency planning** associated with the Clean Air Act and Risk Management Planning.

4. Hazards Analysis of Hazardous Materials

Any facility, public or private, that has at any given time during the year, extremely hazardous materials at or above established threshold amounts is required to report annually. It is termed a Section 302 facility (relating to the clause in EPCRA which pertains to Extremely Hazardous Substances facilities). A hazards analysis on the facility is usually performed by the county in which the facility is located. See Figure II-18 for maps showing the general location of Section 302 facilities in District 11.

The hazard analysis looks at the amounts of hazardous materials present, the risk to the surrounding community, public facilities vulnerable to potential release such as schools, hospitals, etc. Additionally, any facility which possesses in excess of 10,000 pounds, a hazardous material for which the Occupational Safety and Health Administration (OSHA) requires the facility to keep a Material Safety Data Sheet is also required to render the annual report.

While the number of hazardous substance facilities continues to increase as awareness of the law reaches various segments of the community, over the years EPCRA has been successful in reducing facilities possessing extremely hazardous substances (EHSs) by encouraging them to seek alternative products that do not require reporting and thus payment of the reporting fee. The reporting deadline each year is March 1st. Within the South Florida LEPC (District 11), there were 427 Section 302 (EHS) facilities reporting in 2007, out of 3,415 statewide (13%), and 1,760 facilities reporting under Sections 311/312, out of a total of 10,455 statewide (17%).

District 11 had 345 hazardous material incidents in 2007, which was 16 percent of the total of 2,125 incidents statewide. District 11 possesses very low proportions of most Section 302 chemicals by weight and volume in the State of Florida. The exceptions in 2007 were hydrogen peroxide, of which over half was located in South Florida, and chlorine, with 27%. The ten top Section 302 chemicals reported in District 11 for 2007 are as follows:

Table II-14
District 11 Top Ten Section 302 Chemicals, 2007

Chemical	2006 Maximum Inventory (lbs)	2007 Maximum Inventory (lbs)	Change from 2006 (lbs)	Percent of Statewide Inventory, 2007
Sulfuric Acid	5,358,676	16,810,244	11,451,568	4.1%
Chlorine*	5,097,344	5,609,404	512,060	27.3%
Ammonia*	744,665	837,311	92,646	0.3%
Hydrogen Peroxide	**	576,759	**	51.0%
Methyl Bromide	167,264	98,310	-68,954	1.3%
Formaldehyde	102,220	77,303	-24,917	***
Sulfur Dioxide*	59,000	61,000	2,000	2.2%
Nitric Acid*	148,309	52,675	-95,634	0.2%
Vinyl Acetate	**	45,000	**	***
Endosulfan	80,533	37,646	-42,887	***

* These chemicals are also covered under the Clean Air Act, Section 112.
** Did not appear on the 2006 top ten list for District XI
*** Did not appear on the 2007 top ten list for the State
Source: State Emergency Response Commission for Hazardous Materials, ***Annual Report 2008***

a. CAMEOfm, MARPLOT and ALOHA Update

Accidental releases involving hazardous chemicals occur frequently in the United States. Therefore, the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA) and firefighters collaborated to develop the Computer Aided Management of Emergency Operations (CAMEO) software system more than twenty years ago. The CAMEO system is a combination of three programs that work independently or in conjunction to give hazardous materials planners and first responders the tools to plan for and respond to hazardous materials releases. As technology has advanced, numerous revisions have been made to the software. The most recent update was released in November 2010.

One of the programs, CAMEO filemaker (CAMEOfm), contains a chemical library that provides planners and responders with important information on a multitude of chemicals and chemical mixtures. The program also allows the user to create a chemical information database for individual facilities that have hazardous materials on site. CAMEOfm can automatically calculate a vulnerable zone for a simulated or actual chemical release based on specific data entered by the user. The Chemical Library was also updated with the latest Acute Exposure Guideline Levels (AEGLs). The AEGLs are Toxic Levels of Concern that can be used to predict the area in which a toxic gas concentration may be high enough to harm people. Finally, minor changes were made to the Reactivity Report that is used to predict possible reactions that might occur when two or more chemicals are mixed.

The second program, Mapping Application for Response and Planning of Local Operational Tasks (MARPLOT), is a typical Geographic Information System (GIS) with multiple layers that allow the user to view major roads, secondary roads, water bodies, railroads, and other features on selected maps. It also allows the user to plot features like chemical facilities and critical facilities (schools, hospitals, day care centers, etc.) and identify evacuation routes on the maps. MARPLOT may be used in conjunction with CAMEOfm to map a vulnerable zone around a release point and identify populations within the zone that may be affected by a chemical release. The upgraded version of MARPLOT correctly displays multiple plume footprints.

The third program, Areal Locations of Hazardous Atmospheres (ALOHA), was developed to allow the user to model dispersion of a hazardous chemical release. ALOHA gives emergency planners and responders the capability to model chemical plumes. The user chooses from a variety of criteria such as, location, date, time, atmospheric conditions, type/size of container, assorted hole sizes and shapes, source (puddle, gas pipeline etc.) to plot a footprint. In the updated version of ALOHA, users can now estimate the hazards associated with jet fires (flares), pool fires, vapor cloud explosions, Boiling Liquid Expanding Vapor Explosions (BLEVEs), and flammable regions (flashfires), as well as downwind toxic threats.

Over the years, CAMEO has become the most widely used hazardous materials emergency planning and response tool in Florida and the United States. In fact, Florida now requires electronic submission of hazards analyses in CAMEOfm format from local emergency planners. The software is provided at no cost and can be downloaded from the EPA website (www.epa.gov/ceppo/cameo/).

b. South Florida Hazardous Material Emergency Plan

Comprehensive planning depends upon a clear understanding of what hazards exist and what risk they pose for the community. To gain this understanding, the Florida Division of Emergency Management has contracted with the counties within the South Florida Local Emergency Planning Committee (LEPC) district to conduct site-specific hazard analyses for airborne releases of extremely hazardous substances (EHSs) covered under Section 302 of EPCRA. The hazards analyses are made available to the South Florida LEPC and serve as the basis for developing and revising the emergency response plans that are mandatory under the law.

The hazards analyses included in this section of the plan are designed to consider all potential acute health hazards within the South Florida LEPC area and to identify which hazards are of high priority and should be addressed in the emergency response planning process. There are hundreds of facilities in the South Florida LEPC area that are subject to the requirements of EPCRA and the number that have notified the State Emergency Response Commission for Hazardous Materials (SERC), the LEPC, and the local jurisdictional fire department in accordance with the provisions of EPCRA have grown significantly. A complete set of hazards analyses are available through the South Florida LEPC.

The hazards analysis for the South Florida LEPC area consists of the following three components:

(1) Hazards Identification – provides specific information on situations that have the potential for causing injury to life or damage to property. A hazards identification includes information about:

a) Chemical identities;
b) The location of facilities that use, produce, process, or store hazardous materials;
c) The type and design of chemical container or vessel;
d) The quantity of material that could be involved in an airborne release; and
e) The nature of the hazard (e.g., airborne toxic vapors or mists which are the primary focus of this guide; also other hazards such as fire, explosion, large quantities stored or processed, handling conditions) most likely to accompany hazardous materials spills or releases.

(2) Vulnerability Analysis – identifies areas in the community that may be affected or exposed, individuals in the community who may be subject to injury or death from certain specific hazardous materials, and what facilities, property, or environment may be susceptible to damage should a hazardous materials release occur. A comprehensive vulnerability analysis provides information on:

a) The extent of the vulnerable zones (i.e., an estimation of the area that may be affected in a significant way as a result of a spill or release of a known quantity of a specific chemical under defined conditions);
b) The population, in terms of numbers, density, and types of individuals that could be within a vulnerable zone;
c) The private and public property that may be damaged, including essential support systems and transportation facilities and corridors; and
d) The environment that may be affected, and the impact of a release on sensitive natural areas and endangered species.

(3) Risk Analysis is an assessment by the community of the likelihood (probability) of an accidental release of a hazardous material and the actual consequences that might occur, based on the estimated vulnerable zones. The risk analysis is a judgment of probability and severity of consequences based on the history of previous incidents, local experience, and the best available current technological information. It provides an estimation of:

a) The likelihood (probability) of an accidental release based on the history of current conditions and controls at the facility, consideration of any unusual environmental conditions, or the possibility of simultaneous emergency incidents;
b) Severity of consequences of human injury that may occur, the number of possible injuries and deaths, and the associated high-risk groups; and
c) Severity of consequences of damage to critical facilities, property, and the environment.

The hazards analysis summaries for 504 facilities in the South Florida LEPC area, updated or in the process of updating for FY 2008-09, that have reported to the State Emergency Response Commission in compliance with Sections 302 and 303 of EPCRA, are provided in the Regional Hazardous Material Emergency Response Plan.

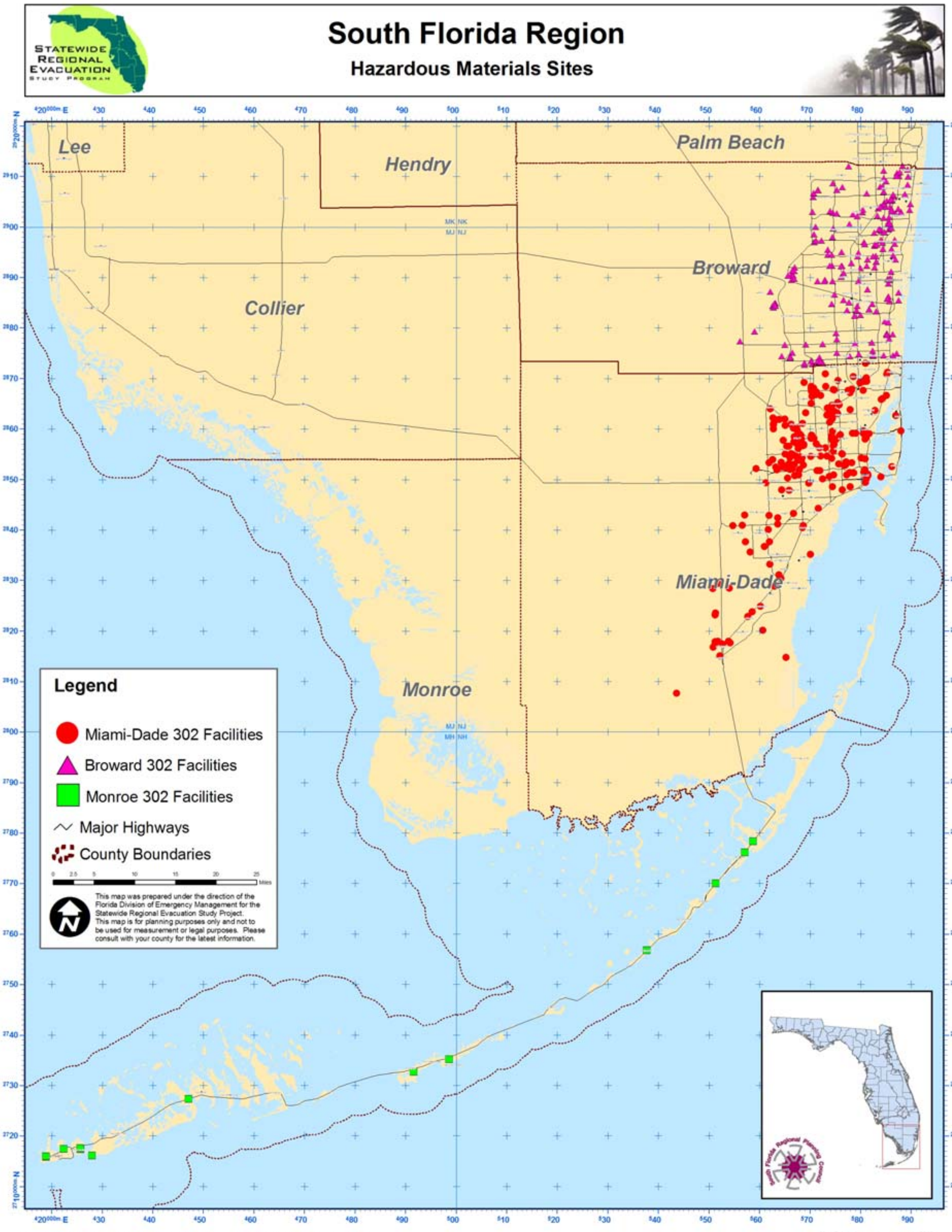
Emergencies involving hazardous materials can be postulated as ranging from a minor emergency with no off-site effects to a major emergency that may result in an off-site release of hazardous/toxic materials. The overall objective of chemical emergency response planning and preparedness is to minimize exposure for a spectrum of emergencies that could produce off-site levels of contamination in excess of Levels of Concern (LOCs) established by the US Environmental Protection Agency. Minimizing this exposure will reduce the consequences of an emergency to persons in the area nearby facilities that manufacture, store or process hazardous materials.

No specific emergency sequence can be isolated as the model for which to plan because each emergency could have different consequences, both in nature and degree. As an alternative to defining a specified emergency, the regional plan identifies various parameters for planning which are based upon knowledge of the possible consequences, timing, and release characteristics of a spectrum of emergencies. The SoFlaLEPC Hazardous Materials Emergency Response Plan then establishes the appropriate response for each level of threat. Therefore the Statewide Regional Evacuation Study will not specifically address hazardous material incidents.

c. Hazardous Materials Commodity Flow Study

The Section 302 Facility Hazards Analysis discussed in the previous section identifies hazardous materials at fixed facilities, but does not address potential hazards arising from the transportation hazardous materials. LEPCs often perform Regional Hazardous Materials Commodity Flow studies to determine what hazardous materials are being transported through their respective regions. The SoFlaLEPC has not performed a Hazardous Materials Commodity Flow Study in recent years.

Figure II-18
Section 302 Facilities in the South Florida Region



F. Terrorism and Domestic Security

1. Overview

Terrorism is the use of force or violence against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion, or ransom.

Terrorists often use threats to:

- Create fear among the public.
- Try to convince citizens that their government is powerless to prevent terrorism.
- Get immediate publicity for their causes.

Acts of terrorism include threats of terrorism, assassinations, kidnappings, hijackings, bomb scares and bombings, cyber attacks (computer-based) and the use of chemical, biological, nuclear and radiological weapons.

High-risk targets for acts of terrorism include military and civilian government facilities, international airports, large cities, and high-profile landmarks. Terrorists might also target large public gatherings, water and food supplies, utilities, and corporate centers. Further, terrorists are capable of spreading fear by sending explosives or chemical and biological agents through the mail.

a. Explosions

Terrorists have frequently used explosive devices as one of their most common weapons. Terrorists do not have to look far to find out how to make explosive devices; the information is readily available in books and other information sources. The materials needed for an explosive device can be found in many places including variety, hardware and auto supply stores. Explosive devices are highly portable using vehicles and humans as a means of transport. They are easily detonated from remote locations or by suicide bombers.

Conventional bombs have been used to damage and destroy financial, political, social and religious institutions. Attacks have occurred in public places and on city streets with thousands of people around the world injured and killed.

b. Biological Threats

Biological agents are organisms or toxins that can kill or incapacitate people, livestock and crops. The three basic groups of biological agents that would likely be used as weapons are bacteria, viruses and toxins. Most biological agents are difficult to grow and maintain. Many break down quickly when exposed to sunlight and other environmental factors, while others, such as anthrax spores, are very long lived. Biological agents can be dispersed by spraying them into the air, by infecting animals that carry the disease to humans and by contaminating food and water. Delivery methods include:

- Aerosols – biological agents are dispersed into the air, forming a fine mist that may drift for miles. Inhaling the agent may cause disease in people or animals.
- Animals – some diseases are spread by insects and animals, such as fleas, mice, flies, mosquitoes and livestock.
- Food and water contamination – some pathogenic organisms and toxins may persist in food and water supplies. Most microbes can be killed, and toxins deactivated, by cooking food and boiling water. Most microbes are killed by boiling water for one minute, but some require longer.
- Person-to-person – spread of a few infectious agents is also possible. Humans have been the source of infection for smallpox, plague and the Lassa viruses.

c. Chemical Threats

Chemical agents are poisonous vapors, aerosols, liquids and solids that have toxic effects on people, animals or plants. They can be released by bombs or sprayed from aircraft, boats and vehicles. They can be used as a liquid to create a hazard to people and the environment. Some chemical agents may be odorless and tasteless. They can have an immediate effect (a few seconds to a few minutes) or a delayed effect (2 to 48 hours). While potentially lethal, chemical agents are difficult to deliver in lethal concentrations. Outdoors, the agents often dissipate rapidly. Chemical agents also are difficult to produce.

A chemical attack could come without warning. Signs of a chemical release include people having difficulty breathing, experiencing eye irritation, losing coordination, becoming nauseated or having a burning sensation in the nose, throat and lungs. Also, the presence of many dead insects or birds may indicate a chemical agent release.

d. Nuclear Blast

A nuclear blast is an explosion with intense light and heat, a damaging pressure wave, and widespread radioactive material that can contaminate the air, water, and ground surfaces for miles around. A nuclear device can range from a weapon carried by an intercontinental missile launched by a hostile nation or terrorist organization, to a small portable nuclear devise transported by an individual. All nuclear devices cause deadly effects when exploded, including blinding light, intense heat (thermal radiation), initial nuclear radiation, blast, fires started by the heat pulse, and secondary fires caused by the destruction.

(1) Hazards of Nuclear Devices

The extent, nature, and arrival time of these hazards are difficult to predict. The geographical dispersion of hazard effects will be defined by the following:

- Size of the device. A more powerful bomb will produce more distant effects.
- Height above the ground the device was detonated. This will determine the extent of blast effects.

- Nature of the surface beneath the explosion. Some materials are more likely to become radioactive and airborne than others. Flat areas are more susceptible to blast effects.
- Existing meteorological conditions. Wind speed and direction will affect arrival time of fallout; precipitation may wash fallout from the atmosphere.

(2) Radioactive Fallout

Even if individuals are not close enough to the nuclear blast to be affected by the direct impacts, they may be affected by radioactive fallout. Any nuclear blast results in some fallout. Blasts that occur near the earth's surface create much greater amounts of fallout than blasts that occur at higher altitudes. This is because the tremendous heat produced from a nuclear blast causes an up-draft of air that forms the familiar mushroom cloud. When a blast occurs near the earth's surface, millions of vaporized dirt particles also are drawn into the cloud. As the heat diminishes, radioactive materials that have vaporized condense on the particles and fall back to Earth. The phenomenon is called radioactive fallout. This fallout material decays over a long period of time, and is the main source of residual nuclear radiation.

Fallout from a nuclear explosion may be carried by wind currents for hundreds of miles if the right conditions exist. Effects from even a small portable device exploded at ground level can be potentially deadly.

Nuclear radiation cannot be seen, smelled, or otherwise detected by normal senses. Radiation can only be detected by radiation monitoring devices. This makes radiological emergencies different from other types of emergencies, such as floods or hurricanes. Monitoring can project the fallout arrival times, which will be announced through official warning channels. However, any increase in surface build-up of gritty dust and dirt should be a warning for taking protective measures.

In addition to other effects, a nuclear weapon detonated in or above the earth's atmosphere can create an electromagnetic pulse (EMP), a high-density electrical field. An EMP acts like a stroke of lightning but is stronger, faster, and shorter. An EMP can seriously damage electronic devices connected to power sources or antennas. This includes communication systems, computers, electrical appliances, and automobile or aircraft ignition systems. The damage could range from a minor interruption to actual burnout of components. Most electronic equipment within 1,000 miles of a high-altitude nuclear detonation could be affected. Battery-powered radios with short antennas generally would not be affected. Although an EMP is unlikely to harm most people, it could harm those with pacemakers or other implanted electronic devices.

e. Radiological Dispersion Device (RDD)

Terrorist use of an RDD – often called "dirty nuke" or "dirty bomb" – is considered far more likely than use of a nuclear explosive device. An RDD combines a conventional explosive device – such as a bomb – with radioactive material. It is designed to scatter dangerous and sub-lethal amounts of radioactive material over a general area. Such

RDDs appeal to terrorists because they require limited technical knowledge to build and deploy compared to a nuclear device. Also, the radioactive materials in RDDs are widely used in medicine, agriculture, industry, and research, and are easier to obtain than weapons grade uranium or plutonium.

The primary purpose of terrorist use of an RDD is to cause psychological fear and economic disruption. Some devices could cause fatalities from exposure to radioactive materials. Depending on the speed at which the area of the RDD detonation was evacuated or how successful people were at sheltering-in-place, the number of deaths and injuries from an RDD might not be substantially greater than from a conventional bomb explosion.

The size of the affected area and the level of destruction caused by an RDD would depend on the sophistication and size of the conventional bomb, the type of radioactive material used, the quality and quantity of the radioactive material and the local meteorological conditions – primarily wind and precipitation. The area affected could be placed off-limits to the public for several months during cleanup efforts.

2. The Regional Domestic Security Task Forces (RDSTFs)

Following 9/11, Florida divided itself into seven Regional Domestic Security Task Forces. These regions follow the Florida Department of Law Enforcement (FDLE) regions within the State. The South East Florida RDSTF (Region 7) consists of four counties: Palm Beach, Broward, Miami-Dade and Monroe.

The goal of the RDSTF is to provide a regional response to any weapons of mass destruction (WMD) or terrorist incident that may occur within the State. It allows smaller counties that do not have lots of resources to draw from those that do. It also allows these smaller counties to provide assistance to larger metropolitan areas if an event occurs there. Addressing security issues at a regional level also allows for “economies of scale” for homeland security funds, especially in recent years as the amount of Department of Homeland Security funding to the States has decreased. Florida has been routinely hailed as a model for domestic security planning throughout the nation as a result of this regional approach.

3. History of Events

There have been no terrorist events in recent history in the South Florida Region.

4. Vulnerability Assessments

The Regional Domestic Security Task Forces (RDSTFs) in the state are in the process of identifying critical infrastructure and key resources (CI/KR) as defined by Department of Homeland Security (DHS) in the National Infrastructure Protection Plan (NIPP). This information will allow for county and regional profiles to be developed outlining risk versus vulnerabilities. Once complied, the region will use a tiering methodology developed by DHS and modified to support regional needs to prioritize the identified CI/KR. Vulnerability assessments will be completed to support mitigation efforts. Emergency Operating Plans have been developed and validated to respond to emergency events ensuring the citizens of Florida are protected and safe when responding to emergency events.

Similar to Hazardous Material incidents, no specific emergency sequence can be isolated as the model for which to plan for evacuation caused by a terrorist event because each emergency could have different consequences, both in nature and degree. As an alternative to defining a specified emergency, the regional and county plans identify various parameters for planning which are based upon knowledge of the possible consequences, timing, and target characteristics of a spectrum of emergencies. The plan then establishes the appropriate response for each level of threat. Therefore, the Statewide Regional Evacuation Study will not address terrorist acts specifically.

G. Nuclear Power Plant Incidents

Florida is home to five commercial nuclear reactors located at three sites:

- Crystal River Nuclear Power Plant (NW of Crystal River)
- St. Lucie Nuclear Power Plant (Units 1 & 2, SE of Ft. Pierce)
- Turkey Point Nuclear Power Plant (Units 3 & 4, South of Miami)

Two additional reactors are located in Alabama near the State line:

- Farley Nuclear Power Plant (SE of Dothan, Alabama)

1. Description of the Turkey Point Nuclear Power Plant

Turkey Point Units 3 and 4 are part of the larger Florida Power and Light (FPL) Turkey Point Plant located in unincorporated Miami-Dade County, Florida. The Turkey Point Plant comprises 11,000 acres and has five steam electric generating units. Units 1, 2 and 5 are fossil fuel-fired and Units 3 and 4 are nuclear-powered. All five of the steam electric generating units are in the developed area of the Turkey Point Plant, which lies approximately 8 miles east of Florida City, and 4.5 miles east of the southeastern limits of the City of Homestead. It is approximately 9 miles east of the intersection of U.S. Highway 1 and Palm Drive (SW 344th Street).

The five existing power generation units and support facilities occupy approximately 130 acres of the 11,000-acre Turkey Point Plant. Turkey Point Units 3 and 4 are south of Turkey Point Units 1, 2 and 5, and comprise approximately 30 acres. Support facilities include service buildings, an administration building, fuel oil tanks, water treatment facilities, circulating water intake and outfall structures, wastewater treatment basins, and a system substation. The cooling canal system occupies approximately 5,900 acres. The two 400-megawatt fossil fuel-fired steam electric generation units at the Turkey Point Plant have been in service since 1967 (Unit 1) and 1968 (Unit 2). These units currently burn residual fuel oil and/or natural gas with a maximum equivalent sulfur content of 1 percent. The two 700-MW pressurized water nuclear reactor units have been in service since 1972 (Unit 3) and 1973 (Unit 4). Turkey Point Unit 5 is a 1,120-MW combined cycle unit that began operation in 2007.

Turkey Point Units 1 through 5 share a single switchyard that supplies power to the 230-kilovolt (kV) transmission lines leaving the Plant. Transmission lines exit the Turkey Point Plant in two corridors, one traveling to the west and one to the north. The Florida City – Turkey Point transmission line leaves the Turkey Point Plant to the west for approximately 5 miles, where it connects to the Florida City substation. The Florida City corridor is 330 feet wide and traverses undeveloped land for most of its distance. Seven other lines leave the Turkey Point Plant to the north, in a second 330-foot wide corridor. This corridor extends approximately 19 miles to the Davis substation, located in southwest Miami at SW 136th Street and SW 127th Avenue. The Turkey Point Unit 3 and 4 power blocks have been elevated to 18 feet (msl) to mitigate flooding and wave impacts.

In January 2008, FPL submitted an application to increase the capacity of the two existing nuclear reactors. The Turkey Point Uprate Project will increase the electrical output from both Units 3 and 4 without changing the footprint of the existing plants. The increase in the output of the Plant will be accomplished by modifications to the existing plant equipment and will require no new construction. The two units will require modifications to the turbine-generators and attendant support and control systems. All turbine modifications will incorporate state-of-the-art technology that will provide greater efficiency in the turbines resulting in fuel savings over the long term. The Project will also require an increase in reactor power or thermal megawatts. The increased reactor power will manifest itself in a higher reactor coolant exit temperature and the heat transfer through the steam generators will increase. The Project will allow each unit to increase gross power by about 14 percent. Net electrical generation per unit is expected to increase from about 700 MW to about 804 MW. The net increase will be about 104 MW per unit for a two-unit total of about 208 MW.

The Turkey Point Plant has received re-licensing approval from the federal Nuclear Regulatory Commission (NRC) for Unit 3 through 2032 and Unit 4 through 2033. The power uprates at the Turkey Point Plant will be implemented in 2012. FPL plans to perform the physical work associated with the Turkey Point Uprate Project at the time of normally scheduled refueling outages in 2010, 2011 and 2012. The estimated cost of the uprate at Turkey Point Units 3 and 4 is approximately $750 million.

Florida Power and Light also submitted a Site Certification Application to the Florida Department of Environmental Protection (DEP) on June 30, 2009. If approved, the application would allow FPL to expand nuclear energy production at its Turkey Point facility. The proposed project consists of the construction of two new 1,100 megawatt (MW) nuclear units, 6 and 7, and supporting facilities, as well as the placement of new transmission lines. The State of Florida would license both the transmission lines and new electrical power plants in one proceeding pursuant to the State Power Plant Siting Act (PPSA), Chapter 403, Part II, Florida Statutes.

The two nuclear generating units with supporting buildings, facilities and equipment will be located due south of the existing Turkey Point plant site, east of the cooling canals. Associated facilities proposed in or around the new or existing plant sites include parking areas; a nuclear administration and training building, a reclaimed water treatment facility and treated reclaimed water delivery pipelines; radial collector wells and delivery pipelines, for cooling water backup; and an equipment barge unloading area. A new electrical substation (Clear Sky) will be constructed on the Turkey Point site. A 230-kV transmission line will also be needed to connect the new substation to the existing substation on the plant property. Proposed off-site facilities include: 1) transmission lines and system improvements within Miami-Dade County, City of Miami, Coral Gables, Doral, Homestead, Medley, Palmetto Bay, Pinecrest, and South Miami and 2) the creation or expansion of access roads and bridges (between SW 328th Street and SW 359th Street and east of SW 137th Avenue).

2. Summary of Incidents

The Division of Emergency Management's Radiological Emergencies Program has the overall responsibility for coordination of the response to a nuclear power plant emergency by federal, state and local agencies. The Division also has the overall authority and responsibility for updating and coordinating the plans with other response organizations.

The **Nuclear/Radiological Incident Annex** provides an organized and integrated capability for a timely, coordinated response by Federal agencies to terrorist incidents involving nuclear or radioactive materials (Incidents of National Significance), and accidents or incidents involving such material that may or may not rise to the level of an Incident of National Significance. The Department of Homeland Security (DHS) is responsible for overall coordination of all actual and potential Incidents of National Significance, including terrorist incidents involving nuclear materials.

Therefore, the South Florida Region Evacuation Study will not address nuclear power plant incidents.

However, two noteworthy events are mentioned below, neither of which required an evacuation related to the nuclear facilities.

In August, 1992, Turkey Point was directly hit by Hurricane Andrew, causing damage to a water tank and to a smokestack of one of the site's fossil-fueled units. No damage was done to the plant's containment buildings. The plant was built to withstand winds of up to 235 mph (380 km/h), greatly exceeding the maximum winds recorded by Category 5 hurricanes.

On February 26, 2008, both reactors were shut down due to the loss of off-site power during a widespread power outage in South Florida. At least 2.5 million people were without power. The blackout was initially caused by an overheated voltage switch that soon caught fire in a power substation in Miami, nowhere near the plant. The fire occurred at 1:08 pm, which caused an automatic shutdown of the power plant. This led to a domino effect that caused outages as far north as Daytona Beach and Tampa. Power was restored by 4:30 pm. Walt Disney World, Orlando International Airport, and Miami International Airport were among the places affected by the outage.

H. Tsunami

Tsunamis, also called seismic sea waves or, incorrectly, tidal waves, generally are caused by earthquakes, less commonly by submarine landslides, infrequently by submarine volcanic eruptions and very rarely by a large meteorite impact in the ocean. Submarine volcanic eruptions have the potential to produce truly awesome tsunami waves.

The possibility of a tsunami impacting the Atlantic or Gulf Coasts of Florida is considered to be remote. This is because most tsunamis are associated with major earthquakes. The Atlantic Ocean basin is not ringed by large faults as is the Pacific, which is associated both with earthquakes and tsunamis. It is thought that rare underwater landslides would pose a greater risk in the Atlantic Ocean. The Caribbean region has a history of both earthquakes and tsunamis. They do not appear to have impacted Florida's coastlines. However because of the horrific tsunami that impacted South East Asia in December 2004 and in recognition of the fact that a tsunami occurrence is possible, the Federal government has decided to expand its warning system to include the Atlantic and Gulf Coasts of the United States.

There is no history of significant tsunami activity in the region.

Although it is highly unlikely that a tsunami will impact Florida, it is not impossible. It is vital to know (and instruct children) that if the ocean suddenly recedes from the shore do not stand and stare. It is necessary immediately to run uphill or away from the shore and go to the highest location possible which may mean up the stairs of a substantial building. Everyone should be aware that no matter where in the world they are, if the sea is observed to recede from the shore, they should immediately run for high ground.

Since it is impossible to predict the exact location, timing or extent of a tsunami event, the tsunami hazards was not specifically addressed in the Statewide Regional Evacuation Study.

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