

SECTION 3: HAZARD IDENTIFICATION AND VULNERABILITY ANALYSIS

This section represents an update of the 2004 hazard and vulnerability analysis. It addresses, in part, the following FEMA requirements:

RISK ASSESSMENT: §201.6(c)(2): The plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

Requirement §201.6(c)(2)(i): The risk assessment **shall** include a description of the type ... of all natural hazards that can affect the jurisdiction.

Requirement §201.6(c)(2)(i): The risk assessment **shall** include a description of the ... location and extent of all natural hazards that can affect the jurisdiction. The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.

Requirement §201.6(c)(2)(ii): The risk assessment **must** also address National Flood Insurance Program (NFIP) insured structures that have been repetitively damaged floods.

Requirement §201.6(c)(2)(ii): The risk assessment **shall** include a description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description **shall** include an overall summary of each hazard and its impact on the community.

3.1 HAZARD IDENTIFICATION

Section 3.1 and Table 3.1 lists the general hazards to which Palm Beach County is vulnerable and indicates their projected impact potential across the entire spectrum of community exposure and services. **Section 3.1, Hazard Identification**, describes these hazards in detail and discusses county-wide exposures; **Section 3.2, Vulnerability Assessment**, discusses specific vulnerabilities faced by the individual governmental entities, County and City, forming the Palm Beach County community. Vulnerability, probability, and risk assessments for the county and municipal jurisdictions, and a county-wide impact analysis are contained in **Appendix A. Section 3.3, Risk Assessment**, describes the elements considered in the risk assessment process. Hazard & Risk Assessment Maps, accompanying narrative, and potential loss values for the county and each jurisdiction are located in **Appendix C**.

Disasters are classified by the magnitude of their effect. The recognized classification system is as follows:

- *Minor Disaster* - Any disaster that is likely to be within the response capabilities of local government and results in only minimal need for state or federal assistance.
- *Major Disaster* - Any disaster that will likely exceed local capabilities and require a broad range of state and federal assistance. The Federal Emergency Management

Agency (FEMA) will be notified and potential federal assistance will be predominantly recovery-oriented.

- *Catastrophic Disaster* - Any disaster that will require massive state and federal assistance, including immediate military involvement.

The hazards identified in **Table 3.1** and discussed in **Section 3.1** are organized based on their maximum projected impact potential. This means that hazards capable of producing the maximum community-wide impact, such as hurricanes and floods, are discussed first. This does not mean other identified hazards are less important or less worthy of mitigation, it simply means that their potential to affect the total community is lower.

3.1.1 Natural Hazards

Figure 3.1 summarizes property damage caused by the most significant natural hazards faced by Palm Beach County from 1950 to the present.

Table 3.1 Identification and projected impact potential for hazards

Hazard Category	Projected Impact Potential																			
	Excessive Wind	Excessive Water	Damaging hail	Soil/beach erosion	Electric power outage	Surface and air transportation	Navigable waterway impairment	Potable water system loss or disruption	Sewer system outage	Telecommunications system outage	Human health and safety	Psychological hardship	Economic disruption	Disruption of community services	Agricultural/fisheries damage	Damage to critical environmental resources	Damage to identified historical resources	Fire	Toxic releases	Storm water drainage impairment
NATURAL																				
Flood		√		√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√
Hurricane/Tropical storm	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Tornado	√				√	√				√	√	√	√							
Severe thunderstorm	√	√	√		√	√				√	√	√	√					√		√
Drought													√		√	√		√		
Temperature extremes					√						√	√	√		√	√				
Agricultural pest/disease											√	√	√		√	√				
Wildfire					√	√				√	√	√	√	√	√	√		√	√	

Muck Fire						√						√		√		√	√		
Soil/beach erosion				√			√						√		√				√
Seismic hazards						√												√	

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	Excessive Wind	Excessive Water	Damaging hail	Soil/beach erosion	Electric power outage	Surface and air transportation	Navigable waterway impairment	Potable water system loss or disruption	Sewer system outage	Telecommunications system outage	Human health and safety	Psychological hardship	Economic disruption	Disruption of community services	Agricultural/fisheries damage	Damage to critical environmental resources	Damage to identified historical resources	Fire	Toxic releases	Storm water drainage impairment
TECHNOLOGICAL																				
Hazardous material accident						√					√	√	√					√	√	
Radiological accidents (nuclear power plant)					√	√				√	√	√	√		√				√	
Communications failure										√			√	√						
Hazardous material release						√					√	√	√	√				√	√	
Transportation accident						√	√				√		√	√				√		
Wellfield contamination								√	√		√	√	√	√						
Power failure (outage)					√	√		√	√	√	√	√	√							
SOCIETAL																				
Civil disturbance						√					√	√	√	√			√			
Terrorism and sabotage					√	√		√		√	√	√	√		√	√	√	√	√	
Immigration crisis											√	√	√	√						

3.1.1.1 Flooding

Frequencies from flooding associated with rain events other than tropical storms and hurricanes are more difficult to estimate. Eastern Florida shows an annual dry cycle stretching from early November through mid-May. During this part of the year, monthly rainfall rarely exceeds 3.5 to 4.0 inches per month. The wet season, beginning in mid-May and running through late October, shows monthly rainfall levels in the area to be 6.0 to 8.5 inches. Heaviest rainfall usually occurs in June and September. In Palm Beach County, the eastern or coastal section of the county receives more rain than the western section. This rainfall pattern coupled with the hurricane season (June through November) makes Palm Beach County particularly vulnerable to flooding associated with late season tropical storms and hurricanes because they typically occur when the water table is high and the ground is saturated. More information is available through the Palm Beach County Flood Information website accessible at: www.pbcgov.com/pubsafety/eoc.

Historical Flooding Events

Flood of Fall 1947. This flood is generally considered to be the most severe flood recorded in southern Florida. Heavy rainfall, including the rains from two hurricanes, occurred over a period of five months. Many parts of Palm Beach County were flooded for months and there was extensive damage to dairy pastures and agriculture in general. Such a flooding event would be much more significant today because of the increase in land development.

Flood of October 1953. As occurred in 1947, this flood was preceded by five months of heavier than normal rainfall which included a tropical storm in October. June through October rainfall was approximately 48 inches. Damage was heaviest in the beef cattle industry, with extensive losses of improved pasture land which required supplemental feeding of cattle. Vegetable growers and dairy farmers also suffered significant losses as a result of this flood.

Rains of January 1957. On 21 January 1957, Palm Beach County received 9 to 21 inches of rainfall within a 24-hour period. There was severe flooding in the vegetable garden areas of the county and much crop damage. Some fields had to be pumped out. Local crop damage was estimated at \$1,000,000.

Flood of June 1959. Heavy rains fell across most of central Florida from 17 June through the 21st. These rains were associated with and followed a tropical depression, and caused extensive flooding in poorly drained, low-lying agricultural areas and some residential sections. Considerable pasture land and some citrus land in Palm Beach County were inundated. Some highways also sustained damage from these flood waters.

Rains of October 1966. On 22 October 1966, heavy rains ranging from 8 to 10 inches over a 24-hour period destroyed approximately 4,300 acres of vegetable crops.

Rains of March 1982. On 28 and 29 March 1982, Palm Beach County was subjected to a severe coastal storm with heavy rains and high winds. Lantana measured 16 inches of rain over a 24-hour period. High seas sunk a Haitian freighter and a total of 11 people were drowned.

The Great Thanksgiving Holiday East Coast Storm of 1984. A strong low pressure system developed east of Florida and coupled with a high pressure system to produce an extremely strong pressure gradient leading to gale force winds and high seas along the entire Florida east coast. Heavy rains fell over most of central Florida, and this surface runoff, coupled with the wind packing of seawater along the coast resulted in extensive coastal erosion and flooding. Many coastal structures were damaged or destroyed, including several in Palm Beach County.

Flood of January 1989. On 21 and 22 January 1989, Palm Beach County experienced a gale with subtropical storm characteristics that caused extensive beach erosion and dropped 4 to 6 inches of rain across the county. This caused ponding of water in low-lying areas. Several homes and a motel were damaged. Road flooding caused several accidents.

The Unnamed Storm of October 1995. Almost exactly one year after the Hurricane Gordon flooding incident in 1994, a stalled frontal system dropped over 15 inches of rain on Palm Beach County over a period of 39 hours. In the intervening year between these two events, some communities in Palm Beach County had conducted a number of mitigation projects and initiatives designed to improve drainage and prevent flooding in known flood prone areas. These mitigation projects and initiatives undoubtedly reduced the extent of flooding and flood related damages during the 1995 flooding event, nevertheless, the county did experience significant flooding again in 1995.

Unnamed Storm of January 1999. On Saturday 2 January of 1999, a cold front stalled over the northern part of Palm Beach County. Warm, moist air from the Bahamas became intrained in this frontal system and produced a fairly localized, intense rain event in northern Palm Beach County. Initial reports indicated 31 inches of rain in a 12-hour period. This later turned out to be an erroneous reading from the recording instrument involved; however, it is generally recognized that between 18 and 22 inches of rain fell in the northern third of the county over a 12 to 18 hour period. Flooding was even more extensive than in the 1995 event, but it is interesting to note that many areas where flooding mitigation projects had been implemented remained dry, or showed a minimum of damage compared to areas where planned mitigation had not yet been implemented. Hardest hit were the Riviera Beach and Lake Park jurisdictions with a total of over \$6,000,000 damage between them. Flooding was extensive along Northlake Boulevard. Erosion caused the collapse of a portion of I-95 that was under construction. **Table 3.2** show the final damage assessment from this storm in Palm Beach County.

Record Rainfall June - July 2002. On July 14, 2002 a record 37 consecutive days of rain came to a conclusion. The combined June - July rainfall total was 6 inches below the all time record. June rainfall was 20.16" (12.5% above normal). The county experienced 5 days of 1" or more rain. The water level in Lake Okeechobee rose to 13.57 feet. Because this rainy period was preceded by an extended dry period and rains were spread over several days, flooding was pretty much limited to street flooding.

Hurricane Frances September 4, 2004. A maximum storm-total rainfall amount of 13.56 inches was measured at West Palm Beach International Airport with 10.36 inches of that occurring in a 24-hour period. Unofficial storm-total rainfalls included 9.56 inches at Boynton Beach, 8 inches at Deerfield Beach and 7.18 inches at Hillsboro Canal. Widespread storm-total amounts of 3 to 5 inches occurred in southeast and interior south Florida with southwest Florida averaging 1 to 3 inches. Rainfall flooding was mostly minor except for a few locations in Palm Beach County which had up to 3 feet of standing water. A section of I-95 in Palm Beach County was closed

due to a large sinkhole. Within the confines of the Herbert Hoover Dike, water levels on Lake Okeechobee fluctuated up to 5 feet above and below normal.

Hurricane Jeanne September 25, 2004. A SFWMD gage measured a maximum storm-total rainfall amount of 10.22 inches over the eastern portion of Lake Okeechobee. A SFWMD gage about four miles west of West Palm Beach International Airport measured 9.10 inches with 8.79 inches of that occurring in a 24-hour period. At Moore Haven, 5.99 inches of rain was measured. Widespread storm-total amounts of one to four inches occurred in most of southeast and interior south Florida with Miami-Dade County and Collier County averaging one half to one inch. Mostly minor rainfall flooding was observed except locally severe in Palm Beach Gardens, Jupiter and in the farmlands of western Palm Beach County. Within the confines of the Herbert Hoover Dike, water levels on Lake Okeechobee fluctuated up to seven feet above and below normal causing severe flooding of some marinas.

Flood of June 5, 2005. Eight inches of rain in three hours caused flooding of streets and businesses in Boca Raton and in Highland. Cars were stalled and Federal Highway was closed for a nine-block section from NE 20 to NE 29 Street.

Hurricane Wilma October 24, 2005. Rainfall amounts across South Florida generally ranged from 2 to 4 inches across southern sections of the peninsula to 4 to 6 inches across western Collier county and around Lake Okeechobee, with a maximum amount of 7.31 inches in Clewiston. There was scattered street flooding.

Flood of December 14, 2006. A slow-moving low pressure trough caused very heavy rains and significant flooding over parts of Palm Beach County. West Palm Beach International Airport received a total of 8.21 inches of rain ending at 7 PM on the 15th. Other locations in Central and Southern Palm Beach County received between 6 and 8 inches of rain. Northern Broward County received lesser amounts in the 2 to 3 inch range. Several streets and roads were closed in the city of West Palm Beach, with water reaching up to 3 feet deep in some areas. Hardest hit was the neighborhood of Pineapple Park. Many vehicles were stranded in the deep water, with local police receiving about 120 calls for assistance. No significant damage was reported to property despite water entering homes and businesses. Florida Power and Light reported 20,000 customers without power during the afternoon and early evening hours. Shelters were opened for people left homeless by the floods, but only 5 people had arrived as of 8:30 PM. A slow-moving low pressure trough caused very heavy rains and flooding over portions of Palm Beach County.

Flood of January 22, 2008. Intense rains affected Boynton Beach and the northwest section of Delray Beach during the late afternoon and evening hours of January 22nd. Maximum observed rainfall amounts were between 4 and 6 inches in Boynton Beach, although Doppler radar estimated as much as 10 inches of rain fell in just over 3 hours. Numerous reports of flooding were reported. A trained spotter reported water getting into houses in the corridor west of Federal Highway and east of Congress Avenue between Boynton Beach Boulevard and Woolbright Road. Water rose to as high as 2 feet along sections of Congress Avenue. Significant flooding was reported at the parking lot of Boynton Beach mall. The I-95 on-ramp at Gateway Boulevard was closed due to the water depth, as was sections of Boynton Beach Boulevard. Dozens of vehicles stalled and 40 traffic accidents were reported due to the rain and standing water. The combination of a mid and upper level trough moving east across South Florida and a developing warm frontal boundary provided the necessary atmospheric conditions

for intense rains and flooding in the Boynton Beach area on January 22nd.

March 22, 2008. Heavy rain across the Wellington area produced multiple reports of knee deep water in yards and across roadways. Heavy rain across central portions of Palm Beach County including the Wellington area produced flooded roads and water approaching a structure.

May 24, 2008. Flooding reported at the intersection of Linton Boulevard and Congress Avenue with the intersection impassable. Flooding also reported along Nassau Street with water intruding on some homes. Flood waters were near 2 feet deep at some locations. A shortwave moved across South Florida during the afternoon hours allowing multiple severe thunderstorms to develop across southeast Florida. A total of 8,300 customers lost power due to the severe thunderstorms in the three-county area of Palm Beach, Broward and Miami-Dade counties.

It is important to note that many of the areas that experienced flooding in both the 1994 and 1995 rainfall events were not in designated flood zones. For those areas where the Flood Insurance Rate Maps (FIRM) did indicate a flooding hazard, these two events both exceeded the 100-year storm levels and they occurred back-to-back. The 1999 event was extremely localized, but rainfall exceeded all previous records in specific areas, and was beyond the design capacity of virtually all drainage systems everywhere in the county.

Often when these types of intense rainfall events occur, streams and drainage ditches tend to reach peak flood flow concurrently with tidal water conditions associated with coastal storm surge. This greatly increases the probability of flooding in the low-lying areas of the coastal zone. Areas along the Intracoastal Waterway are particularly susceptible to flooding under these conditions. The most flood prone areas in the eastern portion of the county feature poorly drained soils, a high water table, and relatively flat terrain; all of which contribute to their flooding problems. Flat terrain and heavily wooded areas aggravate flood problems by preventing rapid drainage in some areas.

Flood Water Sources and Frequency of Occurrence

Sources of flood waters in Palm Beach County include:

- The Atlantic Ocean;
- The Intracoastal Waterway;
- Lake Okeechobee;
- The West Palm Beach Canal;
- The Hillsboro Canal;
- The North New River Canal; and
- The Miami Canal.

Major water retention areas include:

- Corbett Wildlife Management Area;
- Loxahatchee Wildlife Refuge and WCA No. 2; and
- The Rotenberger/Holey Land Area.

Floodplains designated on the FIRM are based on the 1% annual flood chance or the 100-year flood event. The 500-year flood event with a 0.2 % annual chance of occurrence is used to

designate other areas of the community, which may have some vulnerability to flooding. Additional flood information is addressed in **Section 4.1.4.1** Palm Beach County.

Table 3.2 Final damage assessment from the January 1999 storm.*

Jurisdiction or Geographic Area	Number of Structures Damaged	Residential and Business Loss	Public Infrastructure Loss	Total Jurisdiction Loss
Unincorporated Palm Beach County	94	\$884,000	\$119,655	\$1,003,655
Lake Park	3	\$2,008,200	\$67,000	\$2,075, 200
Riviera Beach	201	\$3,927,075	\$38,000	\$3,965,075
Palm Beach Gardens	136	\$675,400	\$13,000	\$688,400
North Palm Beach	25	\$40,000	B	\$40,000
North Jupiter	1	B	B	--
Northern Palm Beach Improvement District	B	B	\$51,000	\$51,000
Total County Losses	460	\$7,534,675	\$288,655	\$7,823,330

* Data from Palm Beach County Division of Emergency Management.

3.1.1.2 Hurricane/Tropical Storm

For many years, the risk of significant loss of life and property due to hurricanes seemed small. Many, if not the majority, of existing homes and businesses along the U.S. Atlantic and Gulf Coasts were constructed during the 1970s and 1980s, a period of relatively inactive hurricane formation. Most of the people currently living and working in coastal areas have never experienced the impact of a major hurricane. Hurricanes that impacted Florida during the 1970s and 80s were infrequent and of relatively low intensity. Homeowners, business interests, and government officials grew to regard hurricane risk as manageable by private insurance

supplemented occasionally by federal disaster funding and subsidized flood insurance. The hurricane risk did not seem sufficient to warrant increased investment in mitigation. Two major hurricanes, Hugo in 1989 and Andrew in 1992, forced a reevaluation of this risk assessment. While experts sometimes disagree on the annual cost of hurricane damage, all sources agree that hurricane Andrew was the most costly hurricane event ever to affect the U.S. Insured losses from hurricane Andrew topped \$17 billion and most sources agree that the total cost of hurricane Andrew exceeded \$25 billion.

Florida is the most vulnerable state in the nation to the impacts of hurricanes and tropical storms. South central Florida is particularly exposed to the dangers presented by hurricanes, due to its topography. The region is largely a flat, low lying plain. The potential for property damage and human casualties in Palm Beach County has been increased by the rapid growth of the county over the last few decades, particularly along the coastline. Population risk has also been exacerbated by some complacency due to the recent period of reduced hurricane frequency.

Florida not only has the most people at risk from hurricanes, but it also has the most coastal property exposed to these storms. Over the fourteen year period between 1980 and 1993, Florida's population increased by 37% while the value of insured residential property rose from \$178 billion in 1980 to \$418 billion in 1993, an increase of 135%. During this same time period, the insured value of commercial property rose from \$155 billion to \$453 billion, an increase of 192%. Dade, Broward, and Palm Beach Counties alone account for \$370 billion in insured property (42% of Florida's total). Palm Beach County had 6 major hurricanes between 1900 and 1950. The peak winds reached 120 -140mph.

Hurricanes are tropical cyclones with winds that exceed 74 mph and blow counter-clockwise about their centers in the Northern Hemisphere. They are essentially heat pumping mechanisms that transfer the sun's heat energy from the tropical to the temperate and polar regions. This helps to maintain the global heat budget and sustain life as we know it. Hurricanes are formed from thunderstorms that form over tropical oceans with surface temperatures warmer than 81° Fahrenheit (26.5° Celsius). The ambient heat in the sea's surface and moisture in the rising air column set up a low pressure center and convective conditions that allow formation of self sustaining circular wind patterns. Under the right conditions these winds may continue to intensify until they reach hurricane strength. This heat and moisture from the warm ocean water is the energy source of a hurricane. Hurricanes weaken rapidly when deprived of their energy source by traveling over land or entering cooler waters.

Since 1886, 51 storms of hurricane intensity have passed within 125 miles of Palm Beach County. This represents an average of one hurricane every two years. The number of direct hits on the southeastern Florida coastline between 1899 and 1999 has been as follows:

- Category 1 Storms: (winds 74 to 95 mph) = 4 storms (4 % annual probability);
- Category 2 Storms: (winds 96 to 110 mph) = 10 storms (10% annual probability);
- Category 3 Storms: (winds 111 to 130 mph) = 7 storms (7% annual probability);
- Category 4 Storms: (winds 131 to 155 mph) = 6 storms (6% annual probability); and
- Category 5 Storms: (> 155 mph) = 1 storm (1% annual probability).

A storm surge is a large dome of water often 50 to 100 miles wide and rising anywhere from 4 to 5 ft in a category 1 hurricane up to 20 ft in a category 5 storm. The storm surge arrives ahead of the storm's actual landfall and the more intense the hurricane is, the sooner the surge arrives. Water rise can be very rapid, posing a serious threat to those who have waited to evacuate flood prone areas. A storm surge is a wave that has outrun its generating source and become a long period swell. The surge is always highest in the right-front quadrant of the direction the hurricane is moving in. As the storm approaches shore the greatest storm surge will be to the north of the hurricane eye.

Such a surge of high water topped by waves driven by hurricane force winds can be devastating to coastal regions. The stronger the hurricane and the shallower the offshore water, the higher the surge will be. In addition, if the storm surge arrives at the same time as the high tide, the water height will be even greater. The storm tide is the combination of the storm surge and the normal astronomical tide.

Damage during hurricanes may also result from spawned tornadoes and inland flooding associated with heavy rainfall that usually accompanies these storms. Hurricane Andrew, a relatively "dry" hurricane, dumped 10 inches of rain on south Florida and left many buildings extensively water damaged. Rain water may seep into gaps in roof sheathing and saturate insulation and ceiling drywall, in some cases causing ceilings to collapse.

Aside from direct property damage, the potential for crop damage and economic disruption from hurricanes and tropical storms is significant. Recently, Tropical Storm Mitch dropped as much as 10 inches of rain in some south Florida areas, which resulted in approximately \$20 million in direct crop damage in Palm Beach County. The largest monetary loss, however, was sustained by the sugar cane mills in the western part of the county, where contracted part-time help and union workers must be paid whether or not the mills run. The six mills in Palm Beach County and the one in Hendry combined lost about \$500,000 a day in wages. The mills remained down until the fields dried out.

Palm Beach County has 671 listed farm proprietors with approximately 8,000 employees and a total annual payroll of \$13,894,000. The county has approximately 637,934 acres of farm land currently valued at \$2,417,525.

Historical Hurricane/Tropical Storm Events

Hurricane of September 1903. This hurricane made landfall near West Palm Beach on 11 September 1903 and exited the State near Tampa Bay on the 12th. Maximum recorded winds were only 78 mph, however 14 deaths were attributed to this storm and one ship was wrecked near Jupiter. Damages specific to Palm Beach County are not recorded.

Hurricane of July 1926. A category 1 hurricane with winds of 90 mph made landfall near Jupiter on the morning of 27 July 1926. This hurricane circled inland along Florida's east coast and exited the state at the Florida/Georgia border on 28 July. By that time it had been downgraded to a tropical storm. Palm Beach County experienced high winds and flooding.

Hurricane of September 1928. This hurricane made Florida landfall near the Town of Palm Beach as a strong category 4 hurricane with one of the lowest barometric pressures ever recorded in this area (928.9 millibars/27.43 in). This was the 5th most intense hurricane ever to

make landfall in U.S. territory. It reached Lake Okeechobee with very little diminishing in intensity and moved across the northern shoreline. This sent a massive storm surge southward flooding lower areas on the southern and western edge of the lake. In excess of, 2,500 people were killed during this storm's passage. Nearly all the loss of life was in the Okeechobee area and was caused by overflowing of the lake along its southwestern shore. While all of central Florida was affected by this killer storm, Palm Beach County mainly experienced wind damage and flooding from the associated rains.

Hurricane of September 1933. This major, category 3 hurricane passed over Jupiter Island with a barometric pressure of 947.5 millibars (27.98 in). Maximum winds recorded were 127 mph. There was considerable property damage all along the Florida east coast, mostly in the area between Jupiter and Fort Pierce. Severe waterfront damage was reported in Stuart. Minimal damage was reported from Palm Beach County, although there was some flooding in the lower areas of the county.

Hurricane of August 1939. A weak hurricane made landfall near Fort Pierce on the morning of 11 August and crossed the state in a northwesterly direction exiting to the Gulf of Mexico near Crystal River on the 12th. Minimal damage and flooding was experienced in Palm Beach County.

Hurricane of June 1945. This hurricane entered Florida from the Gulf of Mexico making landfall near Cedar Key and moving east-northeast to exit the state near St. Augustine. Palm Beach County received heavy rains and high winds from this storm.

Hurricane of August 1949. This category 3/category 4 hurricane made landfall in Florida between Delray and Palm Beach with winds of 130 mph and a barometric pressure of 954.0 millibars (28.17 in). As it moved inland, its center passed over the northern part of Lake Okeechobee, but the levees in that area held and no major flooding occurred. Damages were estimated at \$45 million. Tides of 11.3 ft at Fort Pierce, 8.5 ft at Stuart, and 6.9 ft at Lake Worth were reported. Stuart sustained severe damages in this storm. Statewide, over 500 people lost their homes as a result of this storm.

Hurricane (Donna) of September 1960. Hurricane Donna was the 6th most intense U.S. Hurricane at landfall. This storm crossed the Florida Keys into the Gulf of Mexico then turned back toward the northeast and struck the Florida mainland just south of Naples. It then turned north moved across Ft. Myers, where it turned again to the northeast, moved across the state, and exited Florida at just north of Daytona Beach. Rainfall ranged from 5 to 10 inches in an 80 to 100-mile wide belt following this storm's track. Lakes and streams overflowed their banks and forced the evacuation of many homes throughout central Florida. The high water closed many roads and inundated considerable agricultural land. At least 12 people were killed statewide and more than 1,794 were injured.

Hurricane (Cleo) of August 1964. This small but destructive storm moved northward into Biscayne Bay on 27 August 1964. Palm Beach County received 3 to 5 inches of rain associated with this storm, mostly in the eastern portion of the county. Most sustained damage was associated with wind rather than flooding.

Hurricane (Agnes) of June 1972. Hurricane Agnes moved through the Gulf of Mexico off Florida's west coast. While it never struck central Florida mainland, it spawned the worst

severe weather outbreak in Florida history. The outer rain bands covered virtually the entire peninsula and spawned numerous tornadoes. There were 6 people killed and 40 injured in Okeechobee, 1 killed and 7 injured in La Belle, 40 injured at Big Coppit Key, 2 injured at Bassinger, 3 injured in Haines City, 4 at Crystal Springs, 11 in Malabar, and 12 in Cape Canaveral. Most of those injured lived in manufactured housing. Damage estimates totaled \$5 million to public property and \$36 million to private property.

Hurricane (David) of September 1979. Hurricane David moved over the Dominican Republic with winds of 165 mph, but weakened drastically before reaching Florida's east coast. David raked the eastern coastline of Florida from Palm Beach County northward. Officially classed as a minimal hurricane, its strongest winds were offshore when it officially made landfall approximately 20 miles south of Melbourne. Tides were 3 to 5 feet above normal along the eye track and 1 to 2 feet above normal elsewhere along the Florida's east coast. Light to moderate erosion was reported along the Palm Beach County coastline. Storm rainfall was quite variable from location to location. Totals generally ranged from 6 to 9 inches, but some stations reported as much as 11 inches during the storm's passage.

Tropical Storm (Isidore) of September 1984. Tropical Storm Isidore made landfall near West Palm Beach on 27 September 1984 and moved inland toward Orlando. Highest winds were 73 mph and rainfall was reported to be 5 to 7 inches over a 24-hour period. There was some flooding, but this occurred mostly in northern Florida.

Tropical Storm (Bob) of June 1985. On 23 June 1985, Tropical Storm Bob moved across south Florida in a northeasterly direction from Fort Myers to just north of Palm Beach. Rainfall from this event did minor damage, mostly along Florida's west coast. Palm Beach County suffered moderate agricultural losses.

Tropical Storm (Gordon) of October 1994. Following a similar track to hurricane Donna of 1960, tropical storm Gordon crossed the Florida Keys into the Gulf of Mexico then turned back to the northeast and struck the mainland Florida Peninsula near Fort Myers on 13 October. It moved across the state and exited Florida into the Atlantic just north of Vero Beach on 16 October. Although the maximum sustained winds reported from Gordon were only 53 mph, the storm caused 8 deaths and 43 injuries.

Palm Beach County had experienced a period of extensive growth during the 1970s and 1980s. Most of this growth took place in the form of residential and commercial land development in the eastern portion of the county close to the Intracoastal Waterway and the beaches. The rain event associated with Tropical Storm Gordon in October of 1994 was the most significant rain event to occur after this period of development. Essentially, the county received 17+ inches of rain over a 3-day period. Rainfall was not evenly disbursed over the whole county.

Statewide damages associated with Gordon totaled over \$400 million. Agricultural interests sustained \$275 million in damages primarily from the widespread flooding. Vegetable and citrus crops were hit particularly hard. Exacerbating the flooding associated with Tropical Storm Gordon was the fact that prior to October, 1994 had been a very wet year for Palm Beach County. Rainfall recorded through September of that year had reached 74 inches before the Gordon event occurred. Altogether Palm Beach County received approximately 100 inches of rain in 1994, making that year the wettest year since 1913.

Hurricane (Erin) of August 1995. Hurricane Erin made landfall near Sebastian Inlet on 2 August 1995. Brevard County bore the brunt of this storm with sustained winds of approximately 100 mph. While Palm Beach County was spared most of the damages associated with Erin's wind field, heavy rains of up to 8 inches in 3 hours were associated with the backside of this storm and flooding occurred in low-lying areas along the county's northern edge.

Tropical Storm (Mitch) of October 1998. Hurricane Mitch was one of the deadliest storms in Atlantic history. By the time it reached Florida on 4 and 5 November 1998, it had been downgraded to a tropical storm. Palm Beach County received minimal rains from this storm which passed to the north of the county. Extensive agricultural damage was reported throughout South Florida.

Hurricane Irene October 1999. Hurricane Irene weakened to Tropical Storm force winds by the time it tracked north through the Everglades, but it menaced South Florida and Palm Beach County with incessant rains and its sluggish pace. In the end it dropped 10-20 inches of rain throughout the County, causing extensive flooding in some areas. By Friday evening (October 15) 125,000 homes in Palm Beach County were without power.

Hurricane Frances September 4, 2004. Hurricane Frances formed from a tropical depression in the deep tropical Atlantic on August 25 about 1400 miles east of the Lesser Antilles and reached hurricane strength on August 26. Frances became a Category 4 Hurricane on August 28 while about 700 miles east of the Lesser Antilles. Frances then moved generally west northwest and weakened to a Category 2 hurricane while crossing the northwest Bahamas. After stalling for about 12 hours on September 4 in the Florida Straits between Grand Bahama Island and the southeast Florida coast, the center of the nearly 70-mile diameter eye crossed the Florida coast near Sewalls Point, at 1 A.M. EDT, September 5, 2004 with the southern eyewall affecting the extreme northeast portion of Palm Beach County. Frances moved farther inland just north of Lake Okeechobee and weakened to a tropical storm before crossing the entire Florida Peninsula and exiting into the Gulf of Mexico just north of Tampa late on September 5. It made a second landfall as a tropical storm in the eastern Florida Panhandle.

Sustained tropical storm-force winds likely occurred in all six south Florida counties. Although no sustained hurricane-force winds were officially observed in any of the six south Florida counties, an NWS instrument on the eastern shore of Lake Okeechobee at Port Mayaca, just across the Palm Beach County border, measured a sustained wind of 85 mph. At West Palm Beach International Airport the highest sustained wind was 64 mph with a peak gust of 82 mph and the lowest observed barometric pressure was 972 mb. A South Florida Water Management District instrument measured a peak wind gust of 92 mph over the eastern portion of Lake Okeechobee. The estimated peak wind gust in the Palm Beach metro area was 91 mph at Jupiter Inlet with a peak wind gust of 87 mph measured by a C-MAN station at Lake Worth Pier. In Glades County near the western shore of Lake Okeechobee the highest measured sustained wind was 60 mph with a peak gust of 90 mph. In Clewiston, a sustained wind of 60 mph with a gust of 80 mph was estimated.

A maximum storm-total rainfall amount of 13.56 inches was measured at Palm Beach International Airport with 10.36 inches of that occurring in a 24-hour period. Unofficial storm-total rainfalls included 9.56 inches at Boynton Beach, 8 inches at Deerfield Beach and 7.18 inches at Hillsboro Canal. Widespread storm-total amounts of 3 to 5 inches occurred in southeast and interior south Florida with southwest Florida averaging 1 to 3 inches. Rainfall

flooding was mostly minor except for a few locations in Palm Beach County which had up to 3 feet of standing water. A section of I-95 in Palm Beach County was closed due to a large sinkhole. The maximum storm surge was estimated to have ranged from 2 to 4 feet along the northeast Palm Beach Coast to 1 to 2 feet along the northeast Broward Coast.

Within the confines of the Herbert Hoover Dike, water levels on Lake Okeechobee fluctuated up to 5 feet above and below normal. Coastal beach erosion was moderate in Palm Beach and portions of Broward counties.

There were no confirmed tornadoes. There were no known direct deaths, but at least 9 people died in the aftermath. Six of these deaths occurred in Palm Beach County, mainly as the result of vehicle-related accidents or from drownings. An unknown number of injuries occurred. Property damage at the coast occurred mainly to marinas, piers, seawalls, bridges and docks, as well as to boats. Inland structure damage included 15,000 houses and 2,400 businesses in Palm Beach County. Wind damage to house roofs, mobile homes, trees, power lines, signs, screened enclosures and outbuildings occurred over much of southeast Florida including areas near Lake Okeechobee, but was greatest in Palm Beach County. A preliminary damage estimate for Frances in south Florida was \$620 million, including \$500 million in Palm Beach, \$80 million in Broward, and \$34 million in Miami-Dade. Crop damage in Palm Beach County was estimated at an additional \$70 million to sugar cane and vegetables and additional heavy losses occurred to nurseries. Florida Power and Light reported power outages occurred to 659,000 customers in Palm Beach, 590,000 in Broward, 423,000 in Miami-Dade, 39,200 in Collier, 2,500 in Hendry and 1,700 in Collier. An estimated 17,000 persons sought refuge in public shelters in Palm Beach County and nearly 7,000 in Broward County.

Hurricane Jeanne September 25, 2004. Just three weeks after Hurricane Frances, Hurricane Jeanne struck the same area of southeast Florida. Hurricane Jeanne formed from a tropical depression just east of the Leeward Islands on September 13. She moved across Puerto Rico and Hispaniola then turned north into the Atlantic and became a hurricane on September 20. Jeanne made a clockwise loop for three days in the Atlantic north of Hispaniola before moving west northwest. It strengthened to a Category 3 Hurricane while over the northwest Bahamas and then made landfall around 11 P.M., September 25 near the south end of Hutchinson Island, nearly coincident with the landfall point of Hurricane Frances just three weeks before. The 40-mile diameter eye was not quite as large as Frances, but the southern eyewall again affected northeast Palm Beach County. After landfall, Jeanne initially moved along a track similar to Frances, just north of Lake Okeechobee as it weakened to a tropical storm then turned to the northwest and moved over the northwest Florida Peninsula.

Although slightly smaller and stronger than Hurricane Frances, winds and pressures over southeast Florida were remarkably similar to Frances. Unfortunately, the ASOS at Palm Beach International Airport quit sending data during the height of the hurricane. Sustained tropical storm-force winds likely occurred over most of Palm Beach and northeast Glades counties and portions of Broward, Hendry and Collier counties. Although no sustained hurricane-force winds were officially observed in any of the six south Florida counties, portions of northern Palm Beach County mostly likely experienced them. A South Florida Water Management District (SFWMD) instrument in the Martin County portion of Lake Okeechobee measured a 15-minute sustained wind of 79 mph with a peak gust of 105 mph. In metropolitan Palm Beach the highest official sustained wind speed was 60 mph with a peak gust of 94 mph from the C-MAN station at Lake Worth Pier. An unofficial peak wind gust of 125 mph was measured in West Palm Beach

at the Solid Waste Treatment Plant. Near Clewiston the highest measured sustained wind was 31 mph with a peak wind gust of 72 mph from a SFWMD instrument. The lowest barometric pressure of 960.4 mb was measured at a SFWMD site in the Martin County portion of Lake Okeechobee.

A SFWMD gage measured a maximum storm-total rainfall amount of 10.22 inches over the eastern portion of Lake Okeechobee. A SFWMD gage about four miles west of West Palm Beach International Airport measured 9.10 inches with 8.79 inches of that occurring in a 24-hour period. At Moore Haven, 5.99 inches of rain was measured. Mostly minor rainfall flooding was observed except locally severe in Palm Beach Gardens, Jupiter and in the farmlands of western Palm Beach County.

The estimated maximum storm surge ranged from two to four feet along the northeast Palm Beach Coast to one to two feet along the northeast Broward Coast. Within the confines of the Herbert Hoover Dike, water levels on Lake Okeechobee fluctuated up to seven feet above and below normal causing severe flooding of some marinas. Beach erosion was moderate in Palm Beach.

There were no confirmed tornadoes. There were no known direct deaths but four persons died in the aftermath. An unknown number of injuries occurred. Property damage from storm surge and winds at the coast occurred to condos, marinas, piers, seawalls, bridges and docks, as well as to boats and a few coastal roadways. Inland wind damage to building roofs, mobile homes, trees, power lines, signs, and outbuildings occurred over mainly over Palm Beach County and portions of eastern Glades and Hendry counties. Preliminary damage estimates for Jeanne in southeast Florida were \$330 million, including \$260 million in Palm Beach, \$50 million in Broward and \$10 million in Miami-Dade. Agricultural Damage in Palm Beach County was estimated at \$30 million. Florida Power and Light reported outages occurred to 591,300 customers in Palm Beach, 165,900 in Broward, 25,100 in Miami-Dade, 5,200 in Collier, 3,000 in Hendry and 1,500 in Glades. An estimated 12,534 persons sought refuge in public shelters in Palm Beach County.

Hurricane Wilma October 24, 2005. Wilma was a classic October hurricane which struck South Florida as a Category 3 hurricane on October 24th, 2005. Wilma developed from a tropical depression near Jamaica, a typical source region for October tropical cyclones, on the afternoon of October 15, 2005. It became the 21st named storm of the season during the morning hours of October 17, 2005, which tied the record for the most named storms in one season originally set back in 1933. Wilma underwent a rapid intensification cycle which began on October 18th and ended in the early morning hours of October 19th, with a central pressure decrease of an incredible 88 mb in only 12 hours. The central pressure reached 882 mb., making Wilma the most intense hurricane ever in the Atlantic Basin, a full 6 mb. lower than Hurricane Gilbert in September 1988. Wilma went on to make landfall on Cozumel Island just off the Yucatan Peninsula as a strong category 4 hurricane on Friday, October 21st, then drifted erratically over the Yucatan Peninsula through Saturday evening October 22nd. Wilma began to move off the northeast coast of the Yucatan Peninsula on the night of the 22nd, then gradually accelerated northeast over the southern Gulf of Mexico toward South Florida as a strong mid and upper-level trough over the central United States moved south and forced a southwesterly steering flow.

The hurricane made landfall as a category 3 storm shortly before 7 AM Monday, October 24th on the southwest Florida coast between Everglades City and Cape Romano with maximum sustained winds of 125 mph and an estimated minimum central pressure of 950 mb. Wilma exhibited a very large 55 to 65 mile-wide eye while crossing the state, and the eye covered large portions of South Florida, including the eastern two-thirds of Collier County, extreme northwestern Miami-Dade County, the southern and eastern third of Hendry County, most of Broward County, and all of Palm Beach County. The eye also clipped the southeastern shore of Lake Okeechobee. The eye wall affected virtually all of South Florida. Around 10:30 AM, a South Florida Water Management District (SFWMD) meteorological station located at the south end of Lake Okeechobee reported sustained winds of 103 mph. The highest recorded gusts were in the 100-120 mph range. An interesting and revealing aspect of Wilma was the wind field in the eye wall. The winds on the back (south/west) side of the eye wall were as strong, if not stronger, than those on the front (north/east) side. This goes against the common, but sometimes erroneous, belief that the strongest winds in a hurricane are always in the right-front quadrant of the storm. This occurred over much of South Florida, except for central and southern Miami-Dade County which barely missed the southwestern portion of the eye wall, and likely contributed to the heavier damage across Broward and Palm Beach counties compared to slightly lesser damage across much of Miami-Dade and Collier counties.

Wilma moved rapidly northeast across the state, with an average forward speed of 25 mph. Wilma exited the east coast over northeastern Palm Beach County near Palm Beach Gardens around 11 AM Monday October 24th as a Category 2 hurricane with maximum sustained winds of around 105 mph. It traversed the southern peninsula in about 4 hours. Rainfall amounts across South Florida generally ranged from 2 to 4 inches across southern sections of the peninsula to 4 to 6 inches across western Collier county and around Lake Okeechobee, with a maximum amount of 7.31 inches in Clewiston, Downtown Miami, and Northeast Miami.

In Collier, Miami-Dade, Broward, and Palm Beach Counties, the winds killed a total of 5 people. Total damage estimates from all the effects ranged from \$9 to \$12 billion. Extensive damage to crops was reported, with an estimated \$222 million in crop damage for Miami-Dade County alone. Damage was widespread, with large trees and power lines down virtually everywhere, causing over 3 million customers to lose power. Structural damage was heaviest in Broward and Palm Beach counties where roof damage and downed or split power poles were noted in some areas. High-rise buildings suffered considerable damage, mainly in the form of broken windows. This was observed mainly along the southeast metro areas. An F1 tornado caused snapped power poles, uprooted large trees, and significantly damaged mobile homes. Small swaths of greater damage elsewhere in South Florida have not been attributed to tornadoes, but were instead likely caused by "mini-swirls", small vortices within the eye wall.

Tropical Storm Noel October 30-31, 2007. Tropical Storm Noel moved north from eastern Cuba across the western Bahamas Islands from October 30 through October 31. The interaction of Noel with a strong high pressure area located over the mid-Atlantic states produced strong winds over southeast Florida and the adjacent waters well before Noel made its closest passage to the area early on November 1. Damage was minor and mainly confined to a few downed power lines. Around 5,000 customers lost power in the three-county area of Palm Beach, Broward and Miami-Dade counties. Rainfall amounts were rather light, ranging from a half-inch (0.5) to nearly 2 inches. A strong pressure gradient between high pressure over the Mid-Atlantic states and Tropical Storm Noel over Hispaniola and eastern Cuba caused a prolonged period of strong east winds over Southeast Florida and the adjacent waters. As Noel

moved north across the western Bahamas, the strong winds continued across southeast Florida. The event caused severe beach erosion, coastal flooding, and minor wind damage. The event lasted into the first few days of November.

Tropical Storm Fay August 15-23, 2008. The center of Tropical Storm Fay moved across Key West early in the evening of August 18th and into the mainland of South Florida at Cape Romano shortly before 5 AM on the 19th. Minimum central pressure was 989 MB at landfall, but continued to decrease after landfall to 986 MB at Moore Haven on the southwest shore of Lake Okeechobee.

Maximum sustained winds were estimated to be around 52 knots (60 MPH) at landfall, however as the storm tracked across the western Everglades and Southwest Florida the radar presentation continued to organize and winds increased to around 56 knots (65 MPH) around Moore Haven. A maximum wind gust of 69 knots (79 MPH) was recorded on a South Florida Water Management gauge on Lake Okeechobee as the storm passed. Wind gusts to tropical storm force were felt area-wide, with sustained tropical storm force winds experienced over portions of Mainland Monroe, Collier, Hendry and Glades counties as well as the immediate coastal sections of Miami-Dade, Broward and Palm Beach counties. Wind damage was most significant in the areas affected by tropical storm force sustained winds, primarily around Lake Okeechobee and interior sections of southwest Florida, with only minor wind damage elsewhere.

The storm caused over \$10 million in beach erosion along Palm Beach County's coastline. A maximum rainfall total of 16.17 inches was reported with this event at Moore Haven in Glades County. Flooding from these rains produced total damage estimates of \$380,000, primarily in Glades and Hendry counties. Rainfall elsewhere ranged from 3-6 inches in southeast Florida, and 6-8 inches in southwest Florida, with isolated amounts up to 10 inches in coastal Palm Beach County. All the associated effects of Tropical Storm Fay in South Florida resulted in 1 fatality, 4 injuries, and \$3.949 million in property damage. Two tornadoes produced \$1.25 million in damage, but no injuries or fatalities were reported. The one fatality and 3 of the injuries were indirectly caused by Fay with a traffic accident in Palm Beach County. The direct injury occurred when a kite surfer on Fort Lauderdale Beach lost control during a squall and was slammed into a building along A1A. Fay caused tropical storm force winds, significant rainfall flooding in some areas, as well as two confirmed tornadoes.

3.1.1.3 Tornado

Florida ranks third in the United States in the number of tornado strikes, and the first in the number of tornadoes per square mile. The odds of a tornado striking any specific point in southeastern Florida are 0.04, or once per 250 years.

Tornadoes are classified using the Fujita-Pearson scale as follows:

F = Intensity	P = Path Length	W = Mean Width
F0 = Light Damage	P0 = less than 1 mile	W0 = less than 0.01 mile

F1 = Moderate Damage	P1 = 1.0 to 3.1 miles	W1 = 0.01 to 0.03 mile
F2 = Considerable Damage	P2 = 3.2 to 9.9 miles	W2 = 0.04 to 0.09 mile
F3 = Severe Damage	P3 = 10.0 to 31.0 miles	W3 = 0.10 to 0.31 mile
F4 = Devastating Damage	P4 = 32.0 to 99.0 miles	W4 = 0.32 to 0.99 mile
F5 = Catastrophic Damage	P5 = 100 miles or greater	W5 = 1.00 miles or wider

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud. It is generated by a thunderstorm (or sometimes as a result of a hurricane) and produced when cool air overrides a layer of warm air, forcing the warm air to rise rapidly. The damage from a tornado is a result of the high wind velocity and wind-blown debris. The most common type of tornado, the relatively weak and short-lived type, occurs in the warm season with June being the peak month. The strongest, most deadly tornadoes occur in the cool season, from December through April. Occasional wind-storms accompanied by tornadoes such as the winter storm of 1993 are also widespread and destructive. Of the 134 tornadoes seen in Palm Beach County between 1950 and 2002, 87 were classified as F0 tornadoes (59%), 38 (31%) were classified F1, 8 (9%) were classified as F2, and 1 (1%) was classified as an F3 tornado. Over the years, the citizens of Palm Beach County have been effective by the tornadoes, which have occurred within the county. Between 1950 and 2008 there have been 277 reported tornadoes, 102 people injured and 1 death in Palm Beach County as of a tornado. The damage is estimated at over \$150 million dollars since 1950.

When a tornado threatens, only a short amount of time is available for life-or-death decisions. The National Weather Service (NWS) issues two types of alerts:

- A Tornado Watch means that conditions are favorable for tornadoes to develop.
- A Tornado Warning means that a tornado has actually been sighted.

August 7, 2003 On August 7, 2003, there was a Tornado Watch issued by the NWS. Two tornadoes touched down later that evening in the northern part of Palm Beach County. Jupiter suffered damage to a shopping plaza. No injuries were reported. A second tornado touched down in unincorporated Palm Beach County in a mobile home park causing major damage in some areas. The tornado moved in the direction of east southeast toward Interstate 95. The tornado caused considerable damage to an industrial park located in Unincorporated Palm Beach County/Riviera Beach. The tornado continued in the same direction damaging several neighborhoods in a residential area of Riviera Beach. It continued through additional neighborhoods in Riviera Beach just north of Blue Heron Boulevard. The damage path was narrower until it lifted or dissipated near the intersections of Blue Heron Boulevard and Old Dixie Highway.

From all of the evidence considered, including some damage that was very close to F2 damage, WFO Miami classified the unincorporated Palm Beach County-Riviera Beach tornado as F1 on the Fujita scale, meaning that winds were approximately 73 to 112 mph. The worst damage was apparently caused by winds near the upper end of that range. Miami National Weather Service Forecast Office (WFO) meteorologists determined that the main path of the tornado was approximately 1/6 mile (300 yards) wide at its widest point and about 4 miles long. There were

no deaths, but 28 individuals suffered minor injuries. There were 33 dwellings destroyed and a total of 236 suffered damage. The damage has been estimated to be \$70 to \$80 million dollars.

August 2008 Wellington Tornado At about 1:30 AM on August 19, 2008 a tornado associated with a spiral band of strong thunderstorms rotating around the circulation of Tropical Storm Fay moved through the Village of Wellington. The tornado began near Polo Mark Middle School near the intersection of Lake Worth Road and Isles View Drive and ended just southwest of Wellington High School. The tornado had an approximate damage path of 2.75 miles from the southeast to the northwest and was around 100 yard wide at its widest point, but mostly 70 to 80 yards.

The tornado moved through a number of equine farms and polo grounds as well as two subdivisions in Wellington. The most significant damage was to Palm Beach Equine Clinic, where stables were de-roofed, power poles snapped, and many trees fell in crisscrossing patterns. The Equine Veterinary lost more than 95 percent of its roof tiles; a heavy trailer was tossed about 40 yards from its previous location northwest of the International Polo Club; and an apartment home near Folkstone Circle lost about 70 percent of its roof tiles. There were no deaths or injuries to people or animals.

3.1.1.4 Severe Thunderstorm/Lightning

A severe thunderstorm is defined as a thunderstorm containing one or more of the following phenomena: hail 3/4" or greater, winds gusting in excess of 57.5 mph, and/or a tornado. Severe weather can include lightning, tornadoes, damaging straight-line winds, and large hail. Most individual thunderstorms only last several minutes, however some can last several hours.

Long-lived thunderstorms are called supercell thunderstorms. A supercell is a thunderstorm that has a persistent rotating updraft. This rotation maintains the energy release of the thunderstorm over a much longer time than typical, pulse-type thunderstorms which occur in the summer months. Supercell thunderstorms are responsible for producing the majority of severe weather, such as large hail and tornadoes (National Oceanic and Atmospheric Administration). Downbursts are also occasionally associated with severe thunderstorms. A downburst is a strong downdraft resulting in an outward burst of damaging winds on or near the ground. Downburst winds can produce damage similar to a strong tornado. Although usually associated with thunderstorms, downbursts can even occur with showers too weak to produce thunder (National Oceanic and Atmospheric Administration). Strong squall lines can also produce widespread severe weather, primarily very strong winds and/or microbursts.

When a severe thunderstorm approaches, the National Weather Service will issue alerts. Two possible alerts are:

- Severe Thunderstorm Watch - Conditions are favorable for the development of severe thunderstorms.
- Severe Thunderstorm Warning - Severe weather is imminent or occurring in the area.

Thunderstorms are common in Palm Beach County, and area residents are quite familiar with them and the severe weather they can bring. In 1997, thunderstorms produced 103 tornadoes

and other damaging winds and hail. These winds injured 121 people and caused over \$38 million in damage throughout the state.

Perhaps the most dangerous and costly effect of thunderstorms is lightning. As a thunderstorm grows, electrical charges build up within the cloud. Oppositely charged particles gather at the ground below. The attraction between positive and negative charges quickly grows strong enough to overcome the air's resistance to electrical flow. Racing toward each other, they connect and complete the electrical circuit. Charge from the ground then surges upward at nearly one-third the speed of light and produces a bright flash of lightning (Cappella, 1997).

On average, more people are killed by lightning than any other weather event. Florida leads in the nation in lightning related deaths and injuries (National Lightning Safety Institute). Florida also has the most strikes, about 12 strikes per square kilometer per year in some places (National Lightning Safety Institute). Nationwide, lightning related economic losses amount to over \$5 billion dollars per year, and the airline industry alone loses approximately \$2 billion a year in operating costs and passenger delays from lightning. From July of 1959 to August of 2003 there have been 25 deaths and 93 injuries as a result from lightning strikes. The peak months for lightning strikes are June, July, and August, but no month is safe from lightning danger.

3.1.1.5 Drought

Drought is a normal, recurrent feature of climate, although many perceive it as a rare and random event. In fact, each year some part of the U.S. has severe or extreme drought. Although it has many definitions, drought originates from a deficiency of precipitation over an extended period of time, usually a season or more (National Drought Mitigation Center, 1998) or a lack of water levels on the ground. It produces a complex web of impacts that spans many sectors of the economy and reaches well beyond the area producing physical drought. This complexity exists because water is essential to our ability to produce goods and provide services (National Drought Mitigation Center, 1998).

A few examples of direct impacts of drought are: reduced crop, rangeland, and forest productivity; increased fire hazard; reduced water levels; increased livestock and wildlife mortality rates; and damage to wildlife and fish habitat. Social impacts include public safety; health; conflicts between water users; reduced quality of life; and inequities in the distribution of impacts and disaster relief. Income loss is another indicator used in assessing the impacts of drought; reduced income for farmers has a ripple effect throughout the region's economy (National Drought Mitigation Center, 1998).

The web of impacts is so diffuse that it is very difficult to come up with financial estimates of damages. However, the Federal Emergency Management Agency (FEMA) estimates \$6-8 billion in losses as the annual average. The worst drought in recent history occurred in 1987-1989, and the National Climatic Data Center (NCDC) reports the estimated cost as \$40 billion (National Drought Mitigation Center, 1998).

In Palm Beach County, the primary sources of water are Lake Okeechobee, watershed areas, and the county's wellfields. Normally, excess water from an interconnected series of lakes, rivers, canals, and marshes flows into Lake Okeechobee via the Kissimmee River. When this cycle is disrupted by periods of drought, one of the potentially most damaging effects is

substantial crop loss in the western agriculture areas of the county. In addition to obvious losses in yields in both crop and livestock production, drought in Palm Beach County is associated with increases in insect infestations, plant disease, and wind erosion. The incidence of forest fires increases substantially during extended droughts, which in turn places both human and wildlife populations at higher levels of risk.

The South Florida Water Management District and County staff manage the county's water resources. A county-wide, uniform, forceful, contingency plan is in place to effectively restrict the use of water that complements the District's water management efforts during periods of critical water shortage.

The driest year on record for Florida was 2000. The worst drought on record for Palm Beach County was from 2000 to 2001. From November 2000 until February 2001, Palm Beach County recorded its four driest months on record. An illustration of this dry period is after Irene in 1999, Lake Okeechobee was recorded to be at 18 feet by May of 2001 it dropped to 9 feet. Lake Okeechobee's average is about 13 feet.

Palm Beach County averages rainfall between 50-60 inches of rain a year. In the year 2000, there was less than 40 inches of rain. However, records illustrate rainfall often varies 20 inches above to 20 inches below the annual average. This leads to the potential drought conditions.

Significant droughts since 1970 to impact Palm Beach County include:

1970 -1971 Drought. Lake Okeechobee reached a minimum stage of 10.29 feet NGVD on June 7, 1971. A rainfall deficit of 43 percent was reported as average for Lake Okeechobee and the Northern, Central, and Southern Everglades for the eight-month period from October 1970 to May 1971.

1973 – 1974 Drought. The 1973–1974 drought was comparable to the 1971–1972 drought. The rainfall deficit during the period was 47 percent. The minimum lake stage of 10.98 feet NGVD was reached on May 31, 1974.

1980 – 1982 Drought. The 1980–1982 drought was one of the most severe droughts ever in South Florida. A more than 20-inch rainfall deficit over two years resulted in the decline of the Lake Okeechobee stage from 17.46 feet NGVD on January 1, 1980 to 9.79 feet NGVD on July 31, 1981. The 7.7-foot drop in water level was attributed to a decrease in rainfall and increases in evaporation and water use. The drought for the Lower East Coast and Water Conservation Areas was relieved in 1981 by Tropical Storm Dennis.

1985 Drought. The 1984 wet season and the 1984–1985 dry season had rainfall deficiencies that resulted in the 1985 drought. The upper Kissimmee, lower Kissimmee, and Lake Okeechobee rain areas had an average deficit of 14 inches. The Lake Okeechobee water level declined from 15.14 feet NGVD to 11.82 feet NGVD between January 1, 1985 and June 12, 1985. The South Florida Water Management District had to initiate back pumping to increase water supply. A water shortage plan was also implemented.

1988 – 1989 Drought. South Florida experienced a severe drought from September 1988 to August 1989, during which there was a 21-inch rainfall deficit in the Everglades Agricultural Area and the Lower East Coast. The Lake Okeechobee water level declined from 15.95 feet

NGVD on September 1, 1988 to 11.06 feet NGVD on August 8, 1989. During the same period a record storage depletion was reported for Lake Okeechobee and the Water Conservation Area

1990 Drought. The 1990 drought was a continuation of the 1988–1989 drought. From June 1989 through May 1990, nine inches of rainfall deficit occurred District-wide and was most severe in Everglades National Park. Lake Okeechobee supply-side management and water restrictions were implemented to conserve lake water. The Lake Okeechobee water level declined from 12.25 feet NGVD on January 1, 1990 to 10.47 ft NGVD on June 21, 1990.

2000-2001 Drought. A new low water level record of 8.97 ft NGVD was set for Lake Okeechobee on May 24, 2001 during the 2000–2001 drought in South Florida.

2007 Drought. A severe drought affected the region from late 2006 through 2007. This drought followed back-to-back years of unprecedented hurricane activity and higher-than-normal rainfall.

On July 2, 2007 water levels in Lake Okeechobee reached an all-time record low of 8.82 feet, eclipsing the mark of 8.97 feet set during the 2001 drought. Rainfall directly over the lake was low enough to qualify the 2007 drought as a 1-in-100-year event. Just north of the lake, along the tributary Kissimmee River and Upper Chain of Lakes, low rainfall produced a 1-in-50-year drought. Only 40 inches of rain fell on the region in an 18 month period, about one-half the average. More than 200 days passed without water flowing from the Kissimmee River into Lake Okeechobee.

A combination of voluntary and mandatory water use restrictions were enacted by the SFWMD in early 2007. Drought conditions diminished somewhat on the coasts during the wet season, however, water supplies in the center of the region (Kissimmee Valley and Lake Okeechobee) continued to decline. Widespread drought conditions continued into late 2007, particularly in the Lake Okeechobee watershed, evidenced by record-low water levels and dry water control structures in the vicinity of the lake.

A combination of a wetter than expected February, March and early April 2008 and a wetter than normal summer finally interrupted the extended drought. Punctuating this increased rainfall was the passage of Tropical Storm Fay on August 18 and 19. Fay was a very wet tropical storm, which brought a general average of 7 to 10 inches of rain into southern Palm Beach, including Lake Okeechobee and surrounding areas. Isolated amounts near the southwest shore of Lake Okeechobee were in the 12 to 15 inch range, with Moore Haven recording a two-day total of 16.17 inches. Despite this relief, water use restrictions were continued into 2009 and likely beyond in order to balance longer-term regional water availability and supply needs. As of this writing, the region was still experiencing moderate drought conditions.

The 2007 Drought was different. Typically, when one part of the regional system is experiencing drought conditions, backup water supplies are available through operation of the Central and Southern Florida Flood Control Project. Before the 2007 drought, the SFWMD had never experienced a situation where all three major water storage areas of the system – the Upper Kissimmee Chain of Lakes, Lake Okeechobee, and the Water Conservation Areas – simultaneously had substantially below normal water levels approaching record lows. Lakes in the Upper Kissimmee area were below their regulation schedule and not available as a source of water to Lake Okeechobee. Lake Okeechobee was anticipated to reach a new record and not be available to send backup water supplies to the Lower East Coast. At the same time the

Water Conservation Areas were nearing their minimum regulation schedule, below which no water could be withdrawn. Without a schedule deviation authorized by the U.S. Army Corps of Engineers, the District is not able to withdraw water from these areas to recharge the coastal canals.

The period from November 2005 to March 2007 ranked as the third driest period in recorded history. The Governing Board of the District imposed mandatory water shortage restrictions in areas around Lake Okeechobee in November 2006 and in Southeast Florida in March 2007. Nevertheless, drought conditions intensified substantially. Compounding the lack of rainfall there were consistently windy conditions, low humidity, and lack of cloud cover contributing to above average evapotranspiration rates.

3.1.1.6 Extreme Temperatures

Freezing Temperatures

According to the Department of Agriculture and Consumer Services, a moderate freeze may be expected every one to two years. Severe freezes may be expected on an average of once every 15 to 20 years. Freezes pose a major hazard to the agriculture industry in Palm Beach County on a recurring basis, and are a significant threat to the economic vitality of the state's vital agriculture industry. Palm Beach County has experienced seven significant freezes between 1970 and the present.

Florida has experienced a number of severe or disastrous freezes, when the majority of the winter crops are lost. The lowest temperature ever recorded in the state is 12°F (National Climatic Data Center). Since December 1889, there have been at least 22 recorded severe freezes; the most recent being in 1996, when a Presidential Disaster Declaration was issued for crop losses exceeding \$90 billion. During this event, there was an extensive loss of citrus trees and the majorities were not replanted.

On rare occasions, the winter of 2000-2001 for example, there were over 20 nights between November and March where temperatures or wind chill readings fell below 40 degrees Fahrenheit.

Freezing conditions primarily affect agriculture and homeless indigents in Palm Beach County. When conditions are predicted to fall below 40 degrees Fahrenheit, shelters are opened.

Recent significant freezes include:

The 1977 Freeze. Climaxing one of the coldest winters ever recorded in the eastern United States, a severe cold outbreak of arctic air swept into Florida January 18 thru 21, 1977. Snow was reported as far south as Homestead and a severe freeze affected all of the State's citrus and vegetable crops.

In south Florida agricultural areas, the freeze was one of the most severe of this century. Temperatures were below freezing for 10 to 14 hours, and 28° degrees or colder for 4 to 8 hours. An unusually heavy frost accompanied these freezing temperatures and extended to the immediate coast. West Palm Beach recorded an all-time low of 27°. Some farmers in the area reported temperatures near 20 degrees.

A U. S. Department of Agriculture report indicated the following crop loss statewide: Citrus 35%, Vegetables 95-100%, Commercial Flowers 50-75%, Permanent Pasture Land 50%, Sugar Cane 40%. It is estimated the 1977 freeze cost the Florida economy \$2 billion (1977 dollars).

The 2009 Freeze. At this writing, agricultural damages were being assessed from a January 2009 freeze. Seventy million citrus trees and tens of thousands of acres of fresh fruits and vegetables were in regions where temperatures remained below 30° F for several hours each of two consecutive days. In the Glades freezing temperatures lasted as long as 12 hours. Early estimates were that the bean crop was totaled and as much as 85% of the corn crop could be lost. Sugar cane also took a hit, but damage won't be known until harvest. This event promises to be the most destructive since the 1989 freeze. Tens of millions of dollars, if not 100's of millions of dollars, in losses are possible. A second freeze occurred two weeks later causing some additional crop damage, but was not as severe.

Extreme Heat

Temperatures that remain 10 degrees or more above the average high temperature for a region and last for several weeks are defined as extreme heat (Federal Emergency Management Agency, 1996). Humid conditions, which add to the discomfort of high temperatures, occur when an area of high atmospheric pressure traps hazy, damp air near the ground. The highest temperature ever recorded in the state was on 29 June 1931 at 103°F in Monticello at an elevation of 207 ft. (National Climatic Data Center, 1996). In a normal year, approximately 175 Americans die from extreme heat. However, in 1995 the national death toll was 1,021 (National Weather Service, 1997).

Human bodies dissipate heat in one of three ways: by varying the rate and depth of blood circulation; by losing water through the skin and sweat glands; and by panting. As the blood is heated to above 98.6 degrees, the heart begins to pump more blood, blood vessels dilate to accommodate the increased flow, and the bundles of tiny capillaries penetrating through the upper layers of skin are put into operation. The body's blood is circulated closer to the surface, and excess heat is released into the cooler atmosphere. Water diffuses through the skin as perspiration. The skin handles about 90% of the body's heat dissipating function.

Heat disorders generally have to do with a reduction or collapse of the body's ability to cool itself by circulatory changes and sweating, or a chemical (salt) imbalance caused by too much sweating. When the body cannot cool itself, or when it cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop. Studies indicate that, other factors being equal, the severity of heat disorders tend to increase with age. Heat cramps in a 17-year-old may be heat exhaustion in someone 40, and heat stroke in a person over 60.

When the temperature gets extremely high, the NWS has increased its efforts to alert the general public as well as the appropriate authorities by issuing Special Weather Statements. Residents should heed these warnings to prevent heat related medical complications. As a result of the latest research findings, the NWS has devised the "Heat Index" (HI). The HI, given in degrees Fahrenheit, is an accurate measure of how hot it really feels when relative humidity is added to the actual air temperature. The NWS will initiate alert procedures when the HI is expected to exceed 105°F for at least two consecutive days. Possible heat disorders related to the corresponding HI are listed below.

Heat Index of 130 or Higher	Heatstroke/Sunstroke; exposure for people in higher risk groups
Heat Index of 105-130	Sunstroke, heat cramps, and heat exhaustion likely and heatstroke possible with prolonged physical activity
Heat Index of 90-105	Sunstroke, heat cramps with prolonged exposure
Heat Index of 80-90	Fatigue possible with prolonged exposure and physical activity

This chart represents the averages and potential extreme temperatures of south Florida.

South FL Monthly Averages

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg Temp	65°	66°	70°	73°	78°	81°	82°	83°	82°	78°	72°	67°
Record High	87° '91	90° '49	94° '77	99° '71	96° '71	98° '98	99° '83	98° '63	96° '51	95° '59	91° '92	88° '89
Record Low	27° '77	32° '89	30° '80	43° '87	51° '92	61° '84	68° '75	66° '50	67° '83	46° '68	36° '50	28° '89
Avg Rain	2.8"	2.7"	3.7"	2.9"	6.1"	8.1"	6.1"	6.0"	8.5"	6.6"	4.7"	2.5"

3.1.1.7 Agricultural Pest and Disease

Florida is among the top three agriculture-producing states in the nation. Agriculture generates farm cash receipts of nearly \$6 billion annually, of which citrus and vegetable crops contribute more than 40 percent. The industry is susceptible to many hazards including freezes, droughts, and exotic pests or diseases. Agricultural crops are grown throughout the state and every region is vulnerable to the effects of an exotic pest or disease infestation. As a result, Florida uses the second highest volume of pesticides in the nation.

Agriculture and citrus production play a key role in the Palm Beach County economy; 54% of the county is farmland. The main threats to the Palm Beach County agriculture industry are Citrus Canker, Tomato Yellow Leaf Curl Virus (TYLCV), the Mediterranean Fruit Fly (Medfly), and sugarcane pests.

Citrus Canker

Citrus Canker was found in Palm Beach County in numerous locations in 2002. The Florida Department of Agriculture reported cases of orange and grapefruit trees infected in the southern part of the county as well as in the northern part of the county. Citrus Canker is a bacterial disease of citrus that causes premature leaf and fruit drop. It affects all types of citrus, including oranges, sour oranges, grapefruit, tangerines, lemons, and limes. Symptoms found on leaves and fruit are brown, raised lesions surrounded by an oily, water-soaked area and a yellow ring or halo (Florida Department of Agriculture and Consumer Services).

There is no known chemical compound that will destroy the Citrus Canker bacteria. In order to eradicate the disease, infected trees must be cut down and disposed of properly. In 2002, legal cases began when citrus canker was discovered in Palm Beach County over the cutting down of infected and exposed trees. The Florida Department of Agriculture wanted to search a 70-square-mile area in the county for diseased trees. It is a highly contagious disease that can be spread rapidly by windborne rain, lawnmowers and other landscaping equipment, animals and birds, people carrying the infection on their hands or clothing, and moving infected or exposed plants or plant parts (Florida Department of Agriculture and Consumer Services). There is great potential to impact Florida's \$9.1 billion citrus industry.

Tomato Yellow Leaf Curl Virus (TYLCV)

This virus is believed to have entered the state in Dade County sometime in early 1997. Symptoms vary among tomato types, but in general, leaves produced shortly after infection are reduced in size, distorted, cupped inward or downward, and have a yellow mottle. Fewer than one in ten flowers will produce fruit after TYLCV infection, severely reducing yields.

The virus is transmitted by adult silverleaf whiteflies. Although frequent applications of pesticides help to decrease whitefly populations and suppress the spread of TYLCV, virus management through whitefly control is not possible in years where whitefly populations are high. Fortunately, the virus is not transmitted through seed or casual contact with infected plants (Polston & Brown, 1997).

Mediterranean Fruit Fly (Medfly)

Another threat to Palm Beach County's agriculture industry is the Medfly. It is one of the world's most destructive pests and infests more than 250 different plants that are important for U.S. food producers, homeowners and wildlife. It is considered the greatest pest threat to Florida's \$1.5 billion citrus crop, as well as endangering many other economically significant crops (Florida Department of Agriculture and Consumer Services). For example, a Medfly outbreak in 1997 cost an estimated \$26 million to eradicate. If a long-term or widespread Medfly infestation were to occur, Florida growers would not be permitted to ship numerous fruit and vegetable crops to many foreign and domestic markets. The movement of fruits and vegetables, even within the state, would be disrupted, which could lead to higher prices in the supermarket. If the Medfly is not eradicated in Florida, on-going pesticide treatments by homeowners and commercial growers will be necessary. Costly post-harvest treatment of fruits and vegetables to meet quarantine restrictions of domestic and foreign markets would also be required.

Adult Medflies are up to 1/4" long, black with yellow abdomens, and have yellow marks on their thoraxes. Their wings are banded with yellow. The female Medfly damages produce by laying eggs in the host fruit or vegetable. The resulting larvae feed on the pulp, rendering the produce unfit for human consumption. In addition to citrus, Medflies will feed on hundreds of other commercial and backyard fruit and vegetable crops.

Because Medflies are not strong fliers, the pest is spread by the transport of larval-infested fruit. The major threats come from travelers, the U.S. mail, and commercial fruit smugglers. Several steps have been taken to prevent new infestations. State and federal officials are working with postal authorities to develop ways to inspect packages suspected of carrying infested fruit. In addition, public education efforts carrying the message, "Don't Spread Med" are being expanded (Florida Department of Agriculture and Consumer Services).

Sugarcane Pests

Changes in sugarcane agriculture, including new disease and insect pests have seriously impacted the quality of cane and juice delivered to the mill for processing. These changing developments affect the level of sucrose, purity, fiber, and color of cane resulting in a loss of sugar and decrease in the quantity and quality of sugar produced (United States Department of Agriculture, 1998).

3.1.1.8 Wildfire/Urban Interface Zone

The recent wildfires that burned throughout Florida, specifically central Florida, are examples of the increasing wildfire threat, which results from the Wildland/Urban Interface. The Wildland/Urban interface is defined as the area where structures and other human development meet with undeveloped wildland or vegetative fuels (Federal Emergency Management Agency, 1996). As residential areas expand into relatively untouched wildlands, people living in these communities are increasingly threatened by forest fires.

There are three different classes of wildland fires. A surface fire is the most common type and burns along the floor of a forest, moving slowly and killing or damaging trees. A ground fire is usually started by lightning and burns on or below the forest floor. Crown fires spread rapidly by wind and move quickly by jumping along the tops of trees. Wildland fires are usually identified by dense smoke that fills the area for miles around.

Rural and large tracts of unimproved lands are susceptible to brush and forest fires capable of threatening life, safety and property loss in adjacent developed areas if not effectively controlled. Wildfires are caused by numerous sources ranging from arson, carelessness by smokers, individuals burning debris, operating equipment which throws sparks, to children playing with matches. However, the largest number of fires is caused by lightning strikes which coincides with the height of the thunderstorm season. A major wildland fire can leave a large amount of scorched and barren land, and these areas may not return to prefire conditions for decades. If the wildland fire destroys the ground cover, other potential hazards, such as erosion, may develop (Federal Emergency Management Agency, 1998).

Structures in the wildland/urban interface zone are vulnerable to ignition by three different ways: radiation, convection, and firebrands (National Wildland/Urban Interface Fire Protection Program). Radiating heat from a wildfire can cause ignition by exposure to the structure. The chances of ignition increase as the size of the flames increases, surface area exposed to flames increases, length of exposure time increases, and distance between the structure and the flames decreases. Another source of ignition by wildfire is convection. Ignition of a structure by convection requires the flame to come in contact with the structure. Contact with the convection column is generally not hot enough to ignite a structure. Clearing to prevent flame contact with the structure must include any materials capable of producing even small flames. Wind and steep slopes will tilt the flame and the convection column uphill increasing the chance of igniting a structure. Structures extending out over a slope have the greatest likelihood of ignition from convection.

Firebrands also pose a threat to structures in the wildland/urban interface. A firebrand is a piece of burning material that detaches from a fire due to strong convection drafts in the burning zone. They can be carried a long distance (around 1 mile) by fire drafts and winds. The chance of

these firebrands igniting a structure depends on the size of the firebrand, how long it burns after contact, and the materials, design, and construction of the structure.

On April 15, 1999, just north of Palm Beach County in Port St. Lucie, a wildfire consumed 43 homes in 24 hours. Every fire unit in St. Lucie County and assistance from Indian River, Martin, Palm Beach, Broward and Okeechobee Counties and units from two Division of Forestry Districts, two helicopters and a Type 1 Air Tanker contained the fire after 36 hours. Due to the near perfect wildfire conditions, the fire suppression units were unable to keep up with these rapid moving fires. The estimated damage was \$4.2 million. Over 5000 people were evacuated, most self evacuated from the area.

On Thursday, April 10, 2003, a brush fire occurred in a heavily wooded area just east of the Acreage on the north side of Northlake Boulevard. Fueled by high winds, and low humidity, the fire eventually burned approximately 450 acres, destroyed a number of vehicles and trailers stored on the property, and required several days to fully extinguish. A helicopter was called in to aid in extinguishing the wildfire. The helicopter made a total of 58 water drops. A loss of \$250,000 of timber was lost in relation to the wildfire.

3.1.1.9 Muck Fire

A muck fire is a fire that consumes all the organic material of the forest floor and also burns into the underlying soil. It differs from a surface fire by being invulnerable to wind. If the fire gets deep into the ground, it could smoulder for several years. In a surface fire, the flames are visible and burning is accelerated by wind, whereas in a muck fire wind is not generally a serious factor (Canadian Soil Information System, 1996). Another extraordinary fact about muck fires has to do with their release of carbon dioxide. A peat bog that is on fire can release more carbon dioxide into the atmosphere than all the power stations and car engines emit in Western Europe in one year (New Scientist, 1997). This type of fire could have a significant impact on global warming.

Muck fires are not a frequent threat to Florida. However, during a drought in the 1980s, fires in the Everglades consumed the rich, dried out muck that had once been the bottom of the swamp. These fires burned deep into the ground and required specialized, non-traditional firefighting techniques.

A muck fire occurred in June of 1999. There were about 20,000 acres of muck, brush and sawgrass on fire in the Rotenberger Wildlife Management Area located in Southwestern Palm Beach County.

In May 2008 a muck fire, spawned by an extended drought, scorched the dried up edges of Lake Okeechobee between Moore Haven and Clewiston covering an area of over 5,800 acres.

3.1.1.10 Soil/Beach Erosion

Soil Erosion

Soil erosion is the deterioration of soil by the physical movement of soil particles from a given site. Wind, water, animals, and the use of tools by man may all be reasons for erosion. The two most powerful erosion agents are wind and water; but in most cases these are damaging only after man, animals, insects, diseases, or fire have removed or depleted natural vegetation.

Accelerated erosion caused by human activity is the most serious form of soil erosion because the rate is so rapid that surface soil may sometimes be blown or washed away right down to the bedrock.

Undisturbed by man, soil is usually covered by shrubs and trees, by dead and decaying leaves or by a thick mat of grass. Whatever the vegetation, it protects the soil when the rain falls or the wind blows. Root systems of plants hold the soil together. Even in drought, the roots of native grasses, which extend several feet into the ground, help tie down the soil and keep it from blowing away. With its covering of vegetation stripped away, soil is vulnerable to damage. Whether the plant cover is disturbed by cultivation, grazing, deforestation, burning, or bulldozing, once the soil is bare to the erosive action of wind and water, the slow rate of natural erosion is greatly increased. Losses of soil take place much faster than new soil can be created, and a kind of deficit spending of topsoil begins. With the destruction of soil structure, eroded land is even more susceptible to erosion.

The occurrence of erosion has greatly increased, usually at a rate at which soils cannot be sustained by natural soil regeneration. This is because of the activities of modern development and population growth, particularly agricultural intensification. It is also in the field of agriculture that most efforts have been made to conserve soils, with mixed success (Union of International Associations).

Beach Erosion

Wind, waves, and longshore currents are the driving forces behind coastal erosion. This removal and deposition of sand permanently changes beach shape and structure. Most beaches, if left alone to natural processes, experience natural shoreline retreat. As houses, highways, seawalls, and other structures are constructed upon or close to the beach, the natural shoreline retreat processes are interrupted. The beach jams up against these man-made obstacles and narrows considerably as the built-up structures prevent the beach from moving naturally inland. When buildings are constructed close to the shoreline, coastal property soon becomes threatened by erosion. The need for shore protection often results in "hardening" the coast with a structure such as a seawall or revetment.

A seawall is a large, concrete wall designed to protect buildings or other man-made structures from beach erosion. A revetment is a cheaper option constructed with "rip rap" such as large boulders, concrete rubble, or even old tires. Although these structures may serve to protect beachfront property for a while, the resulting disruption of the natural coastal processes has consequences for all beaches in the area. Seawalls inhibit the natural ability of the beach to adjust its slope to the ever changing ocean wave conditions. Large waves wash up against the seawall and rebound back out to sea carrying large quantities of beach sand with them. With each storm the beach narrows, sand is lost to deeper water, and the longshore current scours the base of the wall. Eventually large waves impact the seawall with such force that a bigger structure becomes necessary to continue to resist the forces of the ocean (Pilkey and Dixon, 1996).

Recent erosion events include:

Hurricanes Frances & Jeanne (September 2004). Both Hurricanes Frances and Hurricane Jeanne in 2004 equaled or exceeded the 100 year return period for storm surge in St Lucie, Indian River and southern Brevard Counties when they made landfall on the Martin County

shoreline. The highest measured surge level for Category 2 Hurricane Frances was 11.8' (NGVD). The highest surge level for Category 3 Hurricane Jeanne was 10.8' (NGVD). Surge levels in Palm Beach County were significantly lower. Both storms caused significant beach erosion along the coastline of Palm Beach County.

Tropical Storm Noel November 2007. Between November 1 and November 4, 2007, high surf associated with Tropical Storm Noel battered the Palm Beach County coast. Hardest hit spots were beaches in Jupiter, Singer Island and South Palm Beach/Lantana, where severe to locally extreme beach erosion occurred. A steel sea wall protecting the Condado condominium complex in Singer Island collapsed, causing cracks to form in the outer walls of the building. In some areas, the dune line was completely eroded, leaving oceanfront buildings sitting precariously on top of 15 foot cliffs looking straight down to the water. A sea wall at the Imperial House condominiums in South Palm Beach collapsed from the pounding surf, and the east portion of the building was evacuated. South of Lantana to Boca Raton, erosion was reported as moderate to severe. Total damage for the County (minus beach restoration costs) was estimated at \$4 million. No tide measurements were available from Palm Beach County, but storm tide was estimated to have been as high as 2-3 feet over northern Palm Beach County. A strong pressure gradient between high pressure over the Mid-Atlantic states and Tropical Storm Noel over Hispaniola and eastern Cuba caused a prolonged period of strong easterly winds over Southeast Florida and the adjacent waters. As Noel moved north across the western Bahamas, the strong winds continued across southeast Florida. The event caused severe beach erosion, coastal flooding, and minor wind damage. The event began in the last week of October.

3.1.1.11 Seismic Hazards

Tsunamis

Recent, widely published, research by British and American scientists warned of potential catastrophic destruction of coastal areas of the Atlantic, including the Florida east coast, by mega tsunami waves generated by a future volcanic collapse in the Canary Islands. The research predicted a gigantic wave would traverse the Atlantic at jet aircraft speeds and devastate the Florida coast as far as 10 miles inland. Such an event would present a tremendous warning challenge and a virtually impossible evacuation response. Subsequent research by the Tsunami Society, a body of scientists solely dedicated to the study of tsunamis, has concluded the threat has been grossly overstated. The society challenged many of the assumptions made relative to the probability and magnitude of a collapse on La Palma and the characteristics of waves should such a collapse occur. The Society notes that there have been no such mega-tsunami events in the Atlantic or Pacific oceans in recorded history. However, the deadly Asian tsunami in December of 2004 has rekindled interest in revisiting the research.

The threat of a tsunamis impacting Palm Beach County is considered to be extremely low (on the order of 5% or less per century). Tsunamis are most often generated by earthquake-induced movement of the ocean floor. Landslides, volcanic eruptions, and even meteorites can also generate a tsunami. They are often incorrectly referred to as tidal waves, but a tsunami is actually a series of waves that can travel at speeds averaging 450 (and up to 600) miles per hour in the open ocean. In the open ocean, tsunamis would not be felt by ships because the wavelength would be hundreds of miles long, with an amplitude of only a few feet. This would also make them unnoticeable from the air. As the waves approach the coast, their speed decreases and their amplitude increases. Unusual wave heights have been known to be over

100 feet high. However, waves that are 10 to 20 feet high can be very destructive and cause many deaths or injuries.

Earthquakes

Although Florida is not usually considered to be a state subject to earthquakes, several minor shocks have occurred over time, but only one caused any damage (Zirbes, 1971).

- In January 1879, a shock occurred near St. Augustine that is reported to have knocked plaster from walls and articles from shelves. Similar effects were reported in Daytona Beach. The shock was felt in Tampa, throughout central Florida, and in Savannah, Georgia as well (Zirbes, 1971).
- In January 1880 another earthquake occurred, this time with Cuba as the focal point. Shock waves were sent as far north as the town of Key West (Zirbes, 1971).
- In August 1886, Charleston, South Carolina was the center of a shock that was felt throughout northern Florida. It rang church bells in St. Augustine and severely jolted other towns along sections of Florida's east coast. Jacksonville residents felt many of the strong aftershocks that occurred in September, October, and November, 1886 (Zirbes, 1971).
- In June 1893, Jacksonville experienced a minor shock that lasted about 10 seconds. Another earthquake occurred in October 1893, and did not cause any damage either (Zirbes, 1971).
- In November 1948, doors and windows rattled in Captiva Island, west of Ft. Myers. It was reportedly accompanied by sounds like distant heavy explosions (Zirbes, 1971).
- In November 1952, a slight tremor was felt in Quincy, a town located 20 miles northwest of Tallahassee. Windows and doors rattled, but no damage was reported (Zirbes, 1971).

3.1.1.12 Geologic Hazards

Sinkholes and Subsidence

Sinkholes are a common feature of Florida's landscape. They are only one of many kinds of karst land forms, which include caves, disappearing streams, springs, and underground drainage systems, all of which occur in Florida. Karst is a generic term which refers to the characteristic terrain produced by erosional processes associated with the chemical weathering and dissolution of limestone or dolomite, the two most common carbonate rocks in Florida. Dissolution of carbonate rocks begins when they are exposed to acidic water. Most rainwater is slightly acidic and usually becomes more acidic as it moves through decaying plant debris. Limestones in Florida are porous, allowing the acidic water to percolate through them, dissolving some limestone and carrying it away in solution. Over time, this persistent erosion process has created extensive underground voids and drainage systems in much of the carbonate rocks throughout the state. Collapse of overlying sediments into the underground cavities produces sinkholes (Florida Geological Survey, 1998).

3.1.1.13 Epidemic

Infectious diseases emerging throughout history have included some of the most feared plagues of the past. New infections continue to emerge today, while many of the old plagues are still with us. As demonstrated by influenza epidemics, under suitable circumstances, a new infection first appearing anywhere in the world could travel across entire continents within days or weeks (Morse, 1996). Due to the potential of complex health and medical conditions that can threaten the general population, Florida's vulnerability to an epidemic is continually being monitored. With millions of tourists arriving and departing the state annually, disease and disease exposure (airborne, vector, and ingestion) are constantly evaluated and analyzed.

Primarily as a result of the entrance of undocumented aliens into south Florida, and the large number of small wildlife, previously controlled or eradicated diseases have surfaced. Health officials closely monitor this potential threat to the public health. The emphasis upon preventive medical measures such as school inoculation, pet licensing, rodent/insect eradication, water purification, sanitary waste disposal, health inspections, and public health education mitigate this potential disaster.

Another potential threat to south Florida's population is food contamination. Frequent news stories document that *E.coli* and botulism breakouts throughout the country are not that uncommon. Most recently, millions of pounds of possibly contaminated beef from the Hudson packing plant were seized by the Department of Agriculture and destroyed.

Avian (Bird Flu) H5N1

Although there are many forms of bird flu, the form that has most recently concerned health officials is the H5N1 flu virus carried by wild birds (many migratory). While wild birds seldom get sick from the virus, they can easily pass the virus to farm birds such as chickens, ducks, and turkeys being raised for food. These farm birds do get very sick, which poses a very serious health risk.

It is thought that both the 1957 Asian Flu and the 1968 Hong Kong Flu pandemics had avian origins. Quarantine and depopulation (culling) and surveillance of affected flocks have helped contain outbreaks. The current bird flu virus originated in Hong Kong in 1997 and disappeared after that. It reemerged in 2003 and has since caused havoc worldwide.

Historically, bird flu viruses had not been passed from birds to humans. But, that changed in 1997, when people became infected by a serious, deadly form of bird flu. Most of these infections occurred in Asian countries among people who had had close contact with farm-raised birds. Sick birds had to be killed in great numbers in hopes of stopping the spread of the virus. It was suspected that the bird flu virus was passed to humans through bird droppings, saliva or contaminated surfaces on cages, tractors, and other farm equipment.

Because viruses can change (mutate) quickly, experts worry that bird flu will one day be passed easily from person to person. This is a scary prospect because the H5N1 bird flu virus has proven to be extremely lethal. Even though only a few hundred people thus far have been stricken by the H5N1 virus, more than half of those have died.

The first case of H5N1 was traced to a farmed goose in China in 1996. Human infections were

first reported in Hong Kong in 1997 (18 cases, 6 fatal). According to the World Health Organization, who monitors global disease outbreaks, as of April 2009, there have been approximately 417 human cases and 257 deaths in 15 countries from H5N1 influenza, none in the United States. The highest number of cases and deaths occurred in Indonesia (141 cases, 115 deaths) and in Vietnam (110 cases, 55 deaths). Other countries with cases and deaths have included Egypt, China and Thailand.

In June 2006 the World Health Organization confirmed a human to human transmission of the bird flu in Indonesia. Although the H5N1 virus had mutated, the mutation apparently was not severe enough to trigger an avian influenza pandemic. Experts believe, however, that the virus may eventually spread to all parts of the world. So far, no cases of H5N1 bird flu in humans have been found in the United States.

Swine Flu A (H1N1)

One way an antigenic shift can occur is through pigs. Pigs can be infected with both avian and human influenza viruses. If pigs become infected with viruses from different species at the same time, it is possible for genes of the viruses to mix and create a new virus for which humans have no natural immunity.

The spread of a new strain of an H1N1 influenza virus was detected in late March 2009. Localized outbreaks of influenza-like illnesses were first discovered in three areas in Mexico and subsequently in the United State and Canada. Its presence was quickly suspected on most continents, with over 1,600 candidate cases identified in the first month. On April 25, 2009, the World Health Organization (WHO) declared the situation to be a formal "public health emergency of international concern."

In an interview on April 24, acting Center for Disease Control (CDC) Director Richard Bessar said that it was still not understood why the early American cases were generally mild (no deaths and only one of the 20 confirmed cases hospitalized) while the Mexican cases led to multiple deaths. Differences in the viruses and co-infection were being considered as possible explanations. At this writing, only fourteen samples from Mexico had been tested by the CDC, with seven found to match the American strain. Dr. Bessar went on to say that the virus had likely passed through several cycles of infection with no known linkages between patients in Texas and California. He believed that, ultimately containment of the virus was "not very likely."

Over 1000 cases of suspected swine flu in humans were detected in Mexico and the southwestern United States in March and April of 2009. The strain was unusually lethal in Mexico, causing 103 deaths (20 confirmed at this writing), mostly in Mexico City. Cases were

also reported in the states of San Luis Potosí, Hidalgo, Querétaro and Mexico State, all in central Mexico. The Mexican fatalities were mainly young, previously healthy adults of 25 to 45, a frequently observed hallmark of pandemic flu. A substantial number of cases in both Mexico and the United States were confirmed by the World Health Organization to be a never-before-seen strain of H1N1. The new swine flu strain was confirmed in 16 of the early deaths and testing was continuing on other cases.

The origins of the new virus are not known. One theory is that Asian and European strains traveled to Mexico via migratory birds or human travelers, then combined with North American

strains in Mexican pig factory farms before jumping over to farm workers. The Mexican health agency believes the original disease vector may have been flies multiplying in manure lagoons of pig farms.

The American cases were found to be made up of genetic elements from four different flu viruses, the North American swine influenza, the North American avian influenza, human influenza, and swine influenza typically found in Asia and Europe.

Within one month of detection, officials in the United States had confirmed that seven people in California, two students from a high school in Texas, and a married couple in Kansas were infected with A/09(H1N1) swine flu. All recovered. New York state had confirmed cases as well. The cases in Kansas and New York were linked to travel to Mexico; most of the cases in California and Texas were not linked to travel, suggesting localized outbreaks of the virus. At this writing, isolated cases of suspected swine flu were surfacing across the U.S. and abroad daily. Deaths will certainly result. Government health agencies continue to closely monitor developments.

West Nile Virus

The Palm Beach County Health Department had reported cases of the West Nile Virus in 2002 and 2003. This disease is transmitted by mosquitoes. Health notifications were given throughout the county during both years to alert and caution the public. Individuals were advised to take precautions when outdoors or try to avoid being outside after dusk.

Mosquitoes become infected when they feed on infected birds, which may circulate the virus in their blood for a few days. Infected mosquitoes can then transmit West Nile virus to humans and animals while biting to take blood. The virus is located in the mosquito's salivary glands. During blood feeding, the virus may be injected into the animal or human, where it may multiply, possibly causing illness. The more DEET a repellent contains the longer time it can protect you from mosquito bites.

Most people who are infected with the West Nile virus will not have any type of illness. It is estimated that 20% of the people who become infected will develop West Nile fever: mild symptoms, including fever, headache, and body aches, occasionally with a skin rash on the trunk of the body and swollen lymph glands.

The symptoms of severe infection (West Nile encephalitis or meningitis) include headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, and paralysis. It is estimated that 1 in 150 persons infected with the West Nile virus will develop a more severe form of disease.

SARS

Severe Acute Respiratory Syndrome (SARS) is a viral respiratory illness caused by a corona virus, called SARS-associated corona virus (SARS-CoV). SARS was first reported in Asia in February 2003. Over the next few months, the illness spread to more than two dozen countries in North America, South America, Europe, and Asia. According to the World Health Organization (WHO), during the SARS outbreak of February – July 2003, a total of 8,437 people worldwide became sick with SARS; of these, 813 died. In the United States, there were 192

cases of SARS among people, all of whom got better. There were eight cases reported in Florida. However, Palm Beach County had no reported cases of SARS.

The main way that SARS seems to spread is by close person-to-person contact. The virus that causes SARS is thought to be transmitted most readily by respiratory droplets (droplet spread) produced when an infected person coughs or sneezes. Droplet spread can happen when droplets from the cough or sneeze of an infected person are propelled a short distance (generally up to 3 feet) through the air and deposited on the mucous membranes of the mouth, nose, or eyes of persons who are nearby. The virus also can spread when a person touches a surface or object contaminated with infectious droplets and then touches his or her mouth, nose, or eye(s). In addition, it is possible that the SARS virus might spread more broadly through the air (airborne spread) or by other ways that are not now known.

Malaria

About 1,200 cases of malaria are diagnosed in the United States each year. Most cases in the United States are in immigrants and travelers returning from malaria-risk areas, mostly from sub-Saharan Africa and the Indian subcontinent. Each year in the United States, a few cases of malaria result from blood transfusions, are passed from mother to fetus during pregnancy, or are transmitted by locally infected mosquitoes. For the year 2003, as of September 14th, eight cases of malaria were reported in Palm Beach County.

Humans get malaria from the bite of a malaria-infected mosquito. When a mosquito bites an infected person, it ingests microscopic malaria parasites found in the person's blood. The malaria parasite must grow in the mosquito for a week or more before infection can be passed to another person. If, after a week, the mosquito then bites another person, the parasites go from the mosquito's mouth into the person's blood. The parasites then travel to the person's liver, enter the liver's cells, grow and multiply. During this time when the parasites are in the liver, the person has not yet felt sick. The parasites leave the liver and enter red blood cells; this may take as little as 8 days or as many as several months. Once inside the red blood cells, the parasites grow and multiply. The red blood cells burst, freeing the parasites to attack other red blood cells. Toxins from the parasite are also released into the blood, making the person feel sick. If a mosquito bites this person while the parasites are in his or her blood, it will ingest the tiny parasites. After a week or more, the mosquito can infect another person.

Symptoms of malaria include fever and flu-like illness, including shaking chills, headache, muscle aches, and tiredness. Nausea, vomiting, and diarrhea may also occur. For most people, symptoms begin 10 days to 4 weeks after infection, although a person may feel ill as early as 8 days or up to 1 year later. Malaria is diagnosed by looking for the parasites in a drop of blood. Blood will be put onto a microscope slide and stained so that the parasites will be visible under a microscope.

Any traveler who becomes ill with a fever or flu-like illness while traveling and up to 1 year after returning home should immediately seek professional medical care. You should tell your health care provider that you have been traveling in a malaria-risk area.

Persons living in, and travelers to, any area of the world where malaria is transmitted may become infected.

Malaria can be cured with prescription drugs.

3.1.2 TECHNOLOGICAL HAZARDS

3.1.2.1 Dike Failure

Dam/levee failure poses a minor threat to population and property in several areas of Palm Beach County. All are earthen structures and are state, regionally, locally, or privately controlled. The most significant risk related to dam/levee failure is flooding due to substantial rainfall and its eastward migration to final discharge in the Indian River Lagoon. Structural and non-structural techniques to slow and contain this runoff incorporate several drainage systems, some dating back to 1919. Rainfall in excess of designed capacities could cause erosion of constructed drainage facilities and flooding of many areas including primary roadway evacuation routes (Palm Beach County Comprehensive Emergency Management Plan, 2002).

The Herbert Hoover Dike was completed in 1937 to protect Palm Beach County citizens from experiencing another flooding event similar to the occurrence in 1928. The flooding derived from the 1928 hurricane, which resulted in over 2,500 deaths and thousands more injured in the western portion of Palm Beach County. The dike protects from major flooding events occurring in Belle Glade, Pahokee, and South Bay municipalities. Also, there is a potential for flooding to occur in The Village of Wellington, Royal Palm Beach, West Palm Beach, Palm Beach Gardens, and unincorporated Palm Beach County. The Herbert Hoover Dike is continuously monitored by the Army Corp of Engineers. Until work to stabilize the dike is completed by the Army Corp of Engineers, there is the potential for stability problems and/or seepage to occur from heavy rainfall raising the level of the lake above 18 feet.

A number of independent assessments by prominent engineering and science organizations call into question the adequacy of the dike to withstand extreme wind and rainfall conditions. There is consensus that a catastrophic failure of the Herbert Hoover Dike would pose a significant danger to the residents, local economies and environment of Palm Beach County and South Florida.

3.1.2.2 Hazardous Materials Accident

Hazardous materials accidents can occur anywhere there is a road, rail line, pipeline, or fixed facility storing hazardous materials. Virtually the entire state is at risk to an unpredictable accident of some type. Most accidents are small spills and leaks, but some result in injuries, property damage, environmental contamination, and other consequences. These materials can be poisonous, corrosive, flammable, radioactive, or pose other hazards and are regulated by the Department of Transportation. However, out of approximately 1,663 hazardous materials incidents reported statewide in 1997, no known fatalities were reported, less than four percent resulted in injuries, and less than six percent resulted in evacuation.

Emergencies involving hazardous materials can be expected to range from a minor accident with no off-site effects to a major accident that may result in an off-site release of hazardous or toxic materials. The overall objective of chemical emergency response planning and preparedness is to minimize exposure for a wide range of accidents that could produce off-site levels of contamination in excess of Levels of Concern (LOC) established by the U.S.

Environmental Protection Agency. Minimizing this exposure will reduce the consequences of an emergency to people in the area near to facilities which manufacture, store, or process hazardous materials (Treasure Coast Regional Planning Council).

A large volume of hazardous materials are transported to and through the county by railroad, highway, air, water, and pipeline daily. Within Palm Beach County, there are a number of both public and private fixed facilities, which produce or use hazardous materials. Coordinating procedures for hazardous material response are found within the County's Emergency Plan for Hazardous Materials.

In addition to the County's Emergency Plan for Hazardous Materials, Local Emergency Planning Committee (LEPC) officials have prepared a plan for use in responding to and recovering from a release of hazardous or toxic materials. This plan addresses the range of potential emergency situations and the appropriate measures to be implemented to minimize exposure through inhalation, ingestion, or direct exposure.

Mishandling and improper disposal or storage of medical wastes and low-level radioactive products from medical use are also a hazard to Palm Beach County. For example, a few years ago an incident occurred in New Jersey when improper disposal of medical wastes resulted in some of the used products ending up on Atlantic Ocean beaches.

3.1.2.3 Radiological Accidents

While an actual release of radioactive material is extremely unlikely and the immediate threat to life extremely low, vulnerability to a nuclear plant disaster could consist of long range health effects with temporary and permanent displacement of population from affected areas. The potential danger from an accident at a nuclear power plant is exposure to radiation. This exposure could come from the release of radioactive material from the plant into the environment, usually characterized by a plume (cloud-like) formation. The area the radioactive release might affect is determined by the amount released from the plant, wind direction and speed and weather conditions (i.e., rain, snow, etc.) which would quickly drive the radioactive material into the ground, hence causing increased deposition of radio nuclides.

- Notification of Unusual Event - The event poses no threat to plant employees, but emergency officials are notified. No action by the public is necessary.
- Alert - An event has occurred that could reduce the plant's level of safety, but back-up systems still work. Emergency agencies are notified and kept informed, but no action by the public is necessary.
- Site Area Emergency - The event involves major problems with the plant's safety and has progressed to the point that a release of some radioactivity into the air or water is possible, but is not expected to exceed Environmental Protection Agency Protective Action Guidelines (PAGs). Thus, no action by the public is necessary.
- General Emergency - The event has caused a loss of safety systems. If such an event occurs, radiation could be released that would penetrate the site boundary. State and local authorities will take action to protect the residents living near the

plant. The alert and notification system will be sounded. People in the affected areas could be advised to evacuate, or in some situations, to shelter in place.

When

the sirens are sounded, radio and television alert will have site-specific information and instructions.

Thirty of the 67 counties in the State of Florida are involved in preparedness planning for a commercial nuclear power plant emergency.

The St. Lucie nuclear power plant is located on Hutchinson Island approximately 4 miles east-northeast of the City of Port St. Lucie, approximately 5.5 miles north of Martin County/St. Lucie County boundary line. This facility is owned and operated by the Florida Power & Light Company. Palm Beach County is located more than 30 miles from the plant and is well outside the 10 mile Emergency Planning Zone/potential plume area so there is not a risk to direct radiation exposure. Therefore, the county will provide assistance to St. Lucie and Martin Counties in the unlikely chance of an accident at the plant. Palm Beach County municipalities located in part or in whole within 50 miles of the power plant (Tequesta, Jupiter Inlet Colony, Jupiter, Juno Beach, Palm Beach Gardens, North Palm Beach, Lake Park, Riviera Beach, Mangonia Park, West Palm Beach, Palm Beach, Pahokee, Royal Palm Beach, Haverhill, Glen Ridge, Wellington, Palm Springs, Greenacres and Lake Clarke Shores) fall within the 'Ingestion Pathway Zone' meaning if there is a major release at the power plant, radioactive contamination could be deposited as far as 50 miles affecting food and water supplies.

The purpose of the county radiological preparedness program is to prepare to receive, shelter and decontaminate (if necessary) potentially contaminated evacuees from an accident at the St. Lucie nuclear power plant. A radiological emergency response plan is developed and exercised in order to have reasonable assurance that adequate protective measures can be taken in the event of a radiological emergency.

3.1.2.4 *Communications Failure*

As society emerges from industrial production into the age of information, we are seeing new kinds of technological accidents/disasters. Recently, a communications failure occurred that was the worst in 37 years of satellite service. Some major problems with the telecommunications satellite Galaxy IV drastically affected 120 companies in the paging industry (Rubin, 1998). Radio and other forms of news broadcasts were also affected. The pager failure not only affected personal and business communications, but emergency managers and medical personnel as well. More commonly, communication failures occur due to power outages.

3.1.2.5 *Hazardous Materials Release*

Palm Beach County's citizens are vulnerable to the harmful effects of the accidental release of hazardous materials. A large volume of hazardous materials are transported to and through the county by railroad, highway, air, water, and pipeline daily, on a routine basis. Within Palm Beach County, there are a number of both public and private fixed facilities, which produce or use hazardous materials. Coordinating procedures for hazardous material response are found within the County's Emergency Plan for Hazardous Materials.

Mishandling and improper disposal or storage of medical wastes and low-level radioactive products from medical use are also a hazard to Palm Beach County. A few years ago an incident occurred in New Jersey when improper disposal of medical wastes resulted in used products ending up on Atlantic Ocean beaches.

3.1.2.6 *Transportation System Accidents*

Florida has a large transportation network consisting of major highways, airports, marine ports, and passenger railroads. The heavily populated areas of Palm Beach County are particularly vulnerable to serious accidents, which are capable of producing mass casualties. With the linear configuration of several major highways in Palm Beach County, such as Interstate highways and the Florida Turnpike, major transportation accidents could occur in a relatively rural area, severely stressing the capabilities of local resources to respond effectively. A recent notorious example is the crash in the Everglades of the Value Jet Flight 597 on May 11, 1996, which resulted in 109 fatalities and cost millions of dollars to respond, severely taxing the financial and public safety resources of Dade County. Similarly, a major transportation accident could involve a large number of tourists and visitors from other countries, given Florida's popularity as a vacation destination, further complicating the emergency response to such an event.

Coastal Oil Spill

As a major industrial nation, the United States produces, distributes, and consumes large quantities of oil. Petroleum-based oil is used as a major power source to fuel factories and various modes of transportation, and in many everyday products, such as plastics, nylon, paints, tires, cosmetics, and detergents. At every point in the production, distribution, and consumption process, oil is invariably stored in tanks. With billions of gallons of oil being stored throughout the country, the potential for an oil spill is significant, and the effects of spilled oil can pose serious threats to the environment.

In addition to petroleum-based oil, the U.S. consumes millions of gallons of non-petroleum oils, such as silicone and mineral-based oils, and animal and vegetable oils. Like petroleum products, these non-petroleum oils are often stored in tanks that have the potential to spill, causing environmental damages that are just as serious as those caused by petroleum-based oils. To address the potential environmental threat posed by petroleum and non-petroleum oils, the U.S. Environmental Protection Agency has established a program designed to prevent oil spills. The program has reduced the number of spills to less than 1% of the total volume handled each year (Environmental Protection Agency, 1998).

Spilled oil poses serious threats to fresh water and marine environments, affecting surface resources and a wide range of subsurface organisms that are linked in a complex food chain that includes human food resources. Most oils tend to spread horizontally into a smooth and slippery surface, called a slick, on top of the water. However, once the oil reaches the shoreline it can escape downward into sand, making it difficult to clean up and reducing its ability to degrade. Spilled oil can harm the environment in several ways, including the physical damages that directly impact wildlife and their habitats (such as coating birds or mammals with a layer of oil), and the toxicity of the oil itself, which can poison exposed organisms.

Not only would an oil spill adversely affect the environment, but the economy would suffer due to a decrease in tourism. Depending on the severity of the spill, the economy could suffer mild, short-term to devastating, long-term effects.

Many advanced response mechanisms are available for controlling oil spills and minimizing their impacts on human health and the environment. Mechanical containment or recovery is the primary line of defense against oil spills. This type of equipment includes a variety of booms, barriers, and skimmers. Natural and synthetic sorbent materials are used as well to capture and store the spilled oil until it can be disposed of properly. Chemical and biological methods can be combined with mechanical means for containing and cleaning up oil spills. Dispersants and gelling agents are most useful in helping to keep oil from reaching shorelines and other sensitive habitats. Physical methods are used to clean up shorelines as well. Wiping with sorbent materials, pressure washing, raking, and bulldozing can be used to assist natural environmental recovery processes. Scare tactics are used to protect birds and animals by keeping them away from oil spill areas.

Palm Beach County has 45 miles of Atlantic Ocean coastline that is subject to contamination caused by an oil spill. By Executive Order, the responsibility for preparing response plans for coastal oil spills is designated to the Department of Environmental Protection, Division of Florida Marine Patrol. There are two active oil field regions in Florida: in Escambia and Santa Rosa counties in the Panhandle, and Collier, Dade, Hendry, and Lee counties in southwest Florida.

3.1.2.7 Wellfield Contamination

As communities become more aware of both the potential health risks and the economic effects of ground water contamination, they are beginning to look increasingly toward preventative efforts. Even when no immediate hazard appears to exist, a community should be concerned about protecting its drinking water supply for three reasons: to reduce potential risks to the health of the community; to avoid the costs of cleaning up contamination and providing alternative water supplies; and to prevent the negative economic impacts on community development that ground water contamination can cause.

The development of wellfield protection programs is a major preventative approach for the protection of community drinking water supplies. Wellfield protection is a means of safeguarding public water supply wells by preventing contaminants from entering the area that contributes water to the well or wellfield over a period of time. Management plans are developed for the wellfield protection area that include inventorying potential sources of groundwater contamination, monitoring for the presence of specific contaminants, and managing existing and proposed land and water uses that pose a threat to groundwater quality.

Ground water is a vitally important natural resource. It is a source of drinking water for more than half of the U.S. population and more than 95 percent of the rural population. In addition, ground water is a support system for sensitive ecosystems, such as wetlands or wildlife habitats.

Between 1971 and 1985, there were 245 ground water related outbreaks of disease nationwide, resulting in more than 52,000 individuals being affected by associated illnesses (Browning).

While most of these diseases were short-term digestive disorders caused by bacteria and viruses, hazardous chemicals found in wells nationwide also pose risks to public health.

The 1986 Amendments to the federal Safe Drinking Water Act require states to implement wellfield protection programs for public water wells. Prevention strategies include maintaining the isolation distances from potential contamination sources, reporting to the state violations of the isolation distance, and asking a local governmental unit to regulate these sources.

Cleaning up contaminated ground water can be technically difficult, extremely expensive, and sometimes it simply cannot be done. Contaminated ground water also affects the community by discouraging new businesses or residents from locating in that community.

3.1.2.8 Power Failure (Outages)

In the U.S., from July 2 to August 10, 1996, the Western States Utility Power Grid reported widespread power outages that affected millions of customers in several western states and adjacent areas of Canada and Mexico. These problems resulted from a variety of related causes, including sagging lines due to hot weather, flashovers from transmission lines to nearby trees, and incorrect relay settings. According to the electric utility industry's trade association, the potential for such disturbances is expected to increase with the profound changes now sweeping the electric utility industry.

On August 14, 2003, the largest power outage occurred in the northeast and Midwest states. The power outage started around 3 o'clock in the afternoon and was out in some places until Monday the 18th. There were major cities without power for an extended period of time. Some of the cities included: New York, Cleveland, Detroit, Buffalo, Toronto. The power outage affected millions of people across states. The source of the outage is unclear at this time. The entire northeast power grid was affected.

In Palm Beach County, the major causes of a power failure are lightning and trees. Lightning strikes and trees falling onto power lines can shut down power for hundreds of people. Other factors that can cause a power failure are:

- Age of facility (transmission and distribution);
- Community growth; and
- High winds.

The location of power lines underground or above ground also has significance. Lines underground have the advantage of being less vulnerable to tree foliage, however they are still at risk from other underground hazards such as tree roots.

To address times when generating capacity is tight, or falls below consumer demand due to state or local emergencies, the Florida Electrical Emergency Contingency Plan was developed. Alerts have been created to give early warning of potential electricity shortfalls and bring utilities, emergency management officials, and the general public to a state of preparedness. The Contingency Plan has four stages (Florida Reliability Coordinating Council):

- **Generating Capacity Advisory** - A Generating Capacity Advisory is primarily for information purposes. It starts utility tracking activities, and it initiates inter-utility and inter-agency communication. No action by the public is required. General information may be distributed to consumers to forewarn them of conditions if necessary.
- **Generating Capacity Alert** - A Generating Capacity Alert starts actions to increase reserves. Available emergency supply options will be explored. When reserves fall below the size of the largest generating unit in the state, loss of that size unit to an unexpected mechanical failure could lead to blackouts somewhere since insufficient backup is available.
- **Generating Capacity Emergency** - A Generating Capacity Emergency occurs when blackouts are inevitable somewhere in Florida. Every available means of balancing supply and demand will be exhausted. Rolling blackouts, manually activated by utilities are a last resort to avoid system overload and possible equipment damage. Frequent status reports are provided to agencies and the media. The Division of Emergency Management will consider using the Emergency Broadcast System to inform citizens of events and to direct them to available shelters if conditions warranted. Recognizing the consequences of a loss of electricity, individual utility emergency plans include provisions for special facilities critical to the safety and welfare of citizens.
- **System Load Restoration** - System Load Restoration is instituted when rolling blackouts have been terminated and power supply is adequate. It is the recovery stage, and efforts are made to provide frequent system status reports.

3.1.3 Societal Hazards

3.1.3.1 Civil Disturbance

As in any other area, Palm Beach County is subject to civil disturbances in the form of riots, mob violence, and a breakdown of law and order in a focalized area. Although they can occur at any time, civil disturbances are often preceded by periods of increased tension caused by questionable social and/or political events such as controversial jury trials or law enforcement actions. Police services are responsible for the restoration of law and order in any specific area of the county.

3.1.3.2 Terrorism and Sabotage

Terrorism

The FBI defines terrorism as, “the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof in furtherance of political or societal objectives.” A terrorist incident could involve the use of a Weapon of Mass Destruction (WMD) that would threaten lives, property and environmental resources by using explosives or incendiary devices and/or by contamination with chemical, biological, and/or radiological materials.

It is recognized that the state has many critical and high-profile facilities, high concentrations of population and other potentially attractive venues for terrorist activity that are inherently vulnerable to a variety of terrorist methods. Governmental/political, transportation, commercial, infrastructure, cultural, academic, research, military, athletic, and other activities and facilities constitute ideal targets for terrorist attacks which may cause catastrophic levels of property and environmental damage, injury and loss of life. Furthermore, some extremist groups are known to be present within Florida. Terrorist attacks may take the form of the hazards described in this section when incidents of these types are executed for criminal purposes, such as induced dam or levee failures, the use of hazardous materials to injure or kill, or the use of biological weapons to create an epidemic. Terrorists have the potential to create disasters which threaten the safety of a large number of citizens.

In the recent years, terrorist acts have become a reality for the nation. Palm Beach County is not immune from acts of terrorism. The 2001 World Trade Center bombing was the largest terrorist attack the United States has ever experienced. After the World Trade Center attack, it was learned that many of the perpetrators resided in and the (terrorists) pilots took flight lessons in Palm Beach County. In addition, Anthrax, which was dispersed via the postal system in late FY 2001, claimed the lives of five US citizens including one person from Palm Beach County. It was determined that he became infected with the disease at American Media Incorporated (AMI), in Boca Raton, which was his place of employment. A second employee became infected and survived.

The federal government has recognized that the United States has entered the post-Cold War era. As a result, federal planning guidelines regarding military threats are in transition. However, nuclear weapons continue to be a serious planning concern especially in areas surrounding military installations. The influx of undocumented aliens into South Florida from areas unfriendly to the interest of the United States is monitored by those involved with the emergency management of government.

Computer Accidents and Sabotage

The President's Commission on Critical Infrastructure Protection (PCCIP) recently reported that there is an increasing threat that the U.S. could suffer something similar to an "Electronic Pearl Harbor". Networked information systems present new security challenges in addition to the benefits they offer. Long-term power outages could cause massive computer outages, with severe economic impacts such as loss of sales, credit checking, banking transactions, and the ability to communicate and exchange information and data. Today, the right command sent over a network to a power generating station's control computer could be just as effective as a backpack full of explosives, and the perpetrator would be harder to identify and apprehend (Rubin, 1998).

With the growth of a computer-literate population, increasing numbers of people possess the skills necessary to attempt such an attack. The resources to conduct a cyber attack are now easily accessible everywhere. A personal computer and an internet service provider anywhere in the world are enough to cause a great deal of harm.

Threats include:

- Human error

- Insider use of authorized access for unauthorized disruptive purposes
- Recreational hackers – with or without hostile intent
- Criminal activity – for financial gain, to steal information or services, organized crime
- Industrial espionage
- Terrorism – including various disruptive operations
- National Intelligence – information warfare, intended disruption of military operations

As the internet becomes more and more important, the loss of its services, whether by accident or intent, becomes a greater hardship for those relying on this new form of communication. The outcomes of such activities may take the form of disruption of air traffic controls, train switches, banking transfers, police investigations, commercial transactions, defense plans, power line controls, and other essential functions. The goal of the hacker or terrorist is mass disruption. Computer failures could affect emergency communications as well as routing civilian applications, such as telephone service, brokerage transactions, credit card payments, Social Security payments, pharmacy transactions, airline schedules, etc.

3.1.3.3 *Immigration Crisis*

Florida’s location as the nearest United States land mass bordering the Caribbean basin makes it a chosen point of entry for many migrants attempting to enter the country illegally. A major consequence of a mass arrival of illegal entrants could be disruptive to the routine functioning of the impacted community, resulting in significant expenditures that are related to the situation. An example of this threat occurred in 1994, when the state responded to two mass migration incidents. In May 1994, there was an unexpected migration of approximately 100 Haitian refugees, while in August 1994, there was an influx of 700 Cubans. These events are typically preceded by periods of increasing tension abroad, which can be detected and monitored. Enforcement of immigration laws is a federal responsibility. However, it is anticipated that joint jurisdictional support of any operation will be required from the state and local governments.

The Atlantic shore of Palm Beach County is the frequent scene of arrival of undocumented aliens, usually Haitian or Cuban. The county has both the history and potential for the unannounced arrival of a large number of aliens. Until relieved of the responsibility by the state and federal government, Palm Beach County must be capable of providing mass refugee care to include shelter, food, water, transportation, medical, police protection, and other social services.

3.2 VULNERABILITY ASSESSMENT

Palm Beach County is a diversified county. While all county residents are exposed to the hazards identified in **Table 3.1** to some degree, geographic location and other factors greatly affect individual vulnerabilities and probabilities relating to specific hazards illustrated in **Appendix A** for the county and each jurisdiction. Factors influencing vulnerability include community location, type of construction, demographics, and cultural characteristics. **Table A - 1** summarizes individual community vulnerability within Palm Beach County. **Table A-2** relates the probability of future hazard events for each identified hazard within Palm Beach County. **Appendix B** includes a descriptive mitigation initiatives to reduce the impacts of each jurisdiction risks for Palm Beach County and each jurisdiction in reference to the individual

hazards identified in **Section 3.1**. A narrative for each identified hazard and its impact on the individual jurisdictions in Palm Beach County is located in **Appendix C**. Additionally, maps will be located in **Appendix C**. These maps will be illustrated by hazard addressing critical facilities having the potential to be effected by hazard. The critical facilities will have a potential dollar loss figure tied to it.

With the assistance of Palm Beach County Division of Emergency Management, the LMS conducted impact analyses to assess the potential for detrimental impacts from all identified natural, technological and societal hazards. Results of these analyses are summarized below. Impacts were categorized into the following groupings: health and safety of the resident population in the affected area; health and safety of incident responders; impacts on the continuity of government and non-government operations; impacts to property, facilities and infrastructure; impacts to the critical community services; impacts to the environment; economic and financial impacts; impacts on regulatory and contractual obligations; and impacts negatively affecting the county's reputation, image, and/or ability to attract public and commercial interests.

- An impact rating of "Low" for any hazard type means the hazard is not likely to have any measurable or lasting detrimental impact of a particular type and consequences will likely be rectified promptly with locally available resources.
- An impact rating of "Medium" means there will likely be a measurable detrimental impact which may require some time to rectify and may require outside resources and/or assistance.
- An impact rating of "High" means the impact will likely be severe and of longer duration, and require substantial time, resources, and/or outside assistance to rectify.
Multiple ratings indicate detrimental impacts might easily vary within the range indicated.

3.2.1 Natural Hazards

3.2.1.1 *Hurricanes and Tropical Storms*

From 1930 through 1959, a total of 58 hurricanes struck the U.S. mainland, 25 of which were category 3 or higher (major storms). Between 1960 and 1989, 43 hurricanes struck the U.S. of which only 16 were category 3 or stronger. Most hurricane experts feel we are entering a period of increased hurricane formation similar to the levels seen in the 1930s and 1940s. Current hurricane risk calculations are complicated by climatic factors suggesting the potential for even greater hurricane frequency and severity in all of the world's hurricane spawning grounds. Since 1995, there have been 33 Atlantic hurricanes, 10 of which occurred in 1998 alone. Global warming may cause changes in storm frequency and the precipitation rates associated with storms. A modest 0.9° Fahrenheit (0.5° centigrade) increase in the mean global temperature will add 20 days to the annual hurricane season, and increase the chances of a storm making landfall on the U.S. mainland by 33%. The warmer ocean surface will also allow storms to increase in intensity, survive in higher latitudes, and develop storm tracts that could shift farther north, producing more U.S. landfalls.

Currently an average of 1.6 hurricanes strike the U.S. every year. Severe (category 4 or 5 on the Saffir-Simpson scale) hurricanes strike the U.S. on the average of one every 5.75 years. Annually, hurricanes are estimated to cause approximately \$1.2 billion in damages. The proximity of dense population to the Atlantic Ocean, as well as the generally low coastal elevations, significantly increases the county's vulnerability. The potential for property damage and human casualties in Palm Beach County has increased over the last several decades primarily because of the rapid growth this county has experienced since 1970, particularly along the vulnerable coastline areas.

Hurricane damage is caused by two factors:

- High winds; and
- Storm surge (discussed under Flooding).

Generally, it is the wind that produces most of the property damage associated with hurricanes, while the greatest threat to life is from flooding and storm surge. Although hurricane winds can exert tremendous pressure against a structure, a large percentage of hurricane damage is caused not by wind, but from flying debris. Tree limbs, signs and sign posts, roof tiles, metal siding, and other loose objects can become airborne missiles that penetrate the outer shells of buildings, destroying their structural integrity and allowing the hurricane winds to act against interior walls not designed to withstand such forces. Once a structure's integrity is breached, the driving rains associated with hurricanes can enter the structure and completely destroy its contents.

Hurricane winds are unique in several ways:

- They are more turbulent than winds in most other type storms;
- They are sustained for a longer period of time (several hours) than any other type of atmospheric disturbance;
- They change slowly in direction, thus they are able to seek out the most critical angle of attack on a given structure; and
- They generate large quantities of flying debris as the built environment is progressively damaged, thus amplifying their destructive power.

In hurricanes, gusts of wind can be expected to exceed the sustained wind velocity by 25 to 50%. This means a hurricane with sustained winds of 150 mph will have wind gusts exceeding 200 mph. The wind's pressure against a fixed structure increases with the square of the velocity. For example, a 100 mph wind will exert a pressure of approximately 40 lbs per square foot on a flat surface, while a 190 mph wind will exert a force of 122 lbs per square foot on that same structure. In terms of a 4 by 8 ft sheet of plywood nailed over a window, there would be 1,280 lbs of pressure against this sheet in a 100 mph wind, and 3,904 lbs or 1.95 tons of pressure against this sheet in a 190 mph wind.

The external and internal pressures generated against a structure vary greatly with increases in elevation, shapes of buildings, openings in the structures, and the surrounding buildings and terrain. Buildings at ground level experience some reductions in wind forces simply because of the drag exerted by the ground against the lowest levels of the air column. High rise buildings, particularly those located along the beach front, will receive the full strength of a hurricane's

wind on their upper stories. Recent studies estimate that wind speed increases by approximately 37% just 15 ft above ground level.

The wind stream generates uplift as it divides and flows around a structure. The stream following the longest path around a building, generally the path over the roof, speeds up to rejoin the wind streams following shorter paths, generally around the walls. This is the same phenomena that generates uplift on an aircraft's wing. The roof, in effect, becomes an airfoil that is attempting to take off from the rest of the building. Roof vortexes generally concentrate the wind's uplift force at the corners of a roof. These key points can experience uplift forces 2 to 5 times greater than those exerted on other parts of the roof.

Once the envelope of the building has been breached through the loss of a window, door, or roof damage, wind pressure on internal surfaces becomes a critical factor. Openings may cause pressurizing or depressurizing of a building. Pressurizing pushes the walls out, while depressurizing will pull the walls in. Internal pressure coupled with external suction adds to the withdrawal force on sheathing fasteners. Damages from internal pressure fluctuations may range from blowouts of windows and doors to total building collapse due to structural failure.

During Andrew, catastrophic failure of one and two-story wood-frame buildings in residential areas was observed more than catastrophic failures in any other type of building. Single family residential construction is particularly vulnerable because less engineering oversight is applied to its design and construction. As opposed to hospitals and public buildings which are considered fully engineered, and office and industrial buildings which are considered "marginally engineered," residential construction is considered "non-engineered." Historically, the bulk of wind damage experienced nationwide has occurred to residential construction. Fully engineered construction usually performs well in high winds due to the attention given to connections and load paths.

Hurricane winds generate massive quantities of debris, which can easily exceed a community's entire solid waste capacity by three times or more. Debris removal is an integral first step toward recovery, and as such must be a critical concern of all those tasked with emergency management and the restoration of community services. The TAOS model predicts the following quantities of debris for Palm Beach County given the following hurricane strengths:

Tropical Storm	156,142 cubic yards/acre
Category 1 Hurricane	1,049,571 cubic yards/acre
Category 2 Hurricane	3,183,532 cubic yards/acre
Category 3 Hurricane	7,431,401 cubic yards/acre
Category 4 Hurricane	16,389,149 cubic yards/acre
Category 5 Hurricane	44,874,888 cubic yards / acre

Both the Town of Palm Beach and City of West Palm Beach are old, historical communities on Palm Beach County's east coast. Their age alone makes them particularly vulnerable to hurricane damage. Both cities have old, historically significant structures whose loss would

represent the loss of irreplaceable cultural resources. The age and construction type of much of the housing in West Palm Beach and to a lesser extent in many of the other coastal communities, suggests these communities would be hit very hard by a major storm.

3.2.1.2 Flooding

Flooding in Palm Beach County results from one or a combination of both of the following meteorological events:

- Tidal surge associated with northeasters, hurricanes, and tropical storms; and
- Overflow from streams and swamps associated with rain runoff.

Major rainfall events occur in association with hurricanes, tropical storms, and thunderstorms associated with frontal systems.

When these types of intense rainfall events occur, streams and drainage ditches tend to reach peak flood flow concurrently with tidal water conditions associated with coastal storm surge. This greatly increases the probability of flooding in the low-lying areas of the coastal zone. Areas along the Palm Beach County coast are particularly susceptible to flooding under these conditions. The most flood prone areas in the eastern portion of the county feature poorly drained soils, a high water table, and relatively flat terrain, all of which contribute to their flooding problems. Flat, swampy terrain and heavily wooded areas in the western part of Palm Beach County aggravate flood problems by preventing rapid drainage in some areas.

In response to mounting losses from flooding nationwide, the United States Congress initiated the National Flood Insurance Program in 1968. The program is administered through FEMA. Under this program, FEMA produces FIRM maps, which show areas subject to various levels of flooding under different conditions. This flood risk information is based on historic, meteorologic, hydrologic, and hydraulic data, as well as open-space conditions, flood control works, and development.

In **Appendix C**, Flood Section, presents a generalized picture of the flood prone areas in Palm Beach County based on the 1993 version of the FIRM maps. Note that NFIP flood zones B and C do not appear in the legend, as they are not on the Palm Beach County FIRM map.

In addition to the FIRM maps there are two numerical models, which predict the effects of storm surge in Palm Beach County. The older model, developed by the National Oceanic and Atmospheric Administration, is called the Sea, Lake and Overland Surges from Hurricanes (SLOSH) model. In **Appendix C**, Flood Section, illustrates the areas of Palm Beach County vulnerable to this type of flooding.

Recently, the State of Florida acquired another model for predicting hurricane storm surge as well as wind and property damage. This model, know as The Arbiter Of Storms (TAOS) model, predicts storm surge height and wind field intensity for Category 1 through Category 5 hurricanes. In **Appendix C**, Flood Section, illustrates the areas of Palm Beach County subject to flooding during a Category 5 Hurricane. It is important to remember that the TAOS model projections are based on a Maximum of Maximums (MOM) or absolute worst case scenario. For this analysis we have considered the TAOS model projections as reflecting total, worst case exposure for Palm Beach County.

3.2.1.3 Severe Thunderstorm/Lightning

Vulnerability to severe thunderstorms and lightning is high in Palm Beach County, but many of the jurisdictions and populations centers shown in **Appendix A Table A-1** have only moderate vulnerabilities relative to these hazards. This variation in relative levels of vulnerability is again due primarily to construction practices and community characteristics. Working communities have a higher vulnerability to economic impacts from lightning than residential or retirement communities. All other factors being equal, residential and retirement communities have a historically higher vulnerability in terms of lightning fatalities.

3.2.1.4 Wildfire/Urban Interface Zone

Less urbanized communities and areas within the county are more vulnerable to wildfires than the more developed communities. Large areas in the western part of the county and many isolated unincorporated pockets of residential development are quite vulnerable to wildfire in Palm Beach County. The southern and western portion of the Village of Wellington, the unincorporated areas west of Boca Raton, South Bay, Pahokee, and Belle Glade, and virtually all of Palm Beach County's unincorporated areas have a high vulnerability to wildfire during the dry season each year. The problems in the Village of Wellington, west Boca Raton area, and in the various unincorporated pockets of development such as Jupiter Farms, Loxahatchee, and the Lion Country Safari area arise from the fact that these areas have an extensive canopy of slash pine (*Pinus elliotii*) and sand pines (*Pinus clausa*), and numerous undeveloped lots interspersed with residences.

Upland pine communities in South Florida are adapted for periodic episodes of fire, and they burn very easily. They also generate large quantities of flammable leaf litter and other combustible by-products, which catch fire easily and generate a very hot, if short lived fire. Clearing of vacant lots, periodic removal of accumulated leaf litter, maintained fire breaks, and controlled burns in the undeveloped or rangeland areas of the county are the best mitigative measures that can be applied for this hazard.

3.2.1.5 Muck Fire

Muck fires have never occurred in Palm Beach County. The only areas where this hazard might produce impacts are the western portions of the county. At the present time, muck fires are not considered a significant hazard anywhere other than the Pahokee, Belle Glade, and South Bay areas in the western county

3.2.1.6 Tornado

Historical data indicates the frequency of tornadoes in Palm Beach County is relatively low. However, the vulnerability does exist as proven in August of 2003 when Palm Beach County was affected by a tornado. Some individual communities have a higher vulnerability to this hazard due to the type of construction or numbers of mobile homes (manufactured housing units) within their boundaries.

3.2.1.7 Extreme Temperatures

Temperature extremes, both freezes and periods of excessive heat, impact communities with a larger senior population to a greater extent than those with younger populations. Inland communities away from the moderating influence of the ocean or the estuary are more vulnerable to temperature extremes, as are areas with significant agricultural assets.

The increase in temperature across the U.S. in this century is slightly smaller, but of comparable magnitude to the increase of temperature that has characterized the world as a whole. The increase in minimum temperature and the related increase in area affected by much above normal minimum temperatures are also found in many other countries of the northern hemisphere. Worldwide precipitation over land has changed little through the twentieth century; increases noted in high latitudes have been balanced by low-latitude decreases. By comparison, the change in precipitation in the U.S. is still relatively moderate compared to some of the increases and decreases at other latitudes. Decreases in the day-to-day differences of temperature observed in the U.S. are also apparent in China and Russia, the only other large countries analyzed as of this date. The persistent increase in the proportion of precipitation derived from extremely heavy precipitation has not been detected in these other countries.

A Climate Extremes Index, defined by an aggregate set of conventional climate extremes indicators, supports the notion that the climate of the U.S. has become more extreme in recent decades, yet the magnitude and persistence of the changes are not now large enough to conclude that the climate has systematically changed to a more extreme state. Similarly, a U.S. Greenhouse Climate Response Index, composed of indicators that measure the changes that are expected to follow increased emissions of greenhouse gases, reflects in recent years the very changes that are predicted. Still, the rate of change of the GCRI, as with the CEI, is not large enough to unequivocally reject the possibility that the increase in the GCRI may have resulted from other factors, including natural climate variability, although statistically this is but a 5 to 10% chance. Both indices increased rather abruptly during the 1970s, at a time of major circulation changes over the Pacific Ocean and North America. There is little doubt that the increase in the indices is at least partially related to these circulation variations, although the role of increased anthropogenic greenhouse gas concentrations in such circulation variations is poorly known.

Since the indices are influenced by natural changes and variations that can either add to or subtract from any underlying long-term anthropogenic-induced change it will be important to carefully follow their behavior over the next decade to see if they sustain their incipient trends or return to previous levels. Such an effort is critical for a better understanding of climate itself, how it changes, and how these changes can affect our own lives and well being.

3.2.1.8 *Soil Collapse and Beach Erosion*

Palm Beach County's vulnerability to soil collapse and beach erosion is moderate along all of its coastline. The most significant areas of beach erosion are the areas south of the stabilized inlets where the natural flow of laterally transported sand has been artificially interrupted. Many areas in Palm Beach County have been the subject of major beach re-nourishment projects sponsored jointly by the County and Army Corps of Engineers. Inland communities report some erosion problems along major canals and around water control structures.

3.2.1.9 *Agricultural Pest and Disease*

Agricultural pests and disease are a more significant hazard in those areas of the county where agriculture is a more significant element in the economic base. The western portion of Palm Beach County is a major ranching and farming area and there are numerous nurseries and smaller agriculture related businesses located throughout the county.

3.2.1.10 Drought

Palm Beach County overall has a moderate vulnerability to the impacts from drought due to the county's large agricultural land use in the west and extensive urbanization in the east. Overall, the county has a narrow reserve of potable water and this could become a significant problem during a long-term drought. The western area of the county is most vulnerable to the impacts of drought because this area is extensively involved in farming and ranching. The urbanized communities along the county's coast are less vulnerable economically due to their location and non-agricultural economic base. Potential impacts to Palm Beach County's potable water supply by saltwater intrusion during drought conditions are generally low, with the exception of the City of West Palm Beach which draws its water from surface supplies.

3.2.1.11 Epidemic

Florida is more vulnerable than many other states to possible outbreaks of infectious diseases due to the large number of international and U.S. tourists it attracts. In addition, vulnerability to disease hazards has increased by the number of illegal aliens reaching U.S. shores. Palm Beach County's vulnerability to epidemic outbreaks, while higher than some other Florida counties due to its large immigrant population is still considered only moderate. Medical facilities are adequate for current needs, but would be stressed if forced to deal with a major disease outbreak.

3.2.1.12 Seismic Hazards

Sink Holes and Dam/Levee Failures

There are areas in Palm Beach County where canal bank failures could cause or exacerbate

flooding during heavy rain events or storms. This problem is, however, more related to soil erosion than to actual levee failure. There has never been any seismic activity, soil failures, or sinkhole activity in Palm Beach County. While these hazards may exist, county vulnerability to them at this time must be considered very low.

Palm Beach County does have a major vulnerability to levee failure around the eastern boundary of Lake Okeechobee. Extensive dyking of Lake Okeechobee has taken place since the hurricane of 1928 when about 2,500 people were killed from lake surge in western Palm Beach County. Palm Beach County has the dubious distinction of having had the second highest number of fatalities (following Galveston, Texas) of any county in the United States. The U.S. Army Corps of Engineers maintains the levees around Lake Okeechobee and they are considered to be sound. A levee failure with today's population would be a catastrophic disaster for Palm Beach County.

Tsunamis

There have been no recorded tsunamis to have ever affected Palm Beach County. However, scientists have been studying La Palma Island in the Canaries as a possible site where a tsunami could originate if a massive landslide were to occur. Research published in 2001 by two prominent geologists (Ward & Day) created a major debate and concern over whether a predicted volcanic collapse in the Canary Islands could generate a mega tsunami, which could traverse the Atlantic Ocean at jet aircraft speeds (8 to 9 hours) and devastate the eastern coast of the U.S., including Florida. It was postulated that the wave, at impact on the Florida coast, could be on the order of 50 meters high and cause damage inland as far as 20 km. This mega tsunami would cause unprecedented destruction and loss of life.

Subsequently, more comprehensive and rigorous research published by several scientists of the Tsunami Society has taken exception with the original research. The original research, they argue, was based on several erroneous assumptions regarding a structural weakness observed in the western flank of the Cumbre Vieja volcano on island of La Palma, the probability of a gravitation collapse of a massive land mass of the ocean bottom, and the magnitude and traveling distance of a wave (s) that might be generated should such a collapse occur.

The mega tsunami was postulated to occur sometime in the next 1500 years. The weight of scientific evidence suggests there is no discernable tsunami threat to the coast of Florida as a result of geological activity in the Canary Islands. The probability of a tsunami is low.

3.2.2 Technological Hazards

3.2.2.1 Hazardous Materials Accident

A community's vulnerability to hazardous materials accidents depends on three factors. These are:

- The major transportation routes that pass through the community;
- The hazardous material generators located in or near the community; and
- The resources in terms of people and property that are in an area of possible impact from a hazardous materials release.

Overall, unincorporated Palm Beach County has a low vulnerability to impacts from hazardous materials releases. There are relatively few major generators within the county and those that do exist are generally away from major population centers.

Specific areas with higher vulnerability for hazardous materials accidents are along the transportation network (both highway and rail) that pass through the county. All the jurisdictions along the eastern sand ridge (Boca Raton, Delray Beach, Boynton Beach, Hypoluxo, Lantana, Lake Worth, West Palm Beach, Riviera Beach, Lake Park, Palm Beach Gardens, Jupiter, and Tequesta) are extremely vulnerable to toxic material spills and releases from transportation system accidents, primarily rail accidents. The Florida East Coast Railroad runs through all these areas and toxic material spills have occurred along the rail line. Given the right set of circumstances, such releases could produce significant detrimental effects on life and property in these communities.

3.2.2.2 Radiological Accidents (Including Nuclear Power Plant Accidents)

The Florida Power and Light St. Lucie Nuclear Power plant is located on south Hutchinson Island in St. Lucie County; the northern part of Palm Beach County falls within the 50-mile radius IPZ for that plant. This means that virtually all Palm Beach County is vulnerable to a nuclear power plant accident to some degree. Fortunately, the frequency with which nuclear power plant accidents occur is very low, and the overall risk to the citizens of Palm Beach County is therefore considered low.

Nuclear emergency is perhaps the single hazard facing Palm Beach County, which has received massive emergency management attention at all levels of government. Emergency management planning and regulation relative to nuclear power plant accidents exists at the federal, state, local, and corporate levels. Drills are held routinely and extensive documentation is required by the Nuclear Regulatory Commission as well as several other federal agencies. Contingency planning for nuclear accidents at the plant itself appears to be well in hand. Of greater risk to the citizens of Palm Beach County is the transport of fissionable material to and from the plant. Such materials transfers are handled with a great deal of care and there has never been a significant accident during any such transfer. Again, while Palm Beach County's vulnerability to such accidents is high, the risk that this hazard will produce an impact within the community appears to be low.

- Loss of life or potential physical injury (including long-term effects such as cancer).
- Loss of property (displacement from homes).
- Palm Beach County is within the 50 mile Ingestion Pathway Zone making contamination of food supplies and drinking water a possibility.
- Exaggerated media reporting could lead to heightened public alarm. Impacts to tourism industry are possible.



In the event of an accidental release of radioactive materials from the St. Lucie evacuation areas would depend on several metrological factors such as wind direction and wind speed. According to the 2000 Census data, there are approximately 200,000 people living within 10 miles of the power plant. If an accident at the plant took place during tourist season, Palm Beach County could expect half this population to evacuate into Palm Beach County (approximately 110,000 evacuees). Palm Beach County must be prepared to shelter 10% (11,000 people) of the evacuating population. All evacuees will be sheltered in Palm Beach, Indian River, or Brevard counties. Currently, there are 19 shelters of which 18 are schools.

There are several safety design measures at the plant and stringent federal safety standards govern plant operations (e.g. plants have protective barriers and are designed to withstand aircraft attack, tornados, severe accidents and earthquakes). It is most likely that an accident would slowly progress from one stage of emergency classification to the next. A "fast breaker" accident is very unlikely, but the plant can shut down operations within 2 seconds if needed. Most likely, an accident would slowly progress providing time to warn the public and implement

protective measures. In the case of a radioactive release, Florida Power and Light and the American Nuclear Insurers organization would reimburse evacuees for damage or re-location.

3.2.2.3 *Communications System Failure*

Communication failures have a greater potential to produce adverse economic impacts in business-based rather than retirement or residential communities. On the other hand, communication system failures in residential and retirement communities may put more human lives at risk. Palm Beach County's vulnerability to communication system failures is generally considered moderate. Basically, Palm Beach County's vulnerability to this hazard is no greater or less than most other Florida coastal counties.

3.2.2.4 *Transportation System Accidents*

Palm Beach International Airport is a major commercial air transportation hub, with extensive commercial passenger and freight business as well as a significant amount of private or general aviation activity as well. The airport is located directly to the south and west of the City of West Palm Beach and the runway approaches pass directly over both the Town of Palm Beach and the City of West Palm Beach. Aviation is an important element of the economy in Palm Beach County, and this activity raises the county's vulnerability to aviation associated accidents.

Vulnerability to transportation system accidents is also associated with the highway and rail systems that run through the county. Individual community and population center vulnerabilities to this hazard are entirely dependent upon location. Again, the communities built on the eastern sand ridge of the county are most vulnerable. Major transportation hubs, rail yards, trucking centers, and the Port of Palm Beach all raise these communities' vulnerabilities to transportation system accidents and breakdowns. Transportation accidents have occasioned blockages on many of the major highways throughout the county. Due to their locations along the rail line, the eastern cities have higher vulnerabilities to rail system accidents. The Town of Palm Beach and the City of West Palm Beach are also more vulnerable to plane crashes due to their location relative to the Palm Beach International Airport. The central, unincorporated portion of the county has a higher vulnerability to major highway accidents due to the presence of Interstate 95 and the Florida Turnpike.

3.2.2.5 *Wellfield Contamination*

Wellfield contamination has not been a major problem for most of Palm Beach County. There is some potential exposure to this hazard in the eastern portion of the county, but overall the vulnerability to this hazard is considered low at this time.

3.2.2.6 *Power Failure*

Power failures have the same potential impacts in all Palm Beach County communities. The vulnerabilities of all communities to power failures is considered moderate. The power grid throughout Palm Beach County is diversified and there is no single choke point or distribution node whose failure would disrupt power distribution to the entire community.

3.2.3 Societal Hazards

3.2.3.1 Civil Disturbance

The overall potential for civil disturbance in Palm Beach County is considered moderate. The Cities of West Palm Beach, Delray Beach, Boynton Beach, and Rivera Beach are considered to have relatively high vulnerability to this hazard. There has been significant civil unrest in certain areas of these cities in the past and a significant potential for such unrest remains. Recently (within the last 3 years), the potential for civil disturbance appears to have been reduced as a result of community based police activities and the generally overall strong national economy.

3.2.3.2 Terrorism and Sabotage

The possibility for terrorism and sabotage in Palm Beach County does exist, but the county's vulnerability to this hazard is low. The City of West Palm Beach has a slightly higher vulnerability to terrorism since it is the center of government and also by the role played by aviation in the local economy, but this vulnerability is still considered only moderate. The Town of Palm Beach, as well as many other wealthy enclaves within Palm Beach County have a slightly higher vulnerability to celebrity terrorism since so many well known and wealthy personalities make their residence there. While this vulnerability exists, it is considered to be no greater than that faced by many other communities around the country where the rich and famous live.

The warm temperatures, onshore winds, high rate of sunshine (UV exposure), and rainfall in Palm Beach County make this area a less favorable target for biological or chemical terrorism than many other areas of the United States. The population here is dispersed when compared to major cities in the northeastern U.S., and the transportation system infrastructure is highly dependent upon individual vehicles. Both of these features make Palm Beach County a less desirable target for transportation system or conventional type (bomb related) terrorist acts.

3.2.3.3 Immigration Crisis

Reviewing the data on past illegal immigration and mass population movements, such as the Haitian influx and Cuban raft incidents of the 1980s, indicates that illegal immigration has never reached a crisis state for the local authorities in Palm Beach County. Palm Beach County's vulnerability to this hazard is moderate, however, due to demographic features. The cities of West Palm Beach, Delray Beach, Boynton Beach, Rivera Beach, South Bay, Pahokee, and Belle Glade all have a slightly higher vulnerability to illegal immigration impacts due their larger populations of Latin American and Caribbean immigrants.

3.2.4 Vulnerability of Critical Facilities

In **Appendix C**, maps demonstrate the vulnerability of each hazard in relation to the county and each jurisdiction's location and critical facilities and/or infrastructure. Structures have been identified for each hazard with jurisdictional boundaries. An estimated dollar figure in relation to potential dollar losses has been identified and summarized in a narrative for each identified hazard by jurisdiction.

Palm Beach County determined a criticality based on the relative importance of its various

assets for the delivery of vital services, the protection of special populations, and other important functions. The types of critical facilities and infrastructure identified within these risk assessment maps are: schools, police stations, fire stations, specific government buildings, nursing homes, assisted living facilities, hospitals, shelters, Herbert Hoover Dike, Turnpike, I-95, water treatment facilities and airports. These facilities can be located on the risk assessment maps and a potential dollar loss will be correlated in the charts broken down by municipality and unincorporated county. The estimated costs are based upon information from the county Auditor's Office. The dollar figures specific to each hazard by municipality or unincorporated area express the potential human and economic impacts within Palm Beach County.

3.3 RISK ASSESSMENT

In order to effectively plan hazard mitigation projects and allocate scarce financial resources, a community's vulnerability to a specific hazard must be coupled with other critical factors to perform a risk assessment.

Risk, or the probability of loss, depends on three elements:

- Frequency – How frequently does a known hazard produce an impact within the community?
- Vulnerability – How vulnerable is a community to the impacts produced by a known hazard?
- Exposure – What is the community's exposure in terms of life and property to the impacts produced by a specific hazard?

Once these three factors are established, the risk level faced by a community with regard to any specific hazard can be calculated using the Risk Triangle approach (Crichton, 1999).

In this approach, these three factors become the sides of a triangle, and the risk or probability of loss is represented by the triangle's area (**Figure 3.1a**). The larger the triangle's area, the higher the community's risk with respect to a given hazard. If a community wishes to reduce its potential for loss or risk of impacts from any given hazard, it can attack the problem by reducing any one of the three elements forming the sides of this triangle; the frequency of a hazard's occurrence, the vulnerability of the community, or the exposure of the community.

For example, if a community wishes to reduce its exposure to hurricanes, it could move off of the barrier islands. This actually happened in the 1870s when an entire community on the North Carolina barrier islands moved to the mainland after suffering two devastating hurricanes in three years. By moving out of harm's way a community drastically reduces its exposure and therefore its potential for loss from a given natural hazard (**Figure 3.1b**).

In today's world, the potential to relocate an entire community off the barrier islands is, to say the least, remote. A community may, however, reduce its vulnerability to hurricanes by strengthening its buildings. If buildings are hardened, vulnerability is reduced and there is a corresponding reduction in a community's probability of loss (**Figure 3.1c**).

In terms of natural hazards, there is very little, if anything that can be done to change the frequency with which they produce impacts in a community. Mitigation planning relative to those hazards must therefore focus on reducing the community's vulnerability or exposure. In terms of technological and societal hazards, the most cost-effective type of mitigation is to limit or reduce the frequency with which such hazards actually occur. **Table A-4** summarizes Palm Beach County's risk or potential for loss relative to each of the hazards identified. In addition, **Appendix C** will include a risk assessment by jurisdiction. Tables in **Appendix C** will include all 37 jurisdictions with each hazard identified. The jurisdictional risk assessment will compare each jurisdiction to the overall strategy. Then, the risk assessments will be illustrated by means of maps located in **Appendix C** by hazard. This is to give a clear image of potential risk throughout Palm Beach County hazard specific with potential dollar losses estimated tied to assessed property values. This assessment will be linked directly to **Appendix D** illustrating mitigation actions being addressed in the county and jurisdictional comprehensive plans. The overall strategy is to mitigate to reduce damage of a potential hazard.

Figure 3.1 a, b, c Risk Triangle

