STATEWIDE REGIONAL EVACUATION STUDY PROGRAM

Volume 1-3
North Central Florida Region
Technical Data Report

CHAPTER II

REGIONAL HAZARDS ANALYSIS

STATE EMERGENCY FLORIDA SERT RESPONSE TEAM

North Central Florida Regional Planning Council

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CHAPTER II REGIONAL HAZARDS ANALYSIS

A. Hazards Identification and Risk Assessment

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

The Statewide Regional Evacuation Study (SRES), utilizing the ***Statewide Hazard Mitigation Plan (SHMP,*** 2009), identified major hazards facing the state and further focused on those hazards with 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 of 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 (hazardous materials), 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 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 Association (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 event 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. • USDA Forest Service Fire, fuel, and WUI mapping. • Input from FL DEM about wildfires and the 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.

Statewide Hazard Mitigation Plan (SHMP), 2009

Hazard	Methodology of Identification	Significant Concerns	Potential to Initiate a Regional Evacuation
Drought & Extreme Heat	• National Weather Service data. • National Oceanographic and Atmospheric Association (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 in2007 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.
Winter Storms and Freezes	• Review of past disaster declarations. • Review of 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. • SHMPAT interview and input. • *Evaluation of Erosion Hazards*, the report from the Heinz Center that was presented to 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 • 80 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 affects 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 • Input from the Central United States Earthquake Consortium • 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.	In Fla. Earthquake is considered very low risk. Sinkholes, while prevalent, will not initiate an evacuation at a regional scale.
Tsunamis	• Input from the NOAA Center for Tsunami Research • Coordination with the Florida Division of Emergency Management • Input from the United State Geological Survey	• Tsunamis 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 tsunamis 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.

Hazard	Methodology of Identification	Significant Concerns	Potential to Initiate a Regional Evacuation
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 FL 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 conducted w/NRC
Terrorism	• Coordination with FEMA and Department of Homeland Security • 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 SRES, 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. Therefore, the location, scope and extent of the evacuation response are difficult to predict or model before the incident. Planning for those events 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 each of the hazards' profiles. 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 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 Storm / 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 (Statewide Hazard Mitigation Plan (SHMP), 2009). 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-minutes 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 Saffir-Simpson Scale, shown in the table below, is 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 currently the indicator in determining the category of the storm. The wind speed is tied to both wind damage, 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), the depth of the ocean bottom (bathymetry), the strength, size and structure of the storm, its angle of approach, and shape of coastline. A narrow shelf produces a lower surge than a wider shelf if all other factors are held constant. Of the total storm surge, there is a greater contribution from wave run up/setup in situations with a narrow shelf. This is the situation along Florida's Atlantic coast. However, the Gulf Coast of Florida, with a long gently sloping shelf and shallow water depths, can expect a higher surge but smaller waves. South Dade County is an exception to these general rules due to Biscayne Bay which has a wide shelf and shallow depth. In this instance, a hurricane has a larger area to "pileup" water in advance of its landfall. In the state of Florida, the Apalachee Bay region has the most prevalent threat of storm surge. The Big Bend region of the state extends out into the Gulf of Mexico creating a naturally enclosed pocket resulting in 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 surge comparable to much more intense categories of storm if measured using only wind speeds.

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

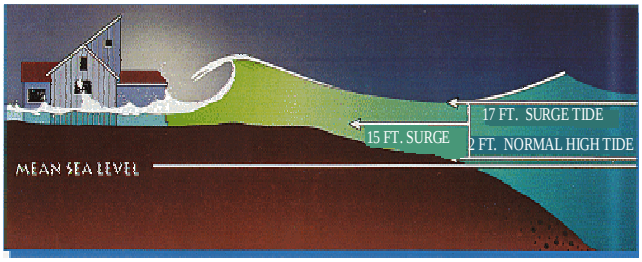
Table II- 2: Saffir-Simpson Hurricane Scale

CATEGORY		CENTRAL PRESSURE		DAMAGE POTENTIAL
		MILLIBARS	INCHES	
1		>980	>28.94	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	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	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
	4	920-944	27.17-27.88	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.
	5	<920	<27.17	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 storm surge, high winds, tornadoes and rainfall (freshwater flooding) and the potential for hazardous material incidents.

The **storm surge** is the abnormal rise in water level, often 50 - 100 miles wide, caused by the wind and pressure forces of a hurricane or tropical storm. Storm surge can range from 4-6 feet for a minimal hurricane to greater than 20 feet for intense hurricanes. It produces most of the flood damage and drownings associated with storms that make landfall or that closely approach the coastline. The destruction along the coastline is not only caused by the flooding resulting from storm surge, but also the impact from waves.



Of the hurricane hazards, the storm surge has historically been considered to be the most dangerous as nine out of ten hurricane-related deaths were attributed to drowning from coastal storm surge. However, over the past two decades, as evacuation plans and warning systems have become more sophisticated, the number of deaths attributed to storm surge has decreased and the greatest number of hurricane related deaths was caused by inland flooding and cleanup accidents. That was until Hurricane Katrina (2005). The total number of fatalities directly related to the forces of Katrina is estimated to be about 1500 spread across four states, with about 1300 of these in Louisiana, about 200 in Mississippi, 6 in Florida, and one in Georgia (www.nhc.noaa.gov). 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 **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. High winds impact coastal and inland areas by impeding traffic movement, damaging structures and producing tornadoes. Evacuation movement becomes hazardous when wind speeds reach 30-40 miles per hour. Sustained gale-force winds of 40 mph will render traffic movement practically impossible and life threatening.

The 1986 Tampa Bay Regional Planning Council's ***Hurricane Shelter Alternative Study***[2] 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 tail spin.

[2] ***Hurricane Shelter Alternative Study***, TBRPC and USACOE, 1986

Rainfall associated with hurricanes varies with hurricane size, forward speed and other meteorological factors. Hurricane related rainfall ranges from 6-12 inches on average, with higher amounts common. While **Freshwater flooding** has historically not been considered a life-threatening hazard, freshwater flooding along rivers and streams causes significant property damage and has the potential of causing personal injury and deaths. Over the past 20 years, freshwater flooding had 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 had significantly reduced the number of deaths (in the U.S.) related to storm surge until 2005. 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 persons from evacuating areas vulnerable to storm surge. Tropical Storm Fay in 2008 impacted the North Central Florida region with over 27" of rain in some areas, flooding roadways and homes with 3-5 feet of water.

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. However, they are also often found elsewhere embedded in the rain bands well away from the center of the hurricane. Some hurricanes produce no tornadoes, while others develop multiple ones. Studies have shown that more than half of the landfalling hurricanes produce at least one tornado; Hurricane Buelah (1967) spawned 141 according to one study.

Currently, there is no way 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.

Like Murphy's Law, sometimes one emergency event can trigger another. Facilities which 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 surge heights resulting 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 modeling system consists of the model source code and model basin or grid. SLOSH model grids 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, thus predicting the degree of propagation of the surge into inland areas.

The model basin 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. A major improvement to the model was 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 also provided more detail and additional information including storm surge projections.

The newest generation of the SLOSH model basin incorporated in the 2010 Statewide Regional Evacuation Study reflects major improvements, including higher resolution basin data and grid configurations. Faster computer speeds allowed additional hypothetical storms to be run for creation of 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 in the Cape Canaveral Basin. For each direction, at each speed, storms were run at two different sizes (20 statute mile radius of maximum winds and 35 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 North American Vertical Datum of 1988 (NAVD88) as opposed to the National Geodetic Vertical Datum of 1929 (NGVD29).

a. Hypothetical Storm Simulations

Surge height depends strongly on the specifics of a given storm including, forward speed, angle of approach, intensity or maximum wind speed, storm size, storm shape, and landfall location. The SLOSH model was used to develop data for various combinations of hurricane strength, wind speed, and direction of movement. Storm strength was modeled by use of the central pressure (defined as the difference between the ambient sea level pressure and the minimum value in the storm's center) 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 tropical storm/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.

Ten storm track headings (WSW, W, WNW, NW, NNW, N, NNE, NE, E, ENE) were selected as being representative of storm behavior in the North Central Florida region, based on observations by forecasters at the National Hurricane Center. Additional inputs into the model included depths of water offshore (bathymetry) and the heights of the terrain and barriers onshore (all measurements were made relative to NAVD 88). In total 16,242 runs were made consisting of the different parameters shown in Table II-3.

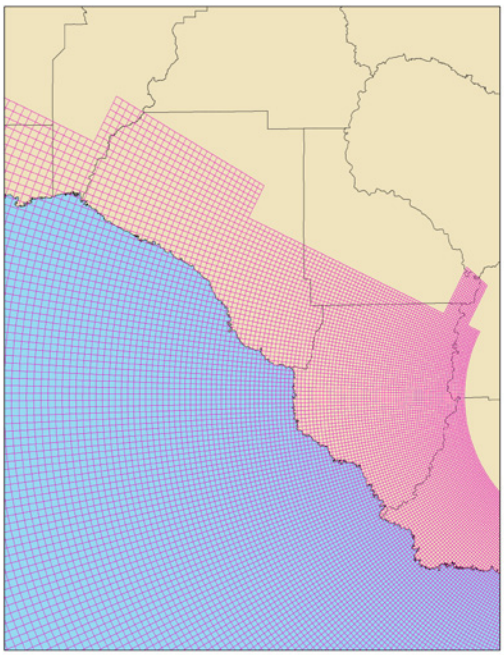
Table II- 3: Cedar Key Basin Hypothetical Storm Parameters

Direction	Speeds (mph)	Size (Radius of Maximum winds)	Intensity	Tides	Tracks	Runs
W	5,15,25 -mph	20 statute miles; 35 statute miles	1 through 5	Mean/High	23	1380
WNW	5,15,25 -mph	20 statute miles; 35 statute miles	1 through 5	Mean/High	31	1860
NW	5,15,25 -mph	20 statute miles; 35 statute miles	1 through 5	Mean/High	22	1320
NNW	5,15,25 -mph	20 statute miles; 35 statute miles	1 through 5	Mean/High	22	1320
N	5,15,25 -mph	20 statute miles; 35 statute miles	Tropical Storm, 1 through 5	Mean/High	24	1584
NNE	5,15,25 mph	20 statute miles; 35 statute miles	Tropical Storm, 1 through 5	Mean/High	30	1980
NE	5,15,25 -mph	20 statute miles; 35 statute miles	Tropical Storm, 1 through 5	Mean/High	36	2376
ENE	5,15,25 -mph	20 statute miles; 35 statute miles	Tropical Storm, 1 through 5	Mean/High	36	2376
E	5,15,25 -mph	20 statute miles; 35 statute miles	Tropical Storm, 1 through 5	Mean/High	31	2046
TOTAL						16,242

b. The Grid for the Cedar Key SLOSH Basin

Figure II-1 illustrates the area covered by the grid for the Cedar Key SLOSH Basin.

Figure II- 1: Cedar Key SLOSH Basin



To determine the surge values the SLOSH model uses a telescoping elliptical grid as its unit of analysis with 188 arc lengths (1< I> 188) and 215 radials (1< J> 215). Use of the grid configuration allows for individual calculations per grid square which is beneficial in two ways: (1) 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) allows economy in computation. The grid size for the North Central Florida model varies from approximately 0.01 square miles or 63 acres closest to the pole (I = 1) to the grids on the outer edges where each grid is approximately 5 square miles.

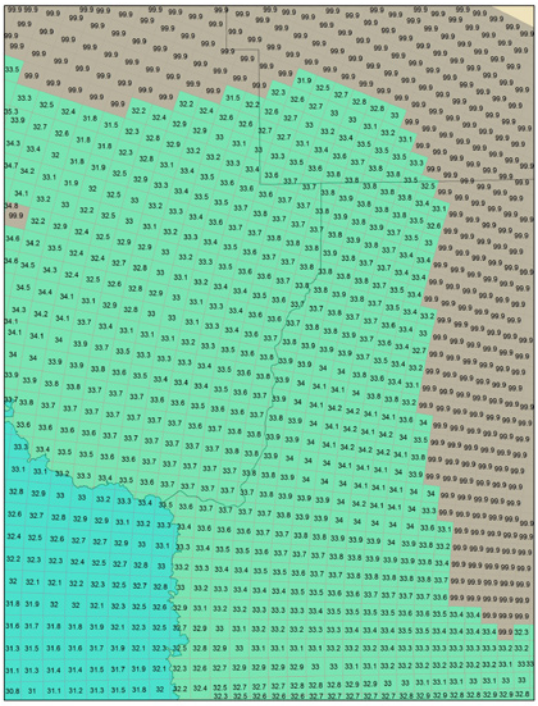
c. Storm Scenario Determinations

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).

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 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).

Figure II- 2: SLOSH Grid with Surge Values



The MOM surge heights, which were furnished by the National Hurricane Center, have 2 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-2. The range of maximum surge heights (high and low) for each county in the region based upon the model is provided for each category of storm on 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 Storm Tide Heights by County*
(In feet above NAVD88)

*Storm Strength	Dixie	Taylor	Gilchrist	Lafayette
Category 1	Up to 10.6	Up to 11.1	Up to 5.7	Up to 5.4
Category 2	Up to 17.4	Up to 19.5	Up to 14.9	Up to 8.5
Category 3	Up to 23.6	Up to 27.7	Up to 21.7	Up to 19.3
Category 4	Up to 29.3	Up to 33.5	Up to 26.5	Up to 28.1
Category 5	Up to 34.2	Up to 38.5	Up to 31.8	Up to 33.8

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

d. Determining Storm Tide Height and Flooding Depth

SLOSH and SLOSH related products reference storm tide heights relative to the model vertical datum, in this case NAVD88. In order to determine the inundation depth of storm tide 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 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 NAV88.

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 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 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[3].

As part of the Statewide Regional Evacuation Study, all coastal areas as well as areas surrounding Lake Okeechobee were mapped using remote sensing laser terrain mapping (LIDAR[4]) 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 USGS 7 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 the ***Storm Tide Atlas***.

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[3] 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.

[4] Light Imaging Detection and Ranging

e. Variations to Consider

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

(1) Storm Surge & Wave Height

Regarding interpretation of the data, it is important to understand that the configuration and depth (bathymetry) of the Atlantic 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. Those regions which 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. Wave height is NOT calculated by the SLOSH model and is not reflected within the storm tide delineations.

In the North Central region, the highest surge value occurs to the north of the point of landfall due to the counter-clockwise motion of the storm. Storm surge values increase rapidly to the south of the eye's landfall and fall off gradually to the north once again. This is also the result of the counter-clockwise motion of the storm, aided by the "damming effect" of the high winds within the hurricane. A hurricane will produce various peak surge values along the coastline.

(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. For example, a minimal hurricane or a storm further off the coast, could cause extensive beach erosion and move large quantities of water into interior lowland areas. In the newest version of the North Central Florida 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

The size of the storm and radii of maximum winds has a significant effect upon the potential storm surge. As indicated previously, the size of the storm or radius of maximum winds (RMW) can have a significant impact on storm surge. All of the hypothetical storms were run at two different sizes, 25 mile radius of maximum winds and 30 mile radius of maximum winds.

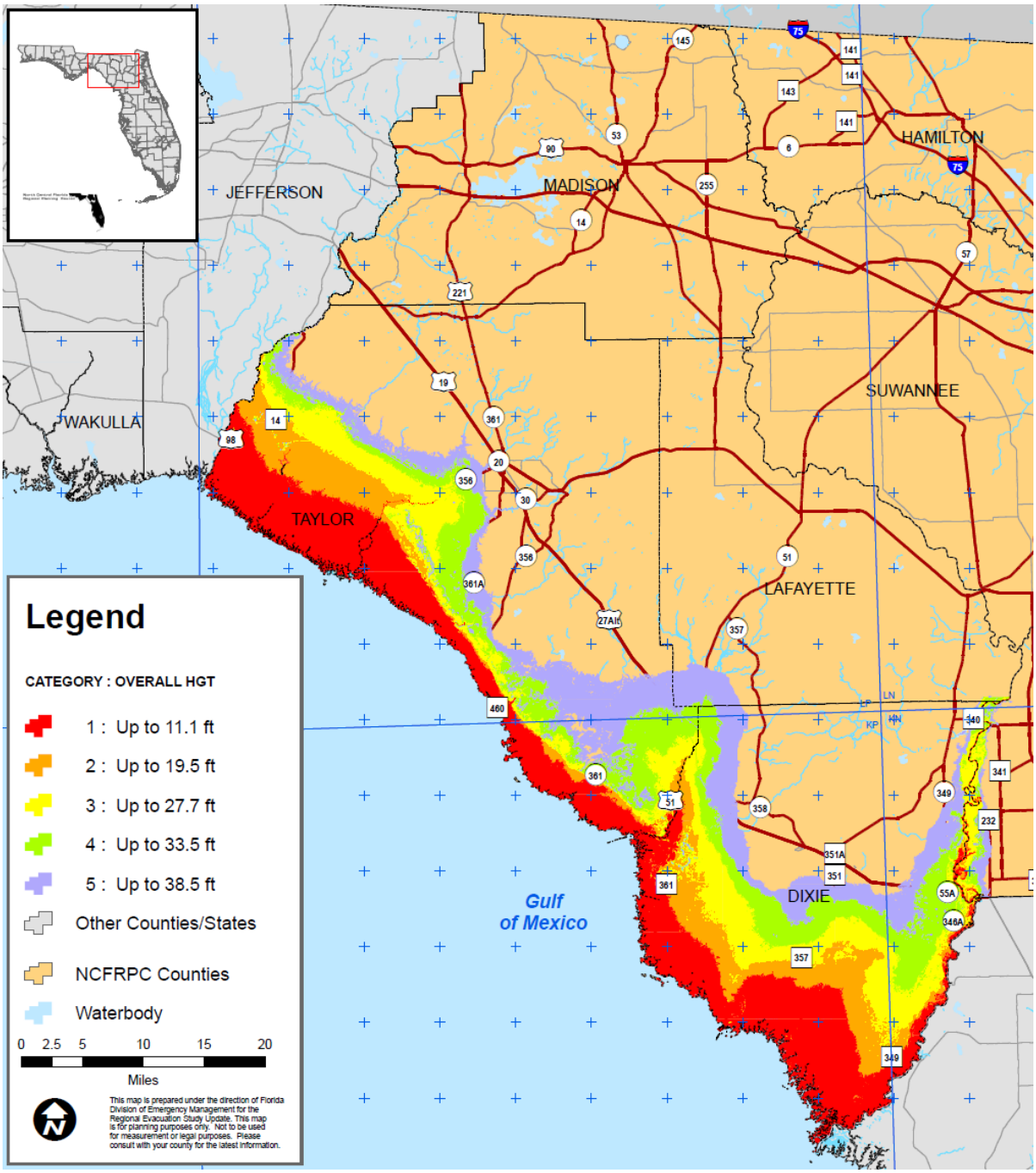
(4) Astronomical Tides

Surge heights were provided for both mean tide and high tide. Both tide levels are referenced to North American Vertical Datum of 1988. The storm tide limits reflect high tide in the region.

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 North Central Florida Region.* The *Atlas* was prepared by North Central Florida Regional Planning Council under contract to the State of Florida, Division of Emergency Management, as part of this statewide study effort. The maps prepared for the *Atlas* consist of base maps (1:24,000) including topographic, hydrographic and highway files. 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.

Figure II- 3: Storm Tide Limits for the North Central Florida 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 still water 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.**

4. Hurricane Wind Analysis

As discussed previously, hurricane winds are a devastating element of the hurricane hazard. Based on the Saffir-Simpson Hurricane 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 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 the 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 dangerous as well. For this reason, emergency managers plan for their evacuations to be 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, particularly higher stories, are vulnerable to hurricane-force winds 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, 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 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 remaining 50-60 mph during most of that period.

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: NOAA 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.

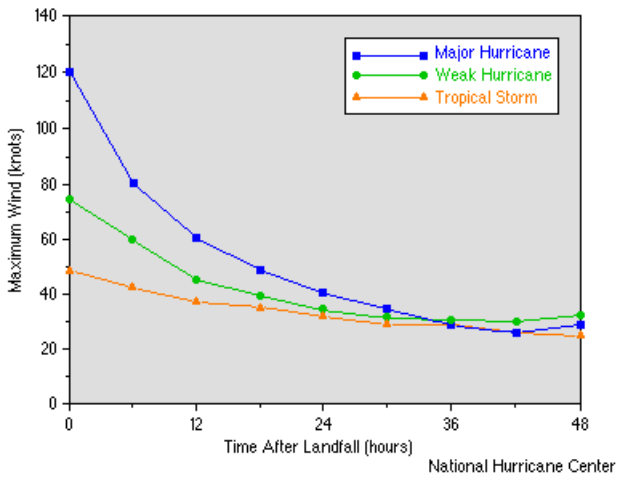
Onshore winds at the coast will decrease as the storm system moves across the land as a result of friction characteristics. The National Hurricane Center has developed adjustment ratios to account for this effect. In addition, as the wind path continues around the storm, further reduction in wind speed 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.

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. It also illustrates how 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: http://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).[5] 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

[5] 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.

"maximum of wind" analysis.[6] Figures II-5 and II-6 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] 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

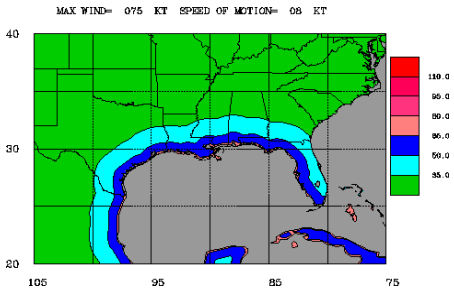
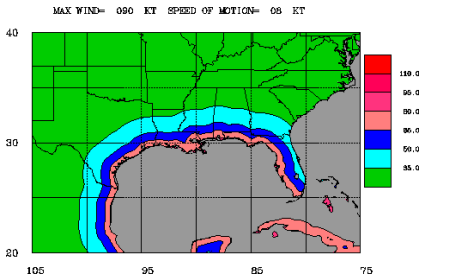
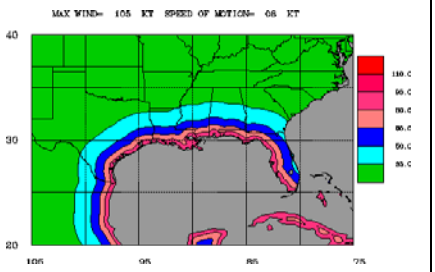
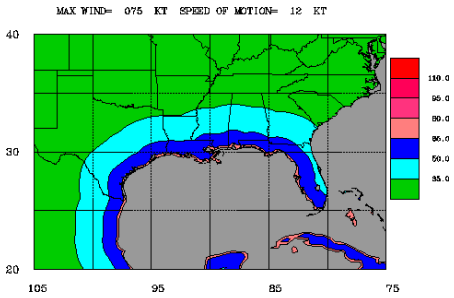
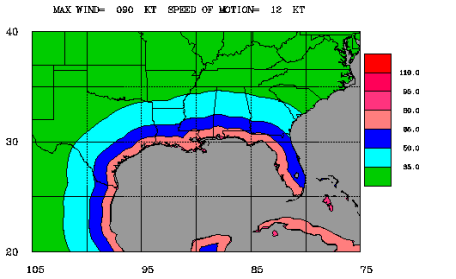
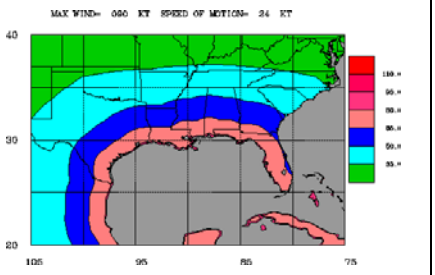
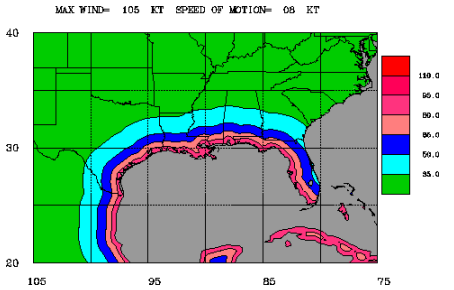
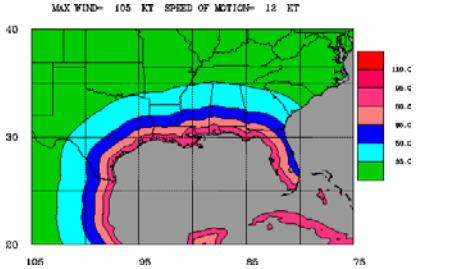
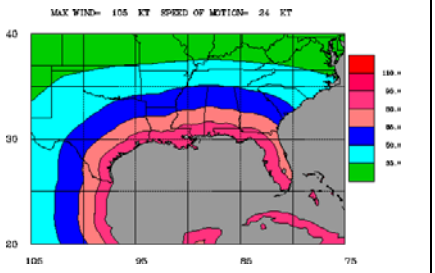
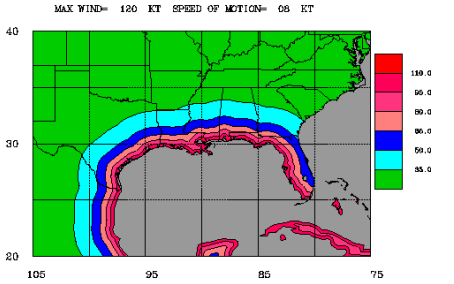
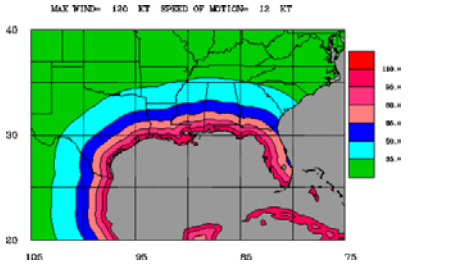
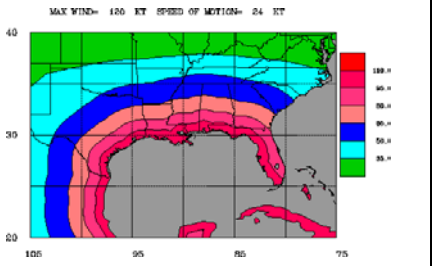
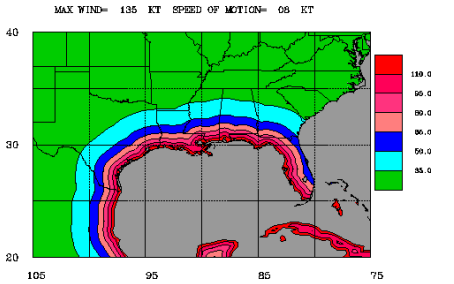
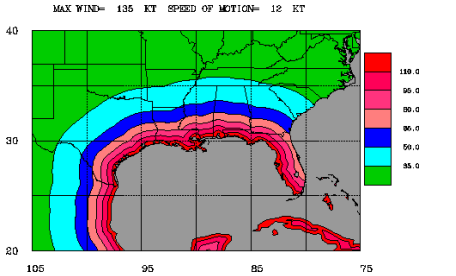
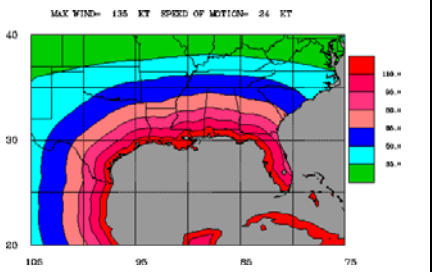
CAT	Forward Speed – 8mph	Forward Speed – 12mph	Forward Speed – 24 mph
1			
2			
3			
4			
5			

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

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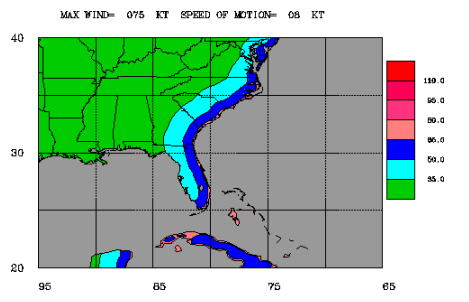
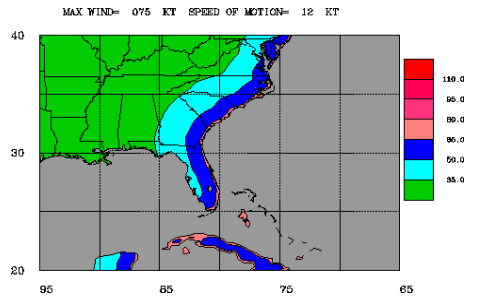
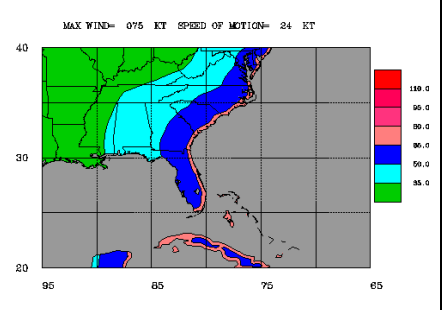
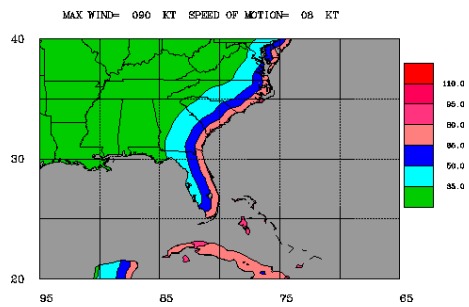
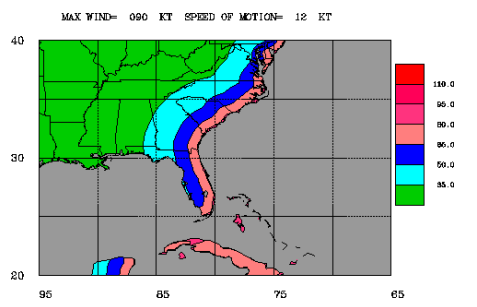
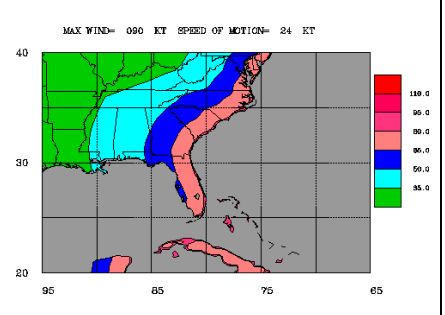
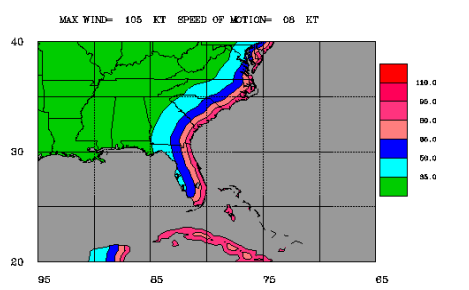
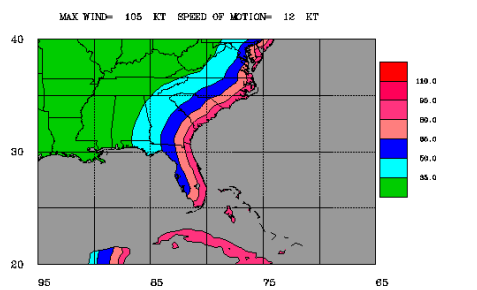
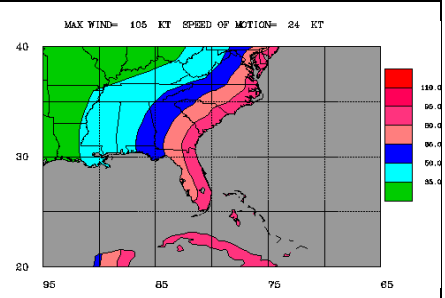
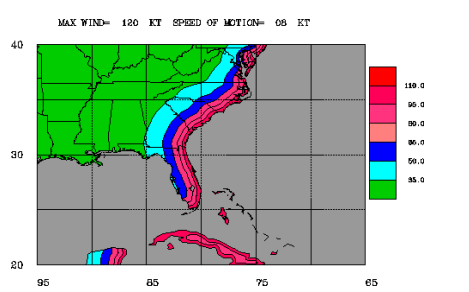
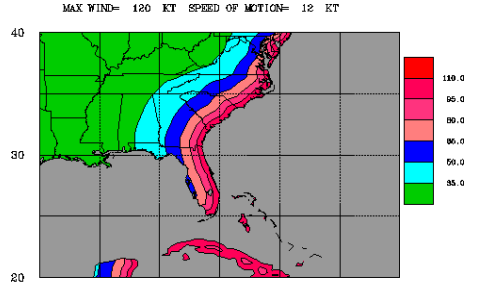
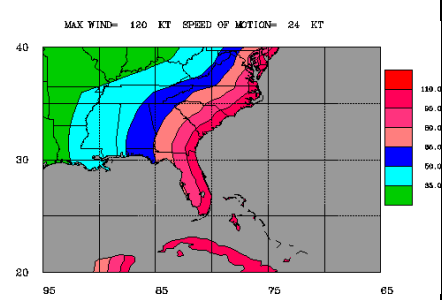
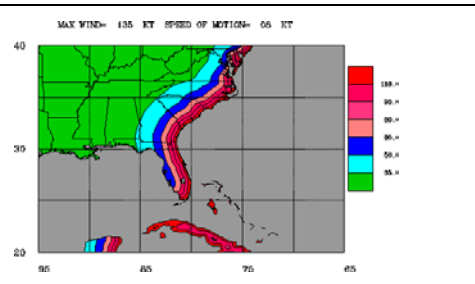
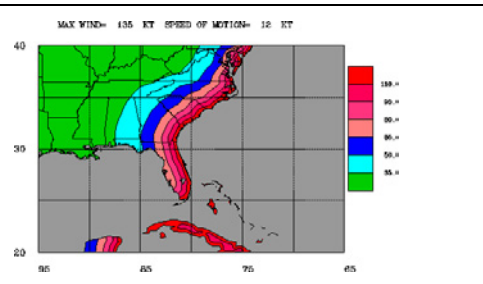
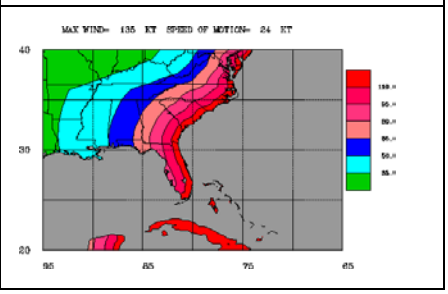
1			
2			
3			
4			
5			

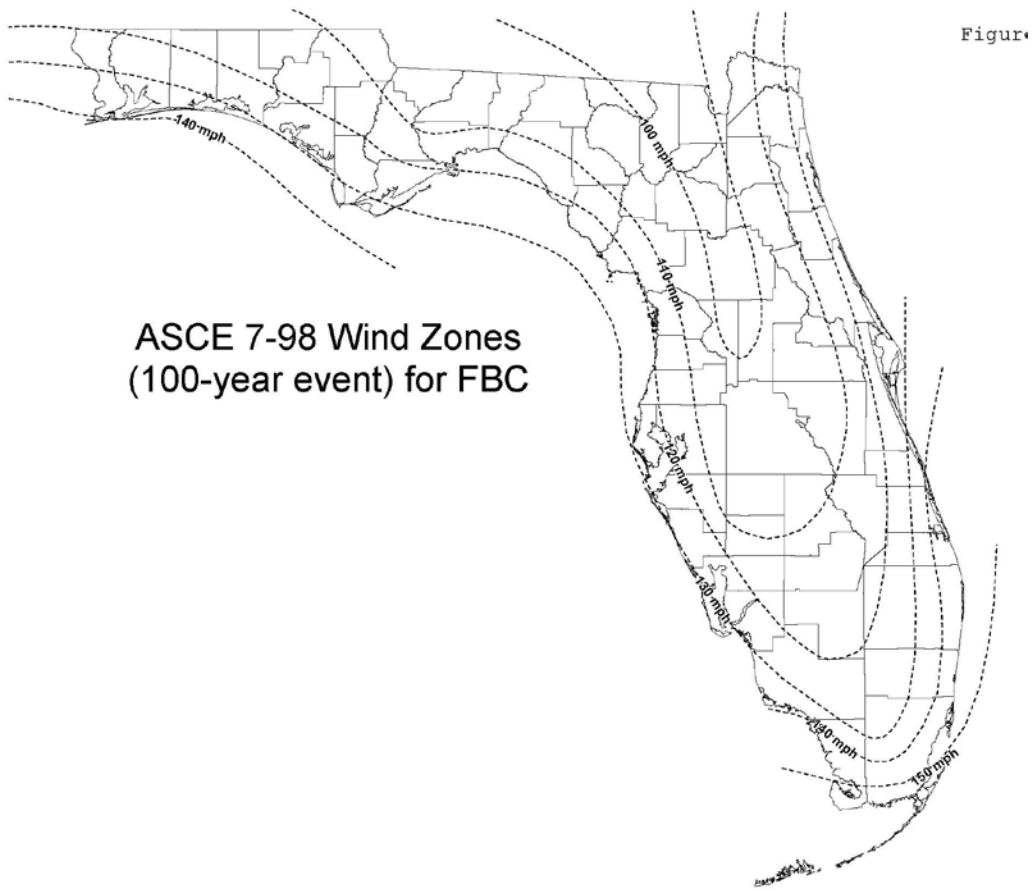
(source: www.nhc.noaa.gov/aboutmeow.shtml)

b. Florida Building Code Wind Risk Assessment

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 upon wind hazard associated with hurricanes. To establish variable building standards for locales throughout Florida, the American Society of Civil Engineer's Standard 7 for the 1998 (ASCE 7-98) was adopted. The ASCE 7-98 provides wind risk assessments for areas throughout Florida along with associated building standards.

Figure II- 7: Wind Risk Assessment: Florida Building Code

Source:

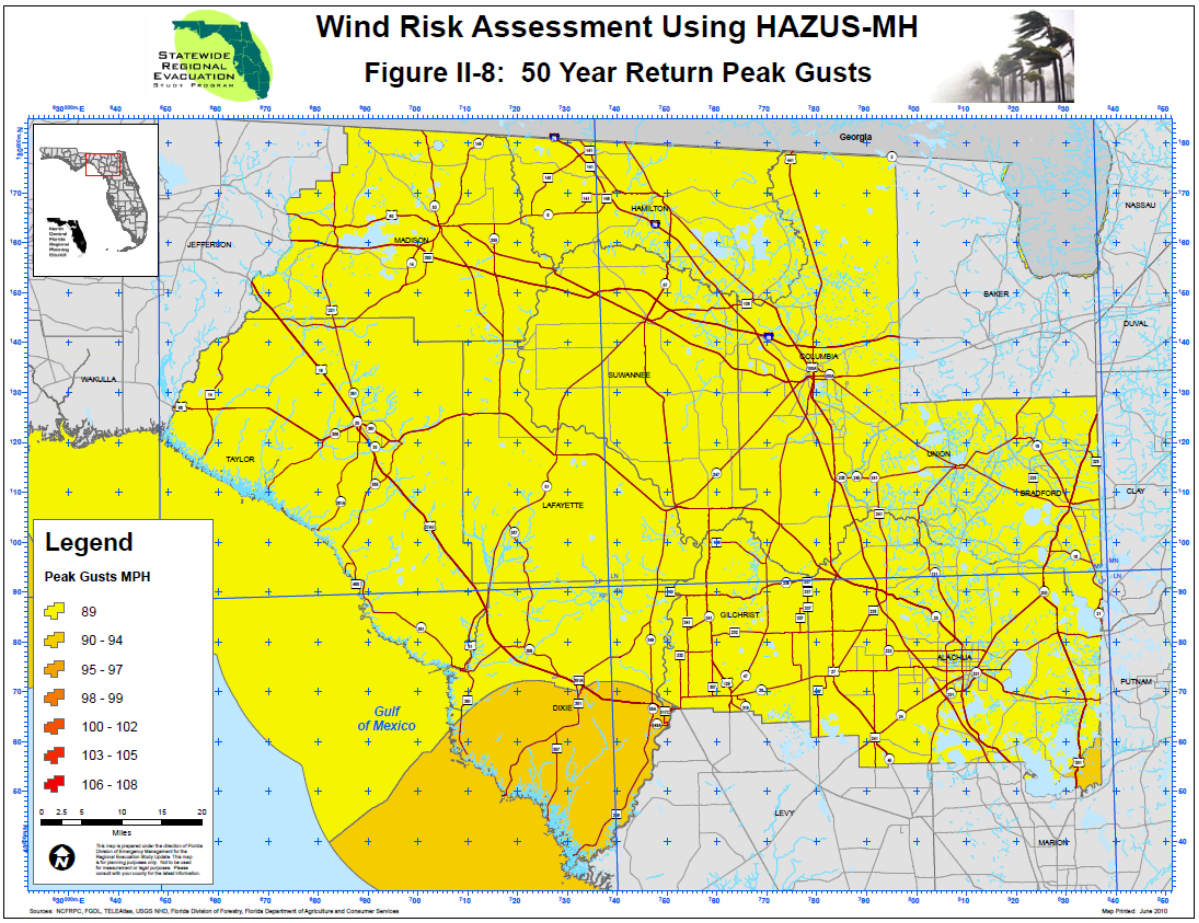


FBC: Florida Building Code 2001, Chapters 2, 16, 17, & 22
ASCE 7-98: "Minimum Design Loads for Buildings and Other Structures", by American Society of Civil Engineers.

c. Wind Risk Assessment: HAZUS

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.

Figure II- 8: 50 Year Return Peak Gusts (using HAZUS)



5. Tornadoes

In general, tornadoes associated with hurricanes are less intense than those that occur in the Great Plains (see the **Enhanced Fujita-Pearson Tornado Intensity Scale** [7]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.

[7] The Enhanced F-scale is a set of wind estimates (not measurements) based on damage. Its 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.

Sixty–nine percent of all tornadoes are weak tornadoes, F0-F2 categories. Twenty-nine percent of all tornadoes are strong and can last 20 minutes or longer. Two percent of all tornadoes fall into the F-4 and F-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. There is 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.

Table II- 5: Enhanced Fujita-Pearson Tornado Intensity Scale

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 136-165 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 >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
Windspeed F scale		17 m/s – 32	32 – 50	50 – 70	70 – 92	92 – 116	116 – 142
		F0	F1	F2	F3	F4	F5
		40 mph – 73	73 – 113	113 – 158	158 – 207	207 – 261	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

6. Hazardous Materials and Hurricanes

Like Murphy's Law, sometimes one emergency event can trigger another. Facilities which 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 North Central region.

The geo-coded inventory of the Section 302 facilities is included in the **Critical Facility Inventory Data Base**. The maps depicting the 302 facilities are included in the Appendices. The database 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 resident's days after as swollen rivers and streams breach their bank or levees.

As noted previously, due to Tropical Storm Fay's very slow motion, storm-total rainfall amounts in some areas were staggering including a few locations in North Central Florida which 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. In regards to hurricane evacuation, however, rainfall may cause the early inundation of roadways sought as evacuation routes. 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/ emergency response personnel. These routes, including those which

were inundated or forced to close during recent flooding events, are presented on maps in Chapter IV Appendices.

Flooding from TS FAY on SR 46

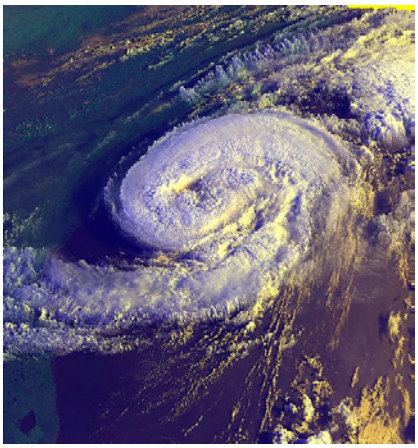
Contingency plans including rerouting, sandbagging and pumping will be coordinated with local and state law enforcement and the State Department of Transportation. The impacts of road closures, rain and ambient conditions on evacuation times are addressed in the transportation analysis.

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 is expected. Hourly records of rainfall rates and accumulation from past hurricanes indicate that rates high enough to surpass drainage capabilities normally parallel the arrival of sustained tropical storm-force winds. Utilizing 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 North Central Florida Region

Hurricanes are a natural yet very dangerous phenomenon and one for which the North Central Florida region must always be prepared. Packing 74-200 mph winds and extensive storm surge, hurricanes represent a serious threat to the safety of residents and visitors and 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 including 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 1920's demonstrates that hurricane activity appears cyclical and after a time of relative inactivity since the early 1960's, the state of Florida and the North Central region are in a more active period.



Hurricane Bonnie. Photo Courtesy of NASA

Until the 1840's, Florida hurricanes were only experienced in cities and ports along the east coast, the northwest panhandle and the Keys. Then 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.

Historians identify a flurry of major hurricane activity in the late 20's, the 1930's and 1940's. The 1920's 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 1200 people (Barnes, 1998 and Blake, 2007).

Florida and the Gulf coast states were hit hard in the 30's by both the Great Depression and hurricanes. Many seniors still remember the horrifying storm of 1935 which swept across the Florida Keys killing 400.

In the 40's, 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, later to become the National Hurricane Center, helped to evacuate low-lying areas along the coast and were credited with saving many lives. The large storm was 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 especially to Florida's citrus crop (approximately $5 million). In 1950, Hurricane Easy parked itself over the west coast of Florida, drenching residents with record-breaking rains. The storm's double-loop track caused it to strike the Tampa Bay region twice in one 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 50's, 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 1960's and 70's, hurricane activity 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- both of which made landfall in 1979 - the 1970's 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 experienced explosive population growth along the coast.

Hurricane Dora crossed Florida from east to west during September 9-12 before turning to southern Georgia. On September 13-16, Dora produced over 20 inches of rainfall and caused flooding throughout one-third of the State of Florida, extensively affecting the St. Mary's, Santa Fe and Steinhatchee River basins. An estimated $150 million in losses were reported, affecting residential, commercial and agricultural operations.

Tropical Storm Josephine impacted Florida's West Coast with 70 mph winds before exiting through the northeast portion of the state. Sixteen counties experienced extensive damage, with losses estimated near $45 million.

The state of Florida was spared the direct hit of a major hurricane in the 1980's, 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** approached within 80 miles of the west coast of Florida. Evacuations in Louisiana, Mississippi, Alabama and Florida were of unprecedented proportions. Almost 1 million residents and visitors were affected in the initial evacuation orders in the Florida panhandle and coastal region of Alabama, Mississippi and Louisiana. As the storm turned and the warnings shifted, 10 additional Florida counties were ordered to evacuate. 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.

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 Hurricane Georges. Hurricane Andrew struck the east coast near Homestead on August 24, 1992 and Hurricane Opal struck the panhandle in 1995. Hurricane Mitch (1998) made landfall in Honduras and killed tens of thousands.

Hurricane Andrew, a category 5 hurricane**,** affected the entire state in many ways. Only two other hurricanes in history, both category 5 storms - the Labor Day storm of 1935, Camille in 1969 - were stronger than Hurricane Andrew when they made landfall in the United States. Hurricane Andrew struck South Florida with a storm surge of over 16 feet and winds gusting over 175 mph. The scale of the disaster was enormous and the massive recovery was of epic proportions. The damages surpassed $50 billion, affecting emergency management policies and procedures, 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 Nino* 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 with two tropical storms and two hurricanes striking 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 region has experienced both evacuations and impacts from exiting storms. In addition, 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 crossed central Florida on August 14th and passed through the Orlando area with a maximum sustained winds of 75 kt and a reported gust of 91 kt. The storm moved off shore near Daytona Beach two hours later with winds between 65 and 70 kt. Charley was the strongest hurricane to hit the United States since Andrew in 1992 and, although small in size, it caused catastrophic wind damage throughout North Central Florida. Hurricane Charley resulted in approximately 5 inches (gauges) to 6-8 inches (radar estimated) of rain in the Central Florida area. The storm produced nine tornadoes in Florida, three of which occurred in the North Central Florida region (one in Osceola County and two in Volusia County). The strongest of all tornadoes was in south Daytona Beach producing a quarter mile of F1 storm damage. Ten total deaths in the United States were associated with Hurricane Charley, one in Orange County. The estimated total damage resulting from the storm was approximately 14 billion dollars (6.7 billion in Florida), making Charley the second costliest hurricane in U.S. History.
(www.nhc.noaa.gov)

August 25 – Sept. 8, 2004 – Hurricane Frances was a Cape Verde-type hurricane reaching 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. Landfall occurred over the southern end of Hutchinson Island, Florida on September 5, 2004 at 0430 UTC as a Category 2 after a slight weakening after is passed over the Gulf Stream. Wind gauges in Fort Pierce, Florida reported sustained winds of 70 kt with a gust of 94 kt. As the hurricane moved slowly west-northwest over Florida, it continued to weaken to tropical storm winds before moving offshore near New Port Richey on the morning of September 6th. The storm then made another and final landfall in the Florida Big Bend area on September 6th and moved over Alabama, western Georgia, Virginia and into the Northeastern U.S.

Hurricane Francis Photo Courtesy of NASA

Hurricane Frances produced a recorded storm surge of 5.89 ft above mean sea level at the St. Lucie Lock on the east coast and an estimated 6 foot storm surge around Cocoa Beach, Florida. Heavy rains and freshwater flooding associated with the Hurricane were widespread throughout the eastern United States with 15.08 inches in Port Orange. Hurricane Frances was directly responsible for five deaths in Florida and an estimated 9 billion dollars in damage. Space and military facilities in Cape Canaveral reported over $100 million in damage.(*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 south east 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 kt 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 resulting 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, 14 of which occurred. The U.S. deaths in the U.S. were cause by: tornado (7), storm surge (5), fresh water floods (4), mud slides (4), wind (3), and surf (2).

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. Extensive beach erosion caused severe damage to or the destruction of numerous beachfront homes, 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 spread well inland damaging homes and downing tress 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 causing major flooding in Haiti resulting in more than 3000 deaths. The storm then moved over the Bahamas and finally strengthened to a Category 3 hurricane with 100 kt winds. Jeanne crossed central Florida while weakening and began to recurve around the western periphery of the migratory ridge.

The swath of hurricane winds stretched for 90 nautical miles, affecting the east coast of Florida from Cape Canaveral south to Stuart, Florida. Fort Pierce reported the highest wind gust of 111kt. Sustained hurricane force winds reached inland across half of the peninsula, while tropical force winds were felt around the remainder of central Florida. Hurricane Jeanne weakened to a tropical storm while centered about 30 n mi north of Tampa on September 26th

and weakened to a tropical depression about 24 hours later while moving northward across central Georgia.

East Central Florida experienced upward of 8 inches of rainfall from Hurricane Jeanne, with Osceola, Broward and Indian River Counties reporting 11 to 13 inches. Port Canaveral (Trident Pier) reported a storm surge of 3.8 feet above normal tides levels an hour after land fall while the east coast from Melbourne south to Ft. Pierce most likely experienced a storm surge flooding of up to 6 feet. Areas still flooded from Frances (three weeks prior) received additional flood waters. *(www.nhc.noaa.gov)*

b. The 2005 Hurricane Season

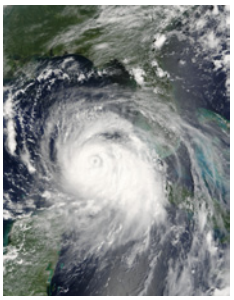
The impact of the 2005 Atlantic hurricane season and the resulting death, injury, destruction, and population displacement were unprecedented in U.S. history. During 2005, 15 tropical storms became hurricanes. For the first time, four major hurricanes made landfall in the United States; three reaching 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 causing thousands more to seek shelter. 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 United States. *(http://www.cdc.gov/mmwr/mguide_nd.html)*

August 23 -30, 2005 - Hurricane Katrina was a large and intense hurricane that struck a vulnerable portion of the United States coastline along the northern Gulf of Mexico, 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.



Hurricane Katrina, Courtesy of NASA

The total number of fatalities known, as of this writing, to be either directly or indirectly related to Katrina is 1336, based

on reports to date from state and local officials in five states: 1090 fatalities in Louisiana, 228 in Mississippi, 14 in Florida, 2 in Georgia, and 2 in Alabama. Especially for Louisiana and Mississippi, the number of direct fatalities is highly uncertain and the true number might not ever be known.

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 probably were 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 fresh water floods produced the majority of fatalities due to tropical cyclones during the past few decades, 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.

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 8000 lives, and it appears to be surpassed by the 1928 Lake Okeechobee, Florida hurricane with over 2500 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 2000 people, while another struck Georgia and South Carolina and claimed somewhere between 1000 and 2000 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. Thousands of homes and businesses throughout entire neighborhoods in the New Orleans metropolitan area were destroyed by flood. Strong winds 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 upon 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 fresh

water 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. Katrina left approximately 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 coasts of Mississippi and Alabama. 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. 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 and 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 far and away the costliest hurricane in United States history. 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)*

September 18-26, 2005 - Hurricane 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, devastating coastal communities in southwestern Louisiana. Its winds, rain and tornadoes caused fatalities and a wide swath of damage from eastern Texas to Alabama. Additionally, Rita 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)*

October 15-25, 2005 - Hurricane 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 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 kt as it approached Florida. Maximum sustained winds were estimated to be near 105 kt (category 3 intensity) when landfall occurred in southwestern Florida near Cape Romano on October 24th. Continuing to accelerate and now moving at a forward speed of 20 to 25 kt, the hurricane crossed the southern Florida peninsula in 4.5 hours with the center emerging into the Atlantic just southeast of Jupiter, Florida. Maximum winds had decreased to near 95 kt (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 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 estimate 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. Tropical Storm Alberto also crossed the eastern Florida panhandle.

August 24 - September 1, 2006- Hurricane Ernesto Hurricane Ernesto initially made land fall at approximately 0300 UTC on August 30th at Plantation Key in the upper Florida Keys. A second landfall occurred in southwestern Miami-Dade County almost two hours later with sustained winds of 40 kt. With sustained tropical storm winds of 35 kt, Ernesto traveled northward over Florida, passing over Lake Okeechobee and turned north northeast and moved offshore near Cape Canaveral early on August 31st. Ernesto then made another landfall on Oak Island, North Carolina with winds between Hurricane 1 and Tropical Storm Status and continued to weaken as it moved across North Carolina and up the eastern states.

The strongest sustained winds associated with Hurricane Ernesto were recorded on Lake Okeechobee and measured 35 kt. It is estimated at landfall the hurricane's winds were approximately 40 kt.

Storm surge associated with Hurricane Ernesto reached about 3 feet at Wrightsville Beach, NC with a total water rise (storm tide) of almost 6 feet in some locations. While the larger metropolitan areas of South Florida received 1-2 inches of rain, areas from Cape Canaveral to Lake Okeechobee experienced 3-6 inches of rain as the storm traversed the Florida peninsula.

Two of the five tornadoes reported to be associated with Hurricane Ernesto touched down in Osceola County during the afternoon on August 30th.

It is estimated the total losses in the U.S. from Hurricane Ernesto totaled approximately $500 million.

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 (five), and is tied as the fifth most active in terms of hurricanes (eight) since 1944, which was the first year aircraft missions flew into tropical storms and hurricanes (www.nhc.noaa.gov).

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). *(www.nhc.noaa.gov)*

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

- 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). 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 receiving as much as 25 inches of rain. Millions of dollars in damage and 15 deaths were caused in Florida by Fay. *(www.nhc.noaa.gov)*

Though Florida was spared a direct hit from a major hurricane, Floridians saw major flooding throughout the state from Tropical Storm Fay. After crossing the state, Tropical Storm Fay slowly moved along Florida's eastern coastline, bringing extensive flooding to the East Central Florida region. The six counties in the region, Brevard, Lake, Orange, Osceola, Seminole, and Volusia experienced more than 1,150 inches of total rainfall over five days. The City of Melbourne in Brevard County recorded more than 11" of rainfall in one twenty four hour period, flooding approximately 80 neighborhoods with homes under nearly 3-5 feet of water. A maximum rainfall total of 27.65" was recorded at Windover Farms, 8 miles northwest of the city.

After the storm had passed over the region, the St. John's River which runs north along portions of Brevard, Seminole, Lake, and Volusia Counties, continued to rise causing major flooding events in De Land (Volusia County) and Sanford and Geneva (Seminole County). Many roadways and homes were

damaged as the river's water level continued to climb even after the storm had passed over the area.

Preliminary assessments indicate at least 2300 homes received flood damage from Tropical Storm Fay with early flood damage assessments of over $33 million in the East Central Florida Region alone. Home and infrastructure damage in Brevard County was estimated to be nearly $10 to $12 million *(ECFRPC).*

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.nhc.noaa.gov)

9. Probability of Future Hurricane Events

Table II-6 provides the number of direct hits on the mainland U.S. coastline (1851-2006) for individual states. Florida is divided into four sections. The North Central region is located in the Northeast area. (Please note that the Florida Keys are included in the Southwest area.)

Table II- 6: U.S. Mainland Hurricane Strikes by State (1851-2006)

Area	Category 1	2	3	4	5	All (1-5)	Major (3-5)
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 (1900-2006) by month. Most major hurricanes occur in the later part of the hurricane season in September, October and November.

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

	Jun	Jul	Aug	Sep	Oct	All
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 (Figures II-9 – 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 various locations and travel much different paths from the average. Nonetheless, having a sense of the general pattern can give a better picture of the average hurricane season for an area.

Figure II- 9: Prevailing Tracks - June

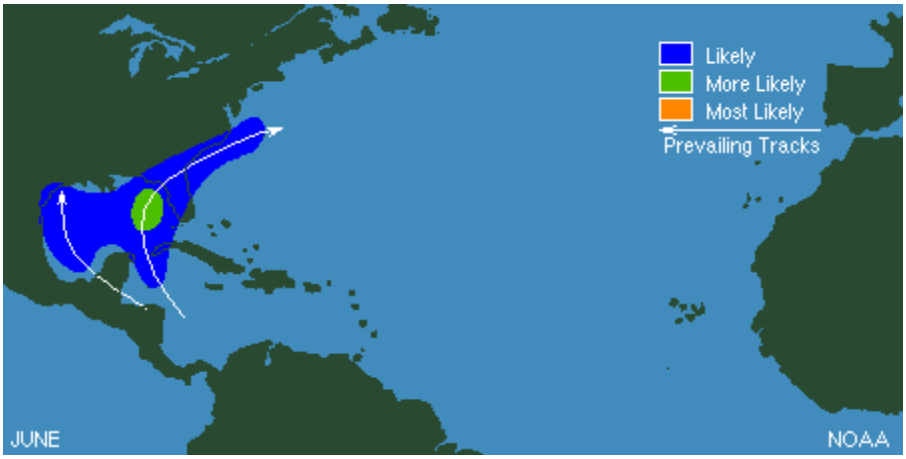


Figure II- 10: Prevailing Tracks - July

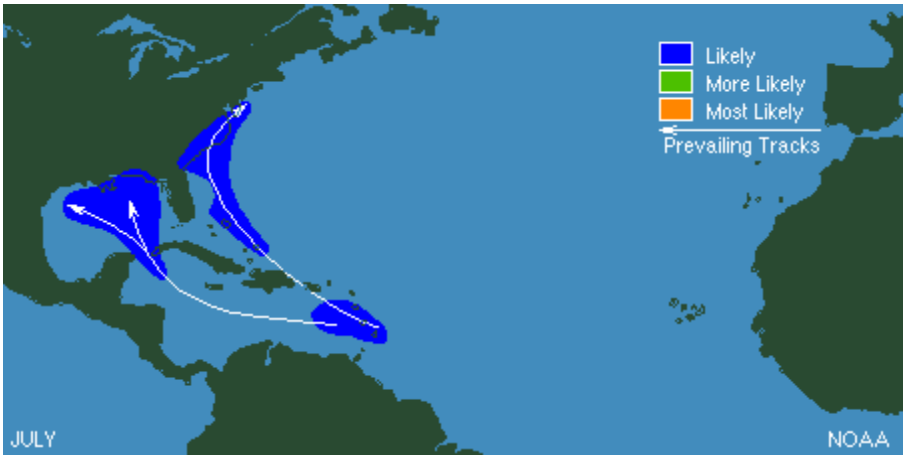


Figure II- 11: Prevailing Tracks - August

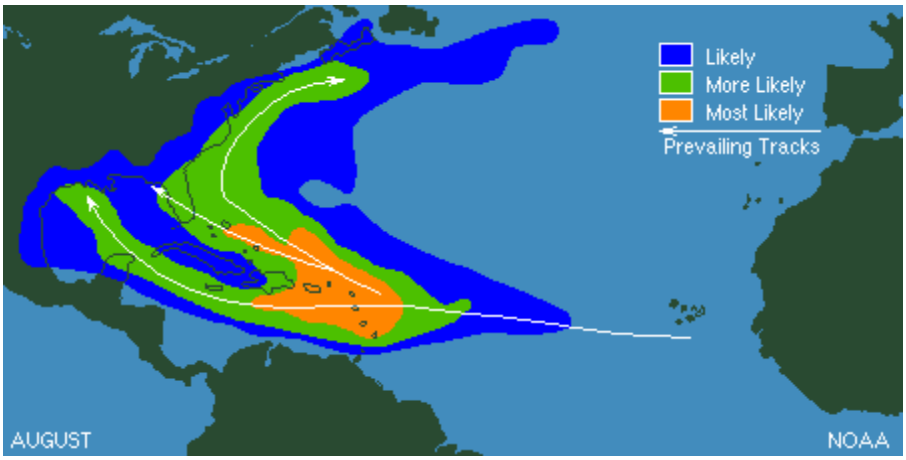


Figure II- 12: Prevailing Tracks - September

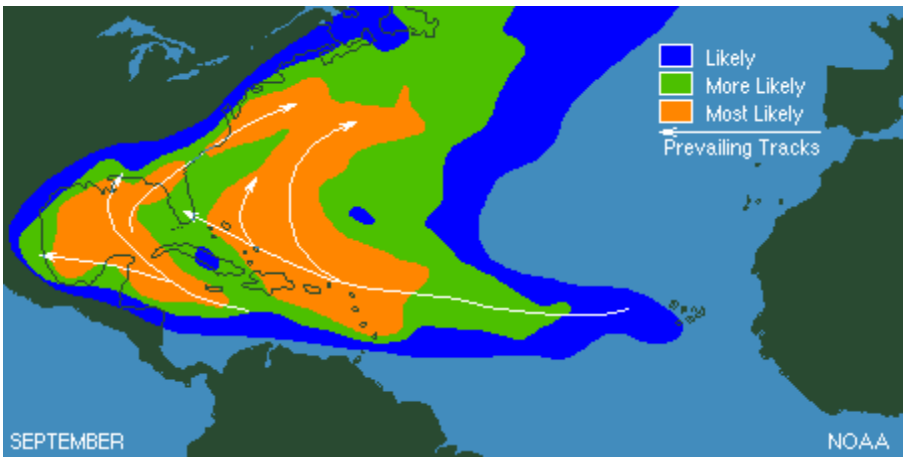


Figure II- 13: Prevailing Tracks - October

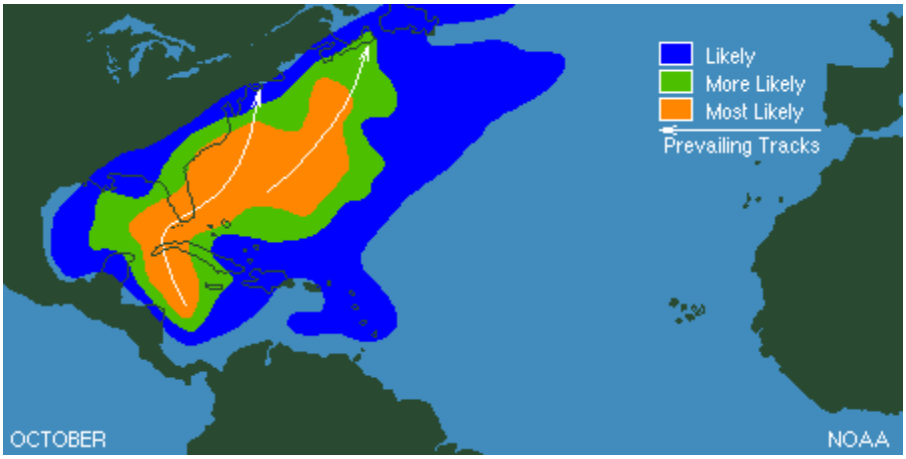
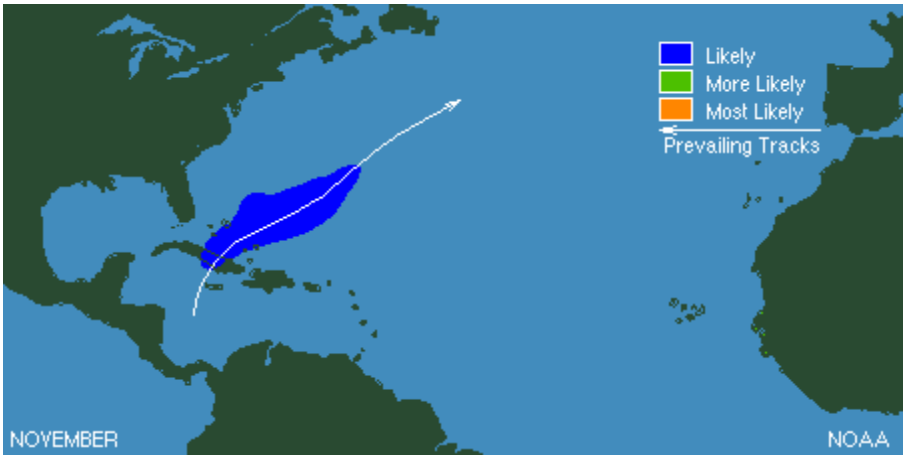


Figure II- 14: Prevailing Tracks - November



b. NOAA Historical Analysis for the North Central Florida 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 two selected points in the North Central Region: Dekle Beach and Horseshoe Point, Florida. Using an historical analysis, return intervals were developed for the North Central Florida Region and presented in Tables II-8a-b.

Table II- 8: Tropical Storms and Hurricanes within 100 NMi of Dekle Beach 1870 - 2007

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF DEKLE 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	1871	AUG	18	3	70(60)	56 (E)	352/ 7.2
2	NOT NAMED	1871	AUG	26	4	50(40)	4 (SW)	314/ 8.0
3	NOT NAMED	1871	SEP	6	6	70(70)	50 (SE)	050/ 9.2
4	NOT NAMED	1871	OCT	5	7	60(55)	17 (NNW)	055/ 8.1
5	NOT NAMED	1873	SEP	19	3	70(70)	27 (NW)	041/21.8
6	NOT NAMED	1874	SEP	28	6	70(70)	57 (SE)	035/19.6
7	NOT NAMED	1875	SEP	27	4	46(33)	71 (NNW)	060/ 9.9
8	NOT NAMED	1877	SEP	20	2	55(43)	69 (NNW)	077/ 8.8
9	NOT NAMED	1877	OCT	3	4	100(70)	69 (NW)	047/11.7
10	NOT NAMED	1877	OCT	26	7	40(40)	35 (SSE)	076/26.9
11	NOT NAMED	1878	SEP	10	5	90(77)	89 (SE)	041/ 6.7
12	NOT NAMED	1878	OCT	11	8	50(40)	45 (NNW)	066/27.6
13	NOT NAMED	1879	OCT	27	7	60(60)	69 (SSE)	057/26.0
14	NOT NAMED	1880	AUG	30	4	70(70)	36 (SSW)	300/ 8.0
15	NOT NAMED	1880	SEP	8	6	50(50)	8 (SE)	043/19.1
16	NOT NAMED	1880	OCT	8	9	70(70)	73 (SE)	050/22.5
17	NOT NAMED	1882	OCT	11	6	70(63)	24 (ESE)	032/ 8.2
18	NOT NAMED	1885	AUG	31	3	50(43)	51 (NNW)	071/18.2
19	NOT NAMED	1885	SEP	21	4	48(43)	34 (NNW)	077/24.9
20	NOT NAMED	1885	OCT	11	8	60(55)	26 (ESE)	020/14.9
21	NOT NAMED	1886	JUN	21	2	85(85)	22 (W)	003/14.0
22	NOT NAMED	1886	JUL	1	3	85(70)	53 (NW)	046/20.6
23	NOT NAMED	1886	JUL	19	4	70(63)	73 (SE)	038/10.1
24	NOT NAMED	1888	SEP	9	5	50(47)	33 (E)	007/ 9.3
25	NOT NAMED	1888	OCT	11	7	95(95)	48 (SE)	049/23.0
26	NOT NAMED	1889	JUN	17	2	45(45)	60 (SE)	049/15.1
27	NOT NAMED	1893	JUN	15	1	60(60)	4 (NW)	047/22.3
28	NOT NAMED	1894	OCT	9	5	98(83)	75 (NW)	055/17.7
29	NOT NAMED	1896	SEP	29	4	110(100)	40 (ESE)	025/29.2
30	NOT NAMED	1898	AUG	2	1	70(60)	48 (SW)	314/13.2
31	NOT NAMED	1899	AUG	1	2	85(85)	55 (WSW)	333/ 5.7
32	NOT NAMED	1900	OCT	12	6	40(40)	23 (SSE)	064/17.6
33	NOT NAMED	1901	JUN	13	1	35(35)	53 (W)	355/10.0
34	NOT NAMED	1901	SEP	28	9	40(40)	50 (W)	005/18.1
35	NOT NAMED	1902	JUN	14	1	50(50)	2 (WNW)	016/10.3
36	NOT NAMED	1903	SEP	13	3	80(77)	83 (SW)	307/ 6.6
37	NOT NAMED	1907	JUN	29	1	48(46)	54 (NNW)	076/20.4
38	NOT NAMED	1907	SEP	29	3	43(40)	73 (NNW)	062/23.0
39	NOT NAMED	1909	JUN	30	3	35(35)	7 (SW)	314/ 7.2
40	NOT NAMED	1910	OCT	19	5	50(50)	89 (E)	360/ 9.0
41	NOT NAMED	1912	JUL	16	2	40(38)	88 (N)	270/12.5
42	NOT NAMED	1912	SEP	10	4	54(30)	54 (SSW)	270/ 1.2
43	NOT NAMED	1914	SEP	17	1	43(37)	80 (N)	277/12.2
44	NOT NAMED	1915	AUG	2	1	42(40)	95 (ENE)	339/ 7.5
45	NOT NAMED	1915	SEP	4	4	80(80)	92 (W)	355/15.2
46	NOT NAMED	1916	MAY	15	1	35(35)	83 (ESE)	018/ 9.4
47	NOT NAMED	1920	SEP	30	5	53(50)	69 (SSE)	063/28.6
48	NOT NAMED	1924	SEP	16	4	54(47)	69 (NNW)	062/ 8.7
49	NOT NAMED	1924	SEP	29	5	50(50)	3 (SE)	039/27.3
50	NOT NAMED	1926	JUL	29	1	58(47)	59 (NE)	312/10.5
51	NOT NAMED	1928	AUG	9	1	40(35)	13 (NE)	314/ 7.2
52	NOT NAMED	1928	AUG	14	2	50(45)	51 (WSW)	333/10.0
53	NOT NAMED	1928	SEP	17	4	84(82)	86 (E)	007/12.1
54	NOT NAMED	1929	SEP	30	2	91(90)	82 (WSW)	330/ 7.4
55	NOT NAMED	1932	SEP	15	5	45(45)	7 (SSE)	063/22.4
56	NOT NAMED	1933	AUG	20	6	40(40)	20 (W)	004/15.5
57	NOT NAMED	1933	SEP	5	12	48(45)	14 (ENE)	339/ 6.6
58	NOT NAMED	1934	JUL	23	3	40(40)	59 (SSE)	247/15.0
59	NOT NAMED	1935	SEP	4	2	83(72)	9 (ESE)	014/10.4
60	NOT NAMED	1936	AUG	22	9	40(33)	20 (N)	280/13.1

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 29.84N 83.61W.

CHART 1A (Page 1)

Table II-8 (continued)

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF DEKLE 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	1937	AUG	31	3	43(33)	3 (NNE)	297/11.6
62	NOT NAMED	1937	SEP	21	6	40(35)	3 (NNW)	061/ 8.8
63	NOT NAMED	1938	OCT	24	7	40(40)	9 (SE)	056/41.4
64	NOT NAMED	1939	AUG	12	2	70(65)	41 (SSW)	301/ 8.3
65	NOT NAMED	1940	AUG	3	2	35(35)	86 (SSE)	244/10.9
66	NOT NAMED	1941	OCT	7	5	85(85)	56 (W)	356/11.1
67	NOT NAMED	1941	OCT	20	6	45(40)	27 (SE)	050/ 4.6
68	NOT NAMED	1944	OCT	19	11	70(68)	96 (ESE)	015/14.4
69	NOT NAMED	1945	JUN	24	1	88(80)	74 (SSE)	063/10.9
70	NOT NAMED	1946	OCT	8	5	40(37)	60 (E)	006/17.1
71	NOT NAMED	1947	SEP	24	6	50(49)	53 (ESE)	016/18.8
72	NOT NAMED	1947	OCT	8	7	37(25)	19 (SE)	042/16.0
73	NOT NAMED	1949	AUG	27	2	62(52)	40 (E)	352/10.2
74	EASY	1950	SEP	5	5	110(101)	58 (SE)	253/ 3.2
75	KING	1950	OCT	19	11	50(32)	55 (NE)	320/14.6
76	LOVE	1950	OCT	21	13	60(30)	31 (ENE)	265/ 2.1
77	NOT NAMED	1953	SEP	20	7	54(50)	1 (NNW)	075/15.3
78	FLORENCE	1953	SEP	27	8	60(52)	81 (NNW)	074/10.7
79	FLOSSY	1956	SEP	25	7	43(41)	91 (NNW)	060/11.5
80	NOT NAMED	1957	JUN	9	1	35(35)	32 (NW)	045/23.7
81	BRENDA	1960	JUL	29	3	35(30)	36 (ESE)	029/15.3
82	DORA	1964	SEP	11	6	93(68)	16 (N)	278/ 4.4
83	HILDA	1964	OCT	5	10	38(35)	63 (N)	083/17.3
84	ALMA	1966	JUN	10	1	87(60)	37 (NW)	052/ 9.5
85	GLADYS	1968	OCT	19	8	70(70)	81 (SE)	045/12.6
86	BECKY	1970	JUL	22	2	40(29)	73 (WNW)	020/18.2
87	AGNES	1972	JUN	20	2	65(45)	92 (WNW)	023/ 9.8
88	SUBTROP	1976	MAY	23	1	40(40)	10 (NW)	054/21.2
89	SUBTROP	1982	JUN	18	2	47(43)	76 (SE)	039/34.7
90	ISIDORE	1984	SEP	28	10	45(45)	81 (ESE)	015/ 8.2
91	ELENA	1985	SEP	1	5	110(95)	63 (S)	103/ 1.5
92	KATE	1985	NOV	22	11	85(75)	71 (NW)	043/19.2
93	MARCO	1990	OCT	12	13	40(25)	28 (E)	004/16.0
94	BERYL	1994	AUG	16	2	50(47)	94 (WNW)	021/ 9.2
95	ALLISON	1995	JUN	5	1	60(60)	38 (NW)	035/13.5
96	ERIN	1995	AUG	2	5	68(62)	72 (S)	275/11.7
97	JOSEPHINE	1996	OCT	8	10	60(60)	5 (NW)	050/24.9
98	EARL	1998	SEP	3	5	66(53)	80 (NW)	050/19.0
99	GORDON	2000	SEP	18	11	58(45)	31 (ESE)	021/ 9.7
100	HENRI	2003	AUG	5	12	50(50)	98 (SSW)	101/ 3.1
101	BONNIE	2004	AUG	12	2	40(30)	29 (NW)	055/25.3
102	FRANCES	2004	SEP	6	6	55(52)	14 (WSW)	345/ 9.4
103	JEANNE	2004	SEP	27	10	52(40)	22 (ENE)	328/10.4
104	TAMMY	2005	OCT	6	20	38(37)	97 (NNE)	301/13.0
105	ALBERTO	2006	JUN	13	1	57(40)	10 (NW)	034/ 9.5

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 29.84N 83.61W.

CHART 1A (Page 2)

Table II- 9: Tropical Storms and Hurricanes Passing within 100 NMi of Horseshoe Pt. 1870 - 2007

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF HORSESHOE PT 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	1871	AUG	18	3	70(60)	44 (ENE)	338/ 7.4
2	NOT NAMED	1871	AUG	26	4	60(40)	4 (NE)	306/ 7.8
3	NOT NAMED	1871	SEP	6	6	70(70)	20 (SE)	050/ 9.2
4	NOT NAMED	1871	OCT	5	7	60(55)	46 (NNW)	055/ 8.1
5	NOT NAMED	1872	OCT	23	5	50(45)	94 (SSE)	059/15.5
6	NOT NAMED	1873	SEP	19	3	70(70)	55 (NW)	041/21.8
7	NOT NAMED	1873	SEP	23	4	50(47)	79 (SE)	042/16.6
8	NOT NAMED	1874	SEP	28	6	70(70)	30 (SE)	035/19.6
9	NOT NAMED	1877	SEP	20	2	47(40)	95 (N)	084/10.3
10	NOT NAMED	1877	OCT	3	4	77(70)	98 (NW)	047/11.7
11	NOT NAMED	1877	OCT	26	7	42(40)	8 (SSE)	076/26.9
12	NOT NAMED	1878	SEP	10	5	90(78)	60 (SE)	041/ 6.7
13	NOT NAMED	1878	OCT	11	8	47(40)	74 (NNW)	066/27.6
14	NOT NAMED	1879	OCT	27	7	60(60)	40 (SSE)	057/26.0
15	NOT NAMED	1880	AUG	30	4	70(70)	23 (SSW)	300/ 8.1
16	NOT NAMED	1880	SEP	8	6	50(50)	20 (NW)	043/19.1
17	NOT NAMED	1880	OCT	8	9	70(70)	44 (SE)	050/22.5
18	NOT NAMED	1882	OCT	11	6	70(70)	3 (WNW)	032/ 8.2
19	NOT NAMED	1885	AUG	31	3	47(42)	79 (NNW)	071/18.2
20	NOT NAMED	1885	SEP	21	4	47(43)	61 (NNW)	077/24.9
21	NOT NAMED	1885	OCT	11	8	60(60)	2 (ESE)	020/15.0
22	NOT NAMED	1886	JUN	21	2	85(85)	40 (W)	003/14.0
23	NOT NAMED	1886	JUL	1	3	85(70)	82 (NW)	046/20.6
24	NOT NAMED	1886	JUL	19	4	70(65)	46 (SE)	036/10.1
25	NOT NAMED	1887	OCT	30	16	40(39)	81 (SE)	056/16.0
26	NOT NAMED	1888	SEP	9	5	50(48)	16 (E)	354/ 9.3
27	NOT NAMED	1888	OCT	11	7	95(95)	19 (SE)	049/23.0
28	NOT NAMED	1889	JUN	17	2	45(45)	30 (SE)	049/15.1
29	NOT NAMED	1893	JUN	15	1	60(60)	33 (NW)	047/22.3
30	NOT NAMED	1896	SEP	29	4	110(110)	15 (ESE)	024/28.4
31	NOT NAMED	1898	AUG	2	1	70(55)	42 (SW)	313/13.6
32	NOT NAMED	1899	AUG	1	2	85(85)	63 (WSW)	341/ 5.3
33	NOT NAMED	1899	OCT	5	6	50(40)	93 (SE)	045/17.9
34	NOT NAMED	1900	OCT	12	6	40(40)	6 (NNW)	064/17.6
35	NOT NAMED	1901	JUN	13	1	35(35)	68 (W)	360/10.0
36	NOT NAMED	1901	SEP	28	9	40(40)	70 (W)	005/18.1
37	NOT NAMED	1902	JUN	14	1	50(50)	25 (WNW)	015/10.3
38	NOT NAMED	1903	SEP	13	3	80(68)	74 (SW)	307/ 6.6
39	NOT NAMED	1906	OCT	21	8	45(39)	94 (E)	179/ 5.0
40	NOT NAMED	1907	JUN	29	1	48(46)	82 (NNW)	076/20.4
41	NOT NAMED	1909	JUN	30	3	35(35)	2 (SW)	318/ 6.6
42	NOT NAMED	1910	OCT	19	5	58(50)	73 (E)	360/ 9.0
43	NOT NAMED	1912	SEP	10	4	53(30)	46 (SW)	270/ 1.2
44	NOT NAMED	1915	AUG	2	1	47(42)	89 (ENE)	337/ 6.5
45	NOT NAMED	1916	MAY	15	1	36(35)	61 (ESE)	010/ 9.4
46	NOT NAMED	1920	SEP	30	5	55(50)	40 (SSE)	063/28.6
47	NOT NAMED	1921	OCT	25	6	105(102)	84 (SE)	056/11.9
48	NOT NAMED	1924	SEP	16	4	48(47)	98 (NNW)	062/ 8.7
49	NOT NAMED	1924	SEP	29	5	50(50)	25 (NW)	039/27.3
50	NOT NAMED	1926	JUL	29	1	68(50)	66 (NE)	313/10.1
51	NOT NAMED	1928	AUG	9	1	40(35)	19 (NE)	313/ 5.9
52	NOT NAMED	1928	AUG	14	2	50(47)	55 (WSW)	332/ 9.1
53	NOT NAMED	1928	SEP	17	4	88(83)	68 (E)	005/12.1
54	NOT NAMED	1929	SEP	30	2	94(90)	84 (WSW)	327/ 8.3
55	NOT NAMED	1930	SEP	9	2	35(35)	78 (SE)	050/ 4.6
56	NOT NAMED	1932	SEP	15	5	45(45)	22 (NNW)	063/22.4
57	NOT NAMED	1933	AUG	20	6	40(40)	39 (W)	007/ 9.1
58	NOT NAMED	1933	SEP	5	12	52(45)	8 (ENE)	335/ 6.5
59	NOT NAMED	1934	JUL	23	3	40(40)	31 (SSE)	247/15.0
60	NOT NAMED	1935	SEP	4	2	85(75)	11 (W)	007/ 9.2

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 29.44N 83.29W.

CHART 1A (Page 1)

Table II-9 (continued)

TROPICAL STORMS AND HURRICANES PASSING WITHIN 100 NMi OF HORSESHOE PT 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	1936	AUG	22	9	43(35)	41 (N)	280/12.8
62	NOT NAMED	1937	JUL	30	1	40(40)	77 (SE)	046/13.3
63	NOT NAMED	1937	AUG	31	3	46(34)	17 (NNE)	294/11.5
64	NOT NAMED	1937	SEP	21	6	40(33)	32 (NNW)	062/ 8.8
65	NOT NAMED	1938	OCT	24	7	40(40)	20 (NW)	056/41.4
66	NOT NAMED	1939	AUG	12	2	70(63)	32 (SW)	308/ 8.7
67	NOT NAMED	1940	AUG	3	2	36(35)	57 (SSE)	243/10.9
68	NOT NAMED	1941	OCT	7	5	85(85)	70 (WSW)	346/11.9
69	NOT NAMED	1941	OCT	20	6	45(40)	2 (NW)	047/ 4.6
70	NOT NAMED	1944	OCT	19	11	82(70)	74 (ESE)	014/14.5
71	NOT NAMED	1945	JUN	24	1	90(80)	45 (SSE)	063/10.9
72	NOT NAMED	1945	SEP	5	7	35(33)	92 (SW)	303/16.5
73	NOT NAMED	1945	SEP	16	9	75(62)	82 (E)	009/ 9.2
74	NOT NAMED	1946	OCT	8	5	65(38)	41 (E)	006/17.1
75	NOT NAMED	1947	SEP	23	6	50(50)	30 (ESE)	016/ 9.4
76	NOT NAMED	1947	OCT	8	7	35(25)	10 (NW)	042/16.0
77	NOT NAMED	1949	AUG	27	2	65(54)	28 (ENE)	347/10.1
78	EASY	1950	SEP	5	5	110(101)	29 (SE)	253/ 3.2
79	KING	1950	OCT	19	11	60(35)	57 (NE)	322/15.2
80	LOVE	1950	OCT	21	13	62(48)	8 (ESE)	018/18.2
81	NOT NAMED	1953	SEP	20	7	53(50)	28 (NNW)	075/15.3
82	NOT NAMED	1957	JUN	9	1	35(35)	61 (NW)	045/23.7
83	BRENDA	1960	JUL	29	3	35(30)	9 (ESE)	030/15.2
84	DONNA	1960	SEP	11	5	57(56)	99 (ESE)	024/16.3
85	DORA	1964	SEP	10	6	94(75)	40 (N)	268/ 3.5
86	HILDA	1964	OCT	5	10	35(35)	89 (N)	083/17.3
87	ALMA	1966	JUN	10	1	88(60)	67 (NW)	052/ 9.5
88	GLADYS	1968	OCT	19	8	70(70)	52 (SE)	045/12.6
89	SUBTROP	1974	JUN	25	1	53(52)	91 (SE)	049/19.8
90	SUBTROP	1976	MAY	23	1	40(40)	39 (NW)	054/21.2
91	SUBTROP	1982	JUN	18	2	50(43)	48 (SE)	039/34.7
92	ISIDORE	1984	SEP	28	10	45(45)	59 (ESE)	013/10.2
93	ELENA	1985	SEP	1	5	110(96)	47 (SSW)	157/ 1.3
94	MARCO	1990	OCT	12	13	45(28)	10 (E)	001/16.0
95	ALLISON	1995	JUN	5	1	60(60)	65 (NW)	035/13.5
96	ERIN	1995	AUG	2	5	67(60)	51 (SSW)	284/12.7
97	JERRY	1995	AUG	25	10	34(30)	4 (W)	006/ 6.4
98	JOSEPHINE	1996	OCT	8	10	60(60)	34 (NW)	050/24.9
99	GORDON	2000	SEP	18	11	60(55)	6 (ESE)	021/ 9.7
100	HENRI	2003	AUG	5	12	50(50)	83 (SSW)	127/ 4.2
101	BONNIE	2004	AUG	12	2	38(30)	59 (NW)	055/25.3
102	FRANCES	2004	SEP	6	6	55(54)	25 (WSW)	344/ 9.4
103	JEANNE	2004	SEP	27	10	58(43)	22 (NE)	326/ 9.5
104	ALBERTO	2006	JUN	13	1	58(42)	38 (NW)	033/ 9.5
105	BARRY	2007	JUN	2	2	37(32)	54 (ESE)	018/28.8

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 29.44N 83.29W.

CHART 1A (Page 2)

Table II- 10: Summary for Hurricanes and Tropical Storms

Number of Years: 137 Number of Hurricanes and Tropical Storms: 80 Mean Number of Occurrences Per Year 0.58 Mean Recurrence Interval: 1.71 Years

Figure II- 15: Hurricane Return Intervals for Dekle Beach

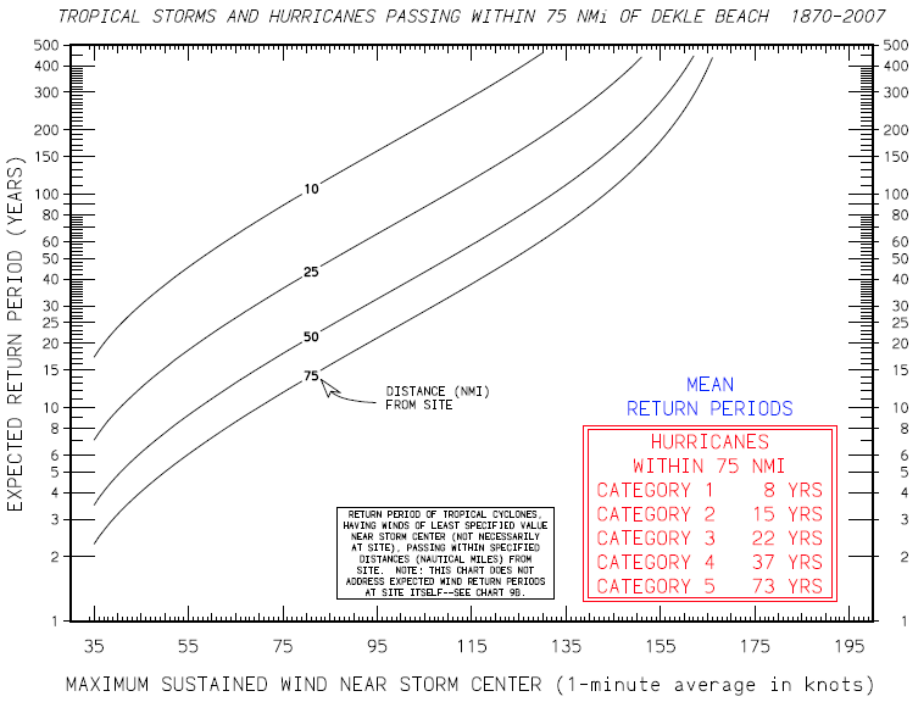
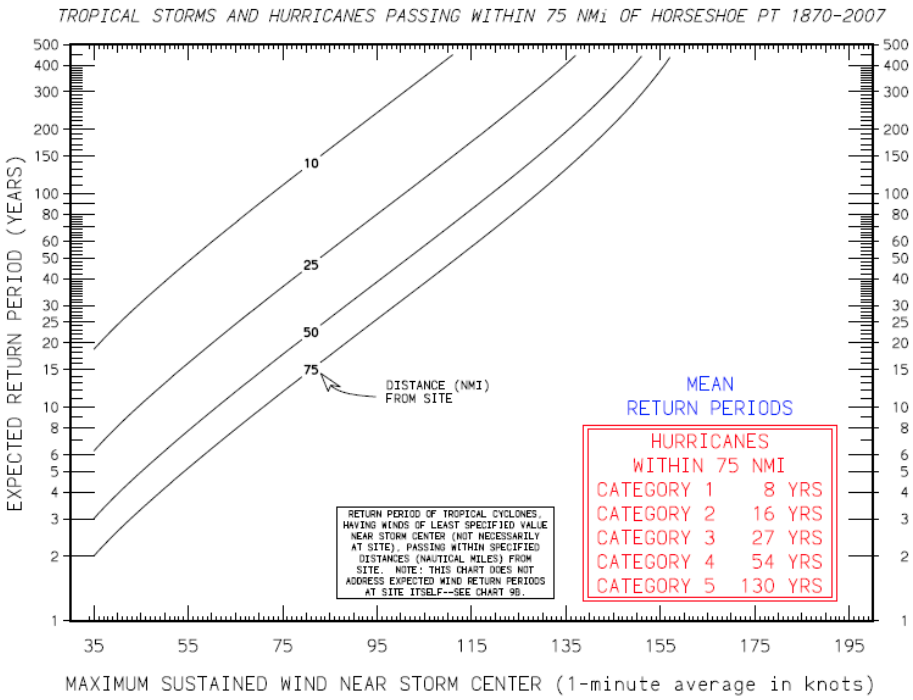


Table II-11: Summary for Hurricanes

Number of Years: 137
Number of Hurricanes: 78
Means Number of Occurrences Per year: 0.57
Means Recurrence Interval: 1.76 Years

Figure II-15b: Hurricane Return Intervals for Horseshoe Point, North Central Florida Region



C. Freshwater Flooding

1. Inland/Riverine Flooding Profile

Lake Harney, Seminole County
Photo courtesy of Chris Gent

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* (SHMP, 2007). The State of Florida and the North Central Florida region are affected by a large number of weather systems which 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. Rain water 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 these states often cause flood conditions in Florida.

Flash floods are much more dangerous and flow 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. 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: FIRM Maps

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- 12: Definitions of National Flood Insurance (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 of 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 shows. 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 SLOSH MEOWs or MOMs and the Inland Wind model, is a cumulative model. It is based on several storm events as 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 death. 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 FEMA's 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 which 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: North Central Florida FEMA Flood Zones

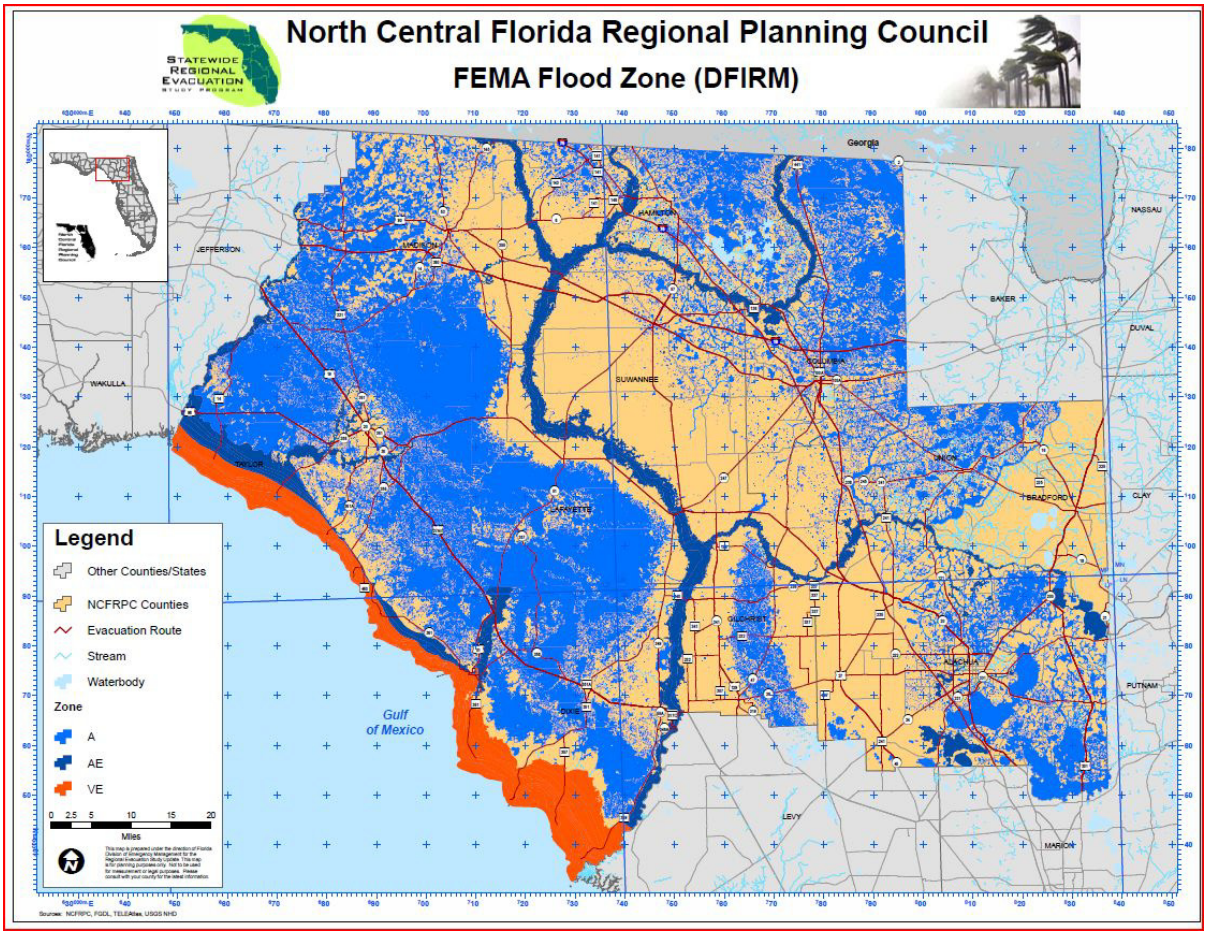


Table II- 13: Floodplain Acreage by County

COUNTY	TOTAL ACREAGE	FLOODPLAIN ACREAGE	PERCENTAGE OF ACREAGE IN FLOODPLAIN
ALACHUA	320,490	184,066	57%
BRADFORD	192,030	N/A	N/A
COLUMBIA	512,600	192,303	38%
DIXIE	457,810	317,575	69%
GILCHRIST	227,510	62,078	27%
HAMILTON	332,230	134,504	40%
LAFAYETTE	350,750	235,011	67%
MADISON	458,110	204,138	45%
SUWANNEE	442,820	64,343	15%
TAYLOR	671,940	500,387	74%
UNION	159,820	60,644	38%

Source: Florida Statistical Abstract, 2008 (Total Acreage); FEMA (Digital Inventory of Flood Plain Acreage), 2006

3. Dam Failure

A flood event may also trigger a dam failure. The dam impounds water in a 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 indicated by 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 which have been identified by their 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 area but could be located in areas with population and significant infrastructure.
- High – A dam where failure or mis-operation will probably cause loss of human life. (*Statewide Hazard Mitigation Plan*, 2009)

The following table lists the names of all dams in the North Central region considered high or significant hazard by the USGS database.

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

Table II- 14: Dams in the North Central Region

DAM NAME	NID ID	LONG	LAT	COUNTY	RIVER	HAZARD
SA 14 S.R.	FL10025	-82.75	30.38	Hamilton	Suwannee	Significant
SA 4 S.C.	FL10006	-82.83	30.40	Hamilton	Swift Creek	Significant
SA 13 S.R.	FL10001	-82.75	30.40	Hamilton	Suwannee	Significant
SA 12 S.R.	FL10000	-82.75	30.41	Hamilton	Suwannee	Low
SA 3 S.C.	FL10005	-82.85	30.42	Hamilton	Swift Creek	Significant
SA 8B S.C.	FL10020	-82.82	30.42	Hamilton	Swift Creek	Significant
SA 6A S.C.	FL10007	-82.81	30.42	Hamilton	Swift Creek	Significant
DOCP2	FL10011	-82.79	30.42	Hamilton		Significant
ALTMAN BAY DAM	FL00443	-82.78	30.42	Hamilton	Swift Creek	Low
DOCP1	FL10010	-82.78	30.42	Hamilton		Significant
SA 9 S.R.	FL10024	-82.75	30.42	Hamilton	Suwannee	Significant
SCGYPSUM	FL10004	-82.87	30.43	Hamilton		Significant
SA 1 S.C.	FL10012	-82.85	30.43	Hamilton	Swift Creek	Significant
SA 2 S.C.	FL10013	-82.84	30.43	Hamilton	Swift Creek	Significant
SC 1,2	FL00719	-82.83	30.43	Hamilton	Swift Creek - Offstream	Low
LONG PERCOLATION POND DAM	FL00551	-82.79	30.43	Hamilton	Swift Creek	Low
CTCGYPSUM	FL10002	-82.79	30.43	Hamilton		Significant
DOGYPSUM	FL10009	-82.78	30.43	Hamilton		Significant
SA 5 S.R.	FL10022	-82.77	30.43	Hamilton	Suwannee	Significant
OXY-9,10	FL00720	-82.73	30.43	Hamilton	Swift Creek - Offstream	Low
SA 8A S.C.	FL10008	-82.81	30.44	Hamilton	Swift Creek	Significant
SA 7 S.R.	FL10017	-82.75	30.44	Hamilton	Suwannee	Significant
SA 4 S.R.	FL10003	-82.79	30.45	Hamilton	Suwannee	Significant
SA 8 S.R.	FL10023	-82.76	30.45	Hamilton	Suwannee	Significant
OXY-2-8	FL00718	-82.74	30.45	Hamilton	Swift Creek - Offstream	Low
SA 6B S.R.	FL10015	-82.74	30.45	Hamilton	Suwannee	Significant

Source: USACE (2009)

4. History of Inland Flooding

Based on data collected by the National Climatic Data Center (NCDC), there were 914 flooding events in Florida between 1993 and 2006, for an average of 70 flooding events per year. Total property damages were estimated at $1.278 billion with an additional $947.081M in crop-related damages. These estimates do not include those of Tropical Storm Fay, 2008, which caused damages upward of $560 million, $10-$12 million for Brevard County alone.

Below is a summary of the major flooding events in the North Central region from 1993-2008.

March 1998: Calhoun, Franklin, Gadsden, Gulf, Holmes, Walton, and Jackson counties were declared federal disaster areas. In 1998, the inland flood caused an overall property damage estimate of $367 million.

In **Lafayette County**, the Suwannee River crested near 33.9 feet at Branford and 14.9 feet at Wilcox on March 9. Floodwaters engulfed High Smith Park and portions of Dowling Park as well as railroad tracks and a municipal park in Branford.

In **Madison County**, water covered some unpaved roads where the Withlacoochee and Suwannee rivers merge. The Withlacoochee River crested near 82 feet at Pinetta on March 15. The Suwannee River crested near 61.7 feet at Ellaville on March 18. Portions of the Suwannee River State Park were closed due to high water.

In **Taylor County**, lowland flooding was observed in Perry where 3 to 5 inches of rain fell within a 48-hour period.

March 1998, El Nino Effect: On March 1st, Alachua, Baker, Bradford, Citrus, Clay, Columbia, DeSoto, Duval, Flagler, Gilchrist, Hamilton, Hillsborough, Marion, Nassau, Pasco, Putnam, St. Johns, Suwannee, Union Counties were flooded. More than 2,800 homes and over 175 businesses were destroyed and property damage totaled $25.5 million. Flooding was claimed to be related to El Nino.

March 4, 2003, Flooding: Periods of heavy rainfall, which ranged from three to six inches in Leon County to 14 inches in Taylor County, flooded many roads, homes and poor drainage areas. Residents along Munson Slough in northern Wakulla County were forced to evacuate as floodwaters seeped into their homes. Widespread flooding forced many families in Taylor County to evacuate to motels, while others were isolated by the rising floodwaters. Many septic tanks and water wells were damaged. Some residents along the swollen Apalachicola and Ocklockonee rivers in Liberty County experienced minor flooding. Minor to moderate flooding occurred near the Aucilla and Suwannee river basins. Floodwaters seeping into homes in Steinhatchee Springs forced residents to evacuate to higher ground. Local states of emergencies were declared in Leon, Wakulla, Taylor, Liberty and Lafayette counties. Total property damages were estimated at $1.0 million.

June 23, 2003: A series of severe thunderstorms swept through southwest Central Florida during June 21-24, 2007. Precipitation associated with these storms resulted in flooding in parts of several Florida counties including Charlotte, Citrus, DeSoto, Dixie, Hardee, Levy, Manatee, Sarasota, and Taylor. Floodwater from these thunderstorms caused damage to public and private property amounting to more than $11 million and damaged or destroyed more than 100 homes.

A federal disaster declaration allowed the affected state and local governments to apply for aid. The relief aid would pay up to 75 percent of the approved costs for debris removal, emergency services related to the disaster, and the repair or replacement of damaged public facilities. The aid was authorized under a major disaster declaration issued by President Bush following a review of FEMA's analysis of the state's request for federal relief. The declaration covers damage to public property from severe storms and flooding beginning on June 13.

5. Repetitive Flood Loss Areas

The location of repetitive loss structures[9] 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 floodprone areas, mitigation will involve significant property owner investment and will probably be delayed until redevelopment/ reconstruction occurs. New construction or significant remodeling will require adherence to current floodplain management regulations. In regards 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 County Local Mitigation Strategies (LMSs). A breakdown of the properties by structure type is provided in the table below.

Table II- 15: North Central Florida Repetitive Loss Areas

County Name	Mitigated?	City	Occupancy	Zone	Losses
ALACHUA	NO	ALACHUA	SINGLE FMLY	A01	2
ALACHUA	NO	GAINESVILLE	NON RESIDNT	X	2
ALACHUA	NO	GAINESVILLE	SINGLE FMLY	A	2
ALACHUA	YES	GAINESVILLE	SINGLE FMLY	A	2
ALACHUA	NO	HIGH SPRINGS	SINGLE FMLY	A10	2
BRADFORD	NO	MELROSE	SINGLE FMLY	A	2
BRADFORD	NO	STARKE	SINGLE FMLY	A	3
BRADFORD	NO	STARKE	SINGLE FMLY	X	2
BRADFORD	NO	STARKE	SINGLE FMLY	A	2
COLUMBIA	NO	BRANFORD	SINGLE FMLY	AE	5
COLUMBIA	NO	COLUMBIA	SINGLE FMLY	X	2
COLUMBIA	YES	COLUMBIA CTY	SINGLE FMLY	EMG	2
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	X	2
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	AE	4
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	AE	4
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	EMG	2
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	EMG	2
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	A	4
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	AE	3
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	EMG	2
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	AE	4

[9] 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.

County Name	Mitigated?	City	Occupancy	Zone	Losses
COLUMBIA	NO	FORT WHITE	SINGLE FMLY	EMG	2
COLUMBIA	YES	FRONT WHITE	SINGLE FMLY	EMG	4
COLUMBIA	NO	FT WHITE	SINGLE FMLY	AE	3
COLUMBIA	YES	FT WHITE	SINGLE FMLY	A	3
COLUMBIA	NO	HIGH SPRINGS	SINGLE FMLY	AE	2
COLUMBIA	NO	LAKE CITY	2-4 FAMILY	X	2
COLUMBIA	NO	LAKE CITY	NON RESIDNT	A	2
COLUMBIA	NO	LAKE CITY	SINGLE FMLY	A	2
COLUMBIA	NO	LAKE CITY	SINGLE FMLY	A	3
COLUMBIA	NO	WHITE SPRINGS	SINGLE FMLY	AE	2
COLUMBIA	NO	WHITE SPRINGS	SINGLE FMLY	AE	2
DIXIE	NO	CY OF SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	HORSESHOE BCH	SINGLE FMLY	V18	2
DIXIE	NO	HORSESHOE BCH	SINGLE FMLY	V18	3
DIXIE	YES	HORSESHOE BEACH	ASSMD CONDO	V18	2
DIXIE	NO	HORSESHOE BEACH	SINGLE FMLY	VE	2
DIXIE	NO	HORSESHOE BEACH	SINGLE FMLY	VE	2
DIXIE	YES	HORSESHOE BEACH	SINGLE FMLY	VE	2
DIXIE	YES	HORSESHOE BEACH	SINGLE FMLY	VE	2
DIXIE	NO	JENA	SINGLE FMLY	VE	2
DIXIE	NO	JENA	SINGLE FMLY	AE	2
DIXIE	NO	LAKELAND	SINGLE FMLY	V16	2
DIXIE	NO	LIUEOAKE	SINGLE FMLY	V16	2
DIXIE	NO	NAVARRE	ASSMD CONDO	A11	2
DIXIE	NO	OLD TOWN	SINGLE FMLY	AE	2
DIXIE	NO	OLD TOWN	SINGLE FMLY	VE	2
DIXIE	NO	OLD TOWN	SINGLE FMLY	VE	2
DIXIE	NO	OLD TOWN	SINGLE FMLY	VE	2
DIXIE	NO	OLD TOWN	SINGLE FMLY	VE	2
DIXIE	NO	OLD TOWN	SINGLE FMLY	VE	2
DIXIE	NO	OLD TOWN	SINGLE FMLY	A09	3
DIXIE	NO	OLD TOWNE	SINGLE FMLY	X	2
DIXIE	NO	STEINHATCHEE	SINGLE FMLY	VE	2
DIXIE	NO	STEINHATCHEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANEE	SINGLE FMLY	AE	3
DIXIE	NO	SUWANEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANEE	SINGLE FMLY	B	2
DIXIE	NO	SUWANNEE	ASSMD CONDO	VE	3

County Name	Mitigated?	City	Occupancy	Zone	Losses
DIXIE	NO	SUWANNEE	ASSMD CONDO	V16	3
DIXIE	NO	SUWANNEE	NON RESIDNT	VE	3
DIXIE	NO	SUWANNEE	NON RESIDNT	VE	3
DIXIE	NO	SUWANNEE	NON RESIDNT	V16	2
DIXIE	NO	SUWANNEE	NON RESIDNT	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	3
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	3
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	4
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	3
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	3
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	4
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	A	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY		2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	A	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2

County Name	Mitigated?	City	Occupancy	Zone	Losses
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	3
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	5
DIXIE	NO	SUWANNEE	SINGLE FMLY	AE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	4
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	6
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	A	2
DIXIE	NO	SUWANNEE	SINGLE FMLY	VE	4
DIXIE	NO	SUWANNEE	SINGLE FMLY	V16	2
DIXIE	NO	SUWANNEE DIXIE	SINGLE FMLY	VE	2
GILCHRIST	NO	BELL	SINGLE FMLY	EMG	2
GILCHRIST	NO	BELL	SINGLE FMLY	EMG	2
GILCHRIST	NO	BELL	SINGLE FMLY	EMG	2
GILCHRIST	NO	BELL	SINGLE FMLY	AE	2
GILCHRIST	NO	BELL	SINGLE FMLY	A	2
GILCHRIST	NO	BELL	SINGLE FMLY	AE	3
GILCHRIST	NO	BELL	SINGLE FMLY	X	4
GILCHRIST	NO	BELL	SINGLE FMLY	AE	2
GILCHRIST	NO	BELL	SINGLE FMLY	AE	2
GILCHRIST	NO	BELL	SINGLE FMLY	A	4
GILCHRIST	NO	BELL	SINGLE FMLY	AE	4
GILCHRIST	NO	BRANFORD	SINGLE FMLY	AE	2
GILCHRIST	NO	BRANFORD	SINGLE FMLY	AE	2
GILCHRIST	NO	BRANFORD	SINGLE FMLY	AE	2
GILCHRIST	NO	BRANFORD	SINGLE FMLY	AE	2
GILCHRIST	NO	FANNIN SPRINGS	SINGLE FMLY	EMG	2
GILCHRIST	NO	FANNING SPRINGS	SINGLE FMLY	AE	2
GILCHRIST	NO	FT WHITE	SINGLE FMLY	AE	2
GILCHRIST	NO	GILCHRIST CITY	SINGLE FMLY	EMG	4
GILCHRIST	NO	GILCHRIST COUNT	SINGLE FMLY	EMG	2
GILCHRIST	NO	GILCHRIST CTY	OTHER RESID	A	2
GILCHRIST	NO	GILCHRIST CTY	SINGLE FMLY	A	3
GILCHRIST	NO	HIGH SPRINGS	SINGLE FMLY	AE	2
GILCHRIST	NO	SUWANNEE RVR	SINGLE FMLY	A	3
GILCHRIST	NO	TRENTON	SINGLE FMLY	AE	2
GILCHRIST	NO	TRENTON	SINGLE FMLY	AE	2
GILCHRIST	NO	TRENTON	SINGLE FMLY	EMG	2
GILCHRIST	NO	TRENTON	SINGLE FMLY	AE	4
GILCHRIST	NO	TRENTON	SINGLE FMLY	EMG	2
GILCHRIST	NO	TRENTON	SINGLE FMLY	A	4
GILCHRIST	NO	TRENTON	SINGLE FMLY	EMG	4
GILCHRIST	NO	TRENTON	SINGLE FMLY	AE	2
GILCHRIST	NO	TRENTON	SINGLE FMLY	X	2

County Name	Mitigated?	City	Occupancy	Zone	Losses
HAMILTON	NO	JASPER	SINGLE FMLY		2
HAMILTON	NO	JASPER	SINGLE FMLY	EMG	2
HAMILTON	NO	JASPER	SINGLE FMLY	EMG	2
HAMILTON	NO	JASPER	SINGLE FMLY	A	6
HAMILTON	NO	JASPER	SINGLE FMLY	AE	2
HAMILTON	NO	JASPER	SINGLE FMLY	AE	3
HAMILTON	NO	JASPER	SINGLE FMLY	A	4
HAMILTON	NO	JASPER	SINGLE FMLY	X	2
HAMILTON	NO	JASPER	SINGLE FMLY		2
HAMILTON	NO	JASPER	SINGLE FMLY	AE	2
HAMILTON	NO	JASPER	SINGLE FMLY	AE	2
HAMILTON	NO	JENNINGS	SINGLE FMLY	AE	3
HAMILTON	NO	LAKE CITY	SINGLE FMLY	AE	2
HAMILTON	NO	LAKE CITY	SINGLE FMLY	EMG	2
HAMILTON	NO	LIFE OAKS	SINGLE FMLY	EMG	2
HAMILTON	NO	LIFE OAKS	SINGLE FMLY	AE	2
HAMILTON	NO	RANGE	SINGLE FMLY	EMG	2
LAFAYETTE	NO	BRANDORD	SINGLE FMLY	EMG	2
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	EMG	2
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	AE	7
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	A06	3
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	A	3
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	A09	3
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	A09	4
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	A09	2
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	A09	3
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	AE	2
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	A09	2
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	AE	2
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	A	2
LAFAYETTE	YES	BRANFORD	SINGLE FMLY	EMG	2
LAFAYETTE	NO	BRANFORD	SINGLE FMLY	EMG	3
LAFAYETTE	NO	LAFATETTE	SINGLE FMLY	EMG	3
LAFAYETTE	NO	MAYO	NON RESIDNT	A15	4
LAFAYETTE	NO	MAYO	NON RESIDNT	A12	2
LAFAYETTE	NO	MAYO	NON RESIDNT	A	2
LAFAYETTE	NO	MAYO	NON RESIDNT	A	2
LAFAYETTE	NO	MAYO	NON RESIDNT	A	2
LAFAYETTE	NO	MAYO	SINGLE FMLY	A16	3
LAFAYETTE	NO	MAYO	SINGLE FMLY	EMG	2
LAFAYETTE	NO	MAYO	SINGLE FMLY	A16	2
LAFAYETTE	NO	MAYO	SINGLE FMLY	A	3

County Name	Mitigated?	City	Occupancy	Zone	Losses
LAFAYETTE	NO	MAYO	SINGLE FMLY	A	2
LAFAYETTE	NO	MAYO	SINGLE FMLY	A12	2
LAFAYETTE	NO	MAYO	SINGLE FMLY	AE	3
LAFAYETTE	NO	MAYO	SINGLE FMLY	EMG	2
LAFAYETTE	NO	MAYO	SINGLE FMLY	A	4
LAFAYETTE	NO	MAYO	SINGLE FMLY	A06	2
LAFAYETTE	NO	MAYO	SINGLE FMLY	EMG	2
MADISON	NO	LEE	SINGLE FMLY	AE	5
MADISON	NO	LEE	SINGLE FMLY		4
MADISON	NO	LEE	SINGLE FMLY	AE	4
MADISON	NO	LEE	SINGLE FMLY	AE	6
MADISON	NO	LEE	SINGLE FMLY	A	3
MADISON	NO	PINETA	SINGLE FMLY	A	2
MADISON	NO	PINETTA	SINGLE FMLY	EMG	2
MADISON	NO	PINETTA	SINGLE FMLY		3
SUWANNEE	YES	BRANFORD	NON RESIDNT	A	2
SUWANNEE	NO	BRANFORD	SINGLE FMLY	AE	6
SUWANNEE	NO	BRANFORD	SINGLE FMLY	EMG	2
SUWANNEE	NO	BRANFORD	SINGLE FMLY	EMG	2
SUWANNEE	NO	BRANFORD	SINGLE FMLY	X	3
SUWANNEE	NO	BRANFORD	SINGLE FMLY	AE	2
SUWANNEE	NO	BRANFORD	SINGLE FMLY	AE	2
SUWANNEE	NO	BRANFORD	SINGLE FMLY	AE	3
SUWANNEE	NO	BRANFORD	SINGLE FMLY	AE	5
SUWANNEE	YES	BRANFORD	SINGLE FMLY	EMG	2
SUWANNEE	NO	LAKE CITY	SINGLE FMLY	AE	2
SUWANNEE	NO	LIVE OAK	2-4 FAMILY	X	2
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	A	2
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	A	2
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	X	3
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	X	3
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	X	3
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	EMG	2
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	A	6
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	AE	4
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	AE	2
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	AE	2
SUWANNEE	NO	LIVE OAK	SINGLE FMLY	AE	4
SUWANNEE	NO	O BRIEN	SINGLE FMLY	AE	3
SUWANNEE	NO	OBRIEN	SINGLE FMLY	AE	3
SUWANNEE	NO	O'BRIEN	SINGLE FMLY	AE	5
SUWANNEE	NO	WELLBORN	OTHER RESID	X	2
TAYLOR	NO	PERRY	NON RESIDNT	V17	2

County Name	Mitigated?	City	Occupancy	Zone	Losses
TAYLOR	NO	PERRY	NON RESIDNT	V17	2
TAYLOR	NO	PERRY	NON RESIDNT	V17	2
TAYLOR	NO	PERRY	NON RESIDNT	V17	2
TAYLOR	NO	PERRY	NON RESIDNT	V21	3
TAYLOR	NO	PERRY	SINGLE FMLY	V21	3
TAYLOR	NO	PERRY	SINGLE FMLY	VE	2
TAYLOR	NO	PERRY	SINGLE FMLY	V17	2
TAYLOR	NO	PERRY	SINGLE FMLY	VE	4
TAYLOR	NO	PERRY	SINGLE FMLY	V17	2
TAYLOR	NO	PERRY	SINGLE FMLY	A16	2
TAYLOR	NO	PERRY	SINGLE FMLY	V17	5
TAYLOR	NO	PERRY	SINGLE FMLY	AE	2
TAYLOR	NO	PERRY	SINGLE FMLY	AH	2
TAYLOR	NO	PERRY	SINGLE FMLY	V17	3
TAYLOR	NO	PERRY	SINGLE FMLY	VE	3
TAYLOR	YES	PERRY	SINGLE FMLY	V21	2
TAYLOR	YES	PERRY	SINGLE FMLY	VE	5
TAYLOR	NO	STEINHATCHEE	2-4 FAMILY	AE	3
TAYLOR	NO	STEINHATCHEE	NON RESIDNT	V16	2
TAYLOR	YES	STEINHATCHEE	NON RESIDNT	VE	2
TAYLOR	NO	STEINHATCHEE	SINGLE FMLY	A05	2
TAYLOR	NO	STEINHATCHEE	SINGLE FMLY	A05	2
TAYLOR	NO	STEINHATCHEE	SINGLE FMLY	A13	2
TAYLOR	NO	STEINHATCHEE	SINGLE FMLY	X	2
TAYLOR	NO	STEINHATCHEE	SINGLE FMLY	V16	2
TAYLOR	NO	STEINHATCHEE	SINGLE FMLY	A13	2
TAYLOR	NO	STEINHATCHEE	SINGLE FMLY	VE	3
TAYLOR	YES	STEINHATCHEE	SINGLE FMLY	AE	2
TAYLOR	YES	STEINHATCHEE	SINGLE FMLY	VE	2
UNION	NO	LAKE BUTLER	SINGLE FMLY	A	3

Source: FDEM, 2010

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 http://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). They 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 and burns along the floor of the forest, moving slowly killing or damaging trees.
- Ground fires (muck fires), 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 the fastest of all types of fires by jumping along tree tops.
- Wildland-Urban Interface fires are in a geographical area where structures and other human development meet or intermingle with wildlands or vegetative fuels.

Max Hooks fire in Lake County

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

Each wildfire, especially near development, has the potential to 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 North Central Florida Region

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 which may emit sparks. Because so much of the county is comprised of timber lands, a major portion of the county is vulnerable to forest fires, although the threat to the population at large is not considered significant.

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 thru 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, 1998 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 and for the release of 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 TM 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.

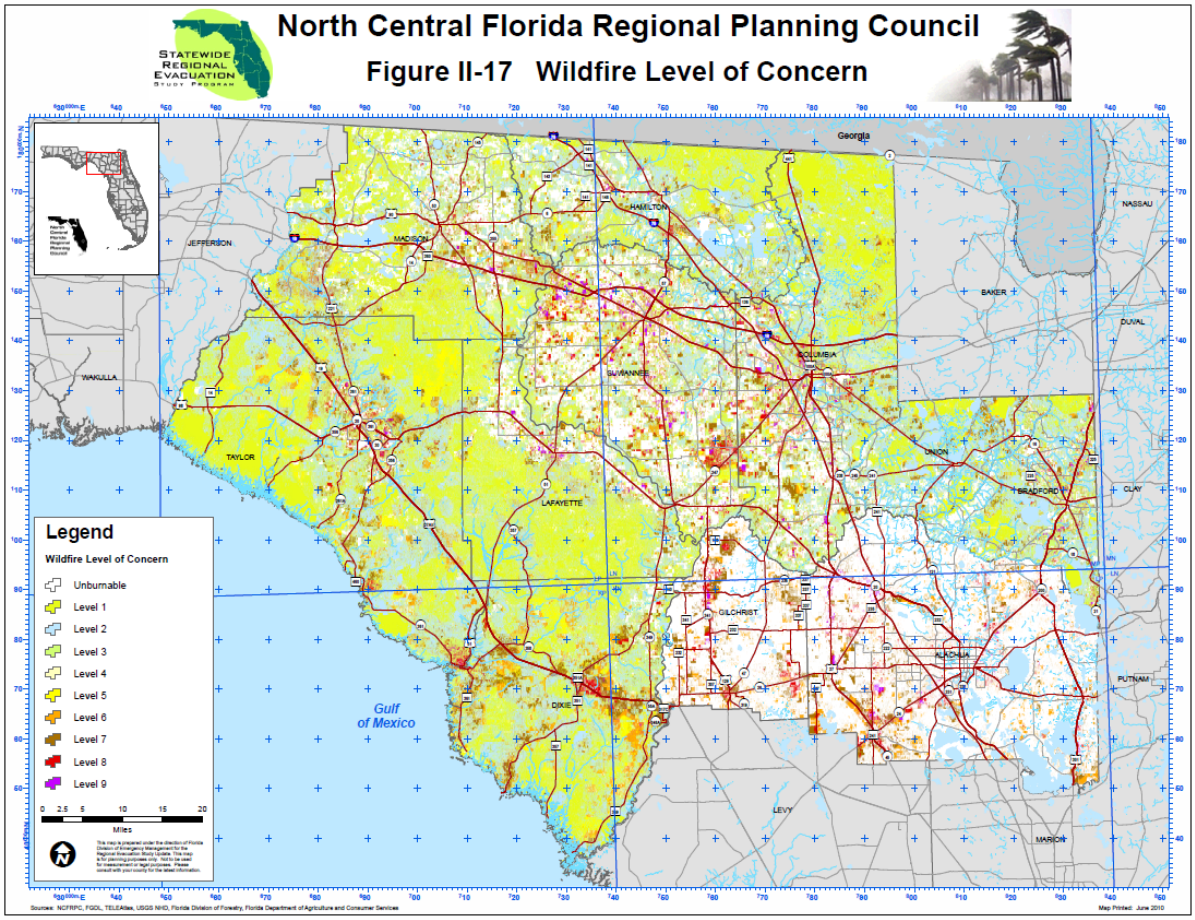
The Levels of Concern (LOC) were computed by multiplying the Wildland Fire Susceptibility Indices by the Fire Effects Indices. The LOC values were then assigned to nine categories of risk and mapped for each Florida Division of Forestry District.

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.

Figure II- 17: Wildfire Level of Concern



Source: http://silvis.forest.wisc.edu/library/WUI_state_download.asp?state=Florida&abrev=FL

E. Hazardous Material Incidents

1. Overview

The North Central Florida region is a primarily rural area outside of our few larger cities. There are a significant number of industrial, manufacturing, and transportation facilities which produce, store, use or transport hazardous materials. Significant amounts of hazardous materials are moved into and throughout the region by rail, highway, air transport, and pipelines on a daily basis. 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 agency's plan for hazardous material incidents and coordinate regionally for response through the Local Emergency Planning Committees (LEPCs).

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

Potential emergencies involving hazardous materials range from a minor release with no off-site impacts 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 exposure 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 nearby facilities that manufacture, store or process hazardous materials.

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 which killed thousands and a more localized event in Institute, West Virginia. In response to this public concern and the hazards that exist, the 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 plan for potential chemical emergencies. This local planning complemented emergency response planning carried out at national and regional levels by the National Response Team and Regional Response Teams organized by the 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 concerning hazardous

chemicals they have on site. EPCRA's reporting requirements foster a valuable dialogue between industry and local communities to help citizens become more informed about the presence of hazardous chemicals that may 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 North Central Florida LEPC was created in 1989 to help the public and emergency responders address hazardous materials public safety issues. The focus of the committee is planning, regional coordination, education and awareness. In Florida, the LEPCs are organized in conjunction with the eleven Regional Planning Councils which provide staff support through funding from the Florida Division of Emergency Management. District VI, which incorporates the counties of Brevard, Lake, Orange, Osceola, Seminole and Volusia counties and their respective jurisdictions, meets quarterly.

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. Membership of the LEPC represents 18 occupational categories as follows: Elected State Official, Elected Local Official, Emergency Management, Firefighting, First Aid (EMS), Health Organizations, Law Enforcement, Local Environmental, Hospital, Transportation, Broadcast media, Print Media, Community Groups (i.e. Red Cross, etc), Facility Owners, Facility Operators, Non-Elected Local Officials, Water Management District Representatives, and Interested Citizens.

3. Mission of the LEPC

The mission of the LEPC is to partner with citizens, facilities, and local emergency management officials to protect communities from the adverse effects of hazardous materials. The LEPC is committed to the following objectives:

a. The LEPC shall **prepare regional 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 the region;

- The data collected by the 11 LEPCs for planning purposes 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 LEPC annually and are approved by the Division of Emergency Management on behalf of the Commission.

b. The LEPC shall serve as the **repository for regional reports** filed under EPCRA;

- In 2008, over 1500 facilities in the North Central Florida LEPC area reported their chemical inventories consisting of listings

of both hazardous and extremely hazardous substances under Sections 311/312 of EPCRA and these reports are available for public review at the LEPC office.

c. The LEPC 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 LEPC 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 the region.

The hazard analysis reports at the amounts of 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, EPCRA has been successful in reducing, over the years, facilities possessing extremely hazardous substances (EHSs) by encouraging that they seek alternative products which do not require reporting and thus, payment of the reporting fee. The reporting deadline each year is March 1st. Within District VI, there are 511 Section 302 (EHS) facilities reporting in 2008 and 1631 facilities reporting under Sections 311/312.

District VI's reported ten top Section 302 chemicals for 2008 are as follows:

Table II- 16: District 3 Top Ten Section 302 Chemicals

Chemical	2006 Maximum Inventory (lbs)	2007 Maximum Inventory (lbs)	Change from 2006	Percent of State-Wide Inventory
Sulfuric Acid	114,759,411	118,941,690	4,182,279	29.1%
Anhydrous Ammonia*	16,032,558	15,581,397	-451,161	4.8%
Chlorine*	1,141,837	1,251,995	110,158	6.1%
Sulfur dioxide*	212,441	202,029	-10,412	7.4%
Ethoprop	70,030	189,000	118,970	62.6%
Trimethylchlorosilane	70,585	95,950	25,365	61.8%
Terbufos	89,800	89,800	89,800	66.6%
Aldicarb	**	74,127	N.A.	3.1%
Hydrogen Sulfide	54,928	57,145	2,217	13.9%
Hydrogen peroxide	**	50,521	N.A.	4.5%

* These chemicals are also covered under the Clean Air Act, Section 112(r).
** Did not appear on the 2006 list for District VI
\# Did not appear in the 2008 list for the state

Source, SERC for Hazardous Materials, *Annual Report 2006 and 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 which 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 February 2009.

One of the programs, CAMEO filemaker (CAMEOfm), contains a chemical library which 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 which 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, Arial 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 (http://www.epa.gov/ceppo/cameo/).

b. North Central Florida Hazardous Materials Emergency Response Plan

The LEPC District 3 maintains the ***North Central Florida Local Emergency Planning Committee Hazardous Materials Emergency Response Plan*** which describes what hazards exist and the risk they pose for the community. As part of the plan update, the LEPC and/or the local counties 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 North Central Florida LEPC and serve as the basis for developing and revising the emergency response plans.

The hazards analysis for the North Central Florida LEPC consists of the following three components:

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

- Chemical identities
- Location of facilities that use, produce, process or store hazardous materials
- The type and design of chemical container or vessel
- The quantity of material that could be involved in an airborne release
- The nature of the hazard (e.g. airborne toxic vapors or mists which are the primary focus of the plan; also other hazards such as fire, explosion, large quantities store or processed, handling conditions)

A complete list of extremely hazardous substances and data for the hazards analysis is provided in by county as appendixes in the plan.

(2) **The 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. The Vulnerable Zone is an estimated geographical area that may be subject to concentrations of an airborne extremely hazardous substance (EHS) at levels that could cause irreversible acute health effects or death to persons within the areas following release of the chemical. Vulnerable zones are based on the estimates of the quantity of an EHS released to air, the rate of release to the air, airborne dispersion and the airborne concentration. The five most prevalent chemicals in the North Central Florida Region of greatest concern, which are also covered under the Clean Air Act, Section 112(r) are: sulfuric acid, chlorine, anhydrous ammonia, sulfur dioxide and nitric acid. The comprehensive vulnerability analysis provides information on:

- The extent of the vulnerable zones
- The population in terms of numbers density and types of individuals
- The private and public property that may be damaged including essential support systems and transportation facilities and corridors
- The environment that may be affected

(3) **Risk Analysis** is the assessment by the community of the likelihood of an accidental release of a hazardous material and the actual consequences that might occur.

The hazards analyses for the 302 facilities is provided in the ***North Central Florida Hazardous Materials Emergency Response Plan*** (2008).

According to the Plan, 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 specific emergency, the plan identifies various parameters for planning which are based upon knowledge of the possible consequences, timing and release characteristics of a spectrum of emergencies.

Authority to issue an immediate evacuation order for any vulnerable zone is delegated to the senior incident commander (on-scene) within a given jurisdiction if the health and safety of person within the critical evacuation area is in imminent danger. A decision to evacuate versus one to shelter-in-place will be based upon a number of considerations to include size of the leak, spill, or release, the weather condition, terrain conditions, risk to people, property or environment, and the class of hazardous materials in question. Normally, explosives, flammable gases, flammable liquids and solids and radioactive material would trigger evacuation decisions especially if the at-risk population would not be served by a decision to shelter-in-place[10]. Another consideration would be the cause of the spill or release and whether or not the flow or source of release could be readily confined or terminated. Evacuation of all or any part (i.e. downwind) of a vulnerable zone will be geographic boundaries. Persons residing in a vulnerable zone which is ordered to be evacuated will be instructed to evacuate according the evacuation plan outlined in the ***North Central Florida Hazardous Materials Emergency Response Plan*** including:

- Evacuation Routes: Evacuation routes leading away from each facility's vulnerable zone will be determined by the incident commander at the time of the incident. Evacuation routes chosen will depend on such variables as wind direction, the area estimated to be impacted by the release and impediments to traffic flow. Evacuation routes are listed in the Hazard Vulnerability Analysis for each facility. Hurricane evacuation routes would be used if mass evacuation of a large area were required.

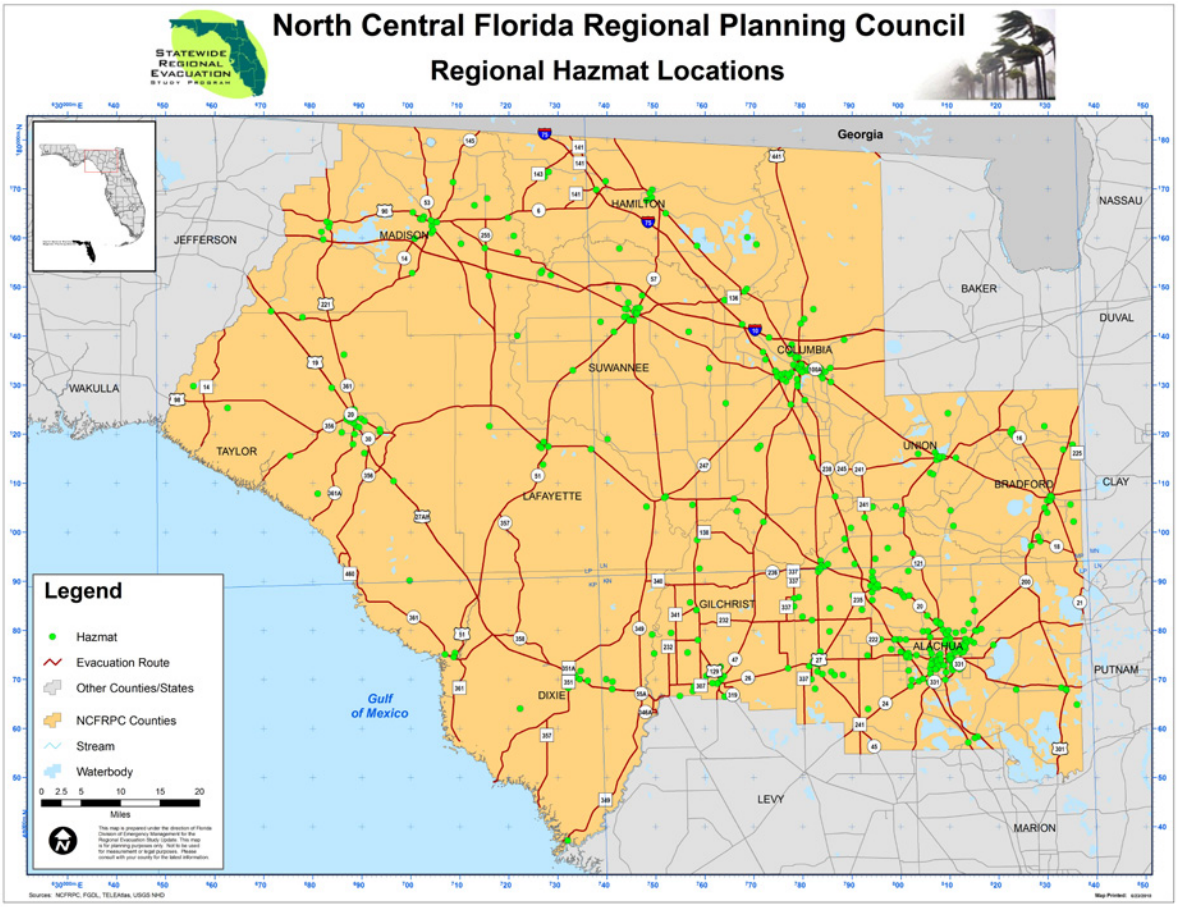
[10] In the event that a toxic cloud has become airborne and poses an immediate threat to persons attempting to evacuate, the decision to recommend sheltering-in-place instead of evacuation will be made by the Incident Commander. Residents will be notified to go indoors immediately, to close windows and doors, to turn off air conditioners and fans, and if time permits, go into a windowless room and seal bottom of door (s) with a damp towel and to remain inside until they receive further instructions.

- Reception and Care: All routes will lead citizens toward reception centers where citizens will be screened for conditions requiring immediate medical attention and transported to medical facilities, if necessary.
- Traffic control and security
- Transportation assistance for transportation disadvantaged and people with Special Needs
- Evacuation of schools, medical facilities, incarceration facilities
- Public Notifications, Warning and Education

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 Regional 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.

Figure II- 18: Hazardous Materials Sites



F. Domestic Security Events

1. Hazard Profile and Current Programs

Terrorism is defined in the Code of Federal Regulations as "the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives." It 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.

Terrorism is often categorized as "domestic" or "international."

• **Domestic terrorism** involves groups or individuals whose terrorist activities are directed at elements of our government or population without foreign direction.
• **International terrorism** involves groups or individuals whose terrorist activities are foreign-based and/or directed by countries or groups outside the United States or whose activities transcend national boundaries.

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

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.

When terrorism strikes, communities may receive assistance from both state and federal agencies under the existing Integrated Emergency Management System. The Department of Homeland Security is the lead federal agency for supporting state and local response to the consequences of terrorist attacks.

Before the September 11, 2001 attacks in New York and the Pentagon, most terrorist incidents in the United States have been bombing attacks, involving detonated and undetonated explosive devices, tear gas, and pipe and fire bombs. The effects of terrorism can vary significantly from loss of life and injuries to property damage and disruptions in services such as electricity, water supply, public transportation and communications. One way governments attempt to reduce our vulnerability to terrorist incidents is by increasing security at airports and other public facilities.

While we can never predict what target a terrorist will choose, we do know some of the factors they use when selecting a target. Terrorists want to achieve one or more of the following:

- Produce a large number of victims
- Attack places that have a symbolic value
- Get the greatest possible media attention
- Produce mass panic

Terrorists also select targets best suited for the type of material being used. For example, some biological agents are not effective in sunlight. Most chemical agents are more effective indoors with limited airflow. A radioactive material will be most effective where large numbers of people will pass close by without detecting it. Terrorists are likely to target heavily populated, enclosed areas like stadiums, government buildings, sporting events, airport terminals, subways, shopping malls and industrial manufacturing facilities. For this reason, it is critical that employers and local government agencies have some type of anti-terrorism plan in place should a terrorist act occur.

There is no sure way to predict future terrorism events. The probability of a major terrorist event in the state of Florida is perceived to be high and planning is being done as part of the larger national Homeland Security initiatives.

2. The Regional Domestic Security Task Forces (RDSTFs)

Following 9/11 and per state statute 943.0312, the Florida Department of Law Enforcement (FDLE) established seven (7) Regional Domestic Security Task Forces. These regions follow the FDLE regions within the State.

The goal of the RDSTF is to provide a regional response to any 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 DHS 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 North Central 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 and vulnerability assessment 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. Two additional reactors are located in Alabama near the State line.

- Crystal River Nuclear Power Plant (NW of CR)
- St. Lucie Nuclear Power Plant (SE of FT. Pierce)
- Turkey Point Nuclear Power Plant (S of Miami)
- Farley Nuclear Power Plant (SE of Dothan, Alabama)

Nuclear power generating facilities have the greatest concentration of radioactive material of any private source.

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 North Central Florida Region Evacuation Study will not address nuclear power plant incidents.

H. Tsunami Events

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 to immediately 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.