	ranging from just a few feet across and a few feet deep to others that are much larger and deeper.
2010	A collapse sinkhole was induced by blasting in the Mazak Mine in Mabel, Florida, leading to the fatality of one blasting expert.
2011	A collapse sinkhole in Trenton, Florida was induced by drilling, causing the fatality of one driller.
June 2012	Tropical Storm Debby brought heavy rainfall after an extended period of drought in Florida. The event led to the formation of hundreds of collapse sinkholes across the state, resulting in highway and residential road closures, evacuations of homes, and building closures.
March 2013	A Hillsborough County man was swallowed by a 50-foot deep sinkhole. Jeffrey Bush, 37, had been sleeping inside the Seffner home when the earth below his bedroom collapsed.[157]
July 2017	A large sinkhole developed in a Land-o-Lakes residential neighborhood leading to evacuations. Two homes were swallowed within 24 hours but the hole continued to slowly grow over the next month, leading to 6 more condemned homes.

4. Probability of Future Occurrences of Geological Events

Landslides

Because of Florida's relatively flat topography, landslides are not likely in Florida.

Sinkholes

It is highly likely that there will continue to be incidences of sinkholes in Florida because as explained above, Florida has terrain that is favorable to sinkholes.

Sinkholes can be triggered by natural and anthropogenic factors, such as heavy rain after an extended drought and groundwater withdrawal or well drilling. This means that heavy rainfall or high levels of groundwater withdrawal can increase the probability of sinkholes in an area.

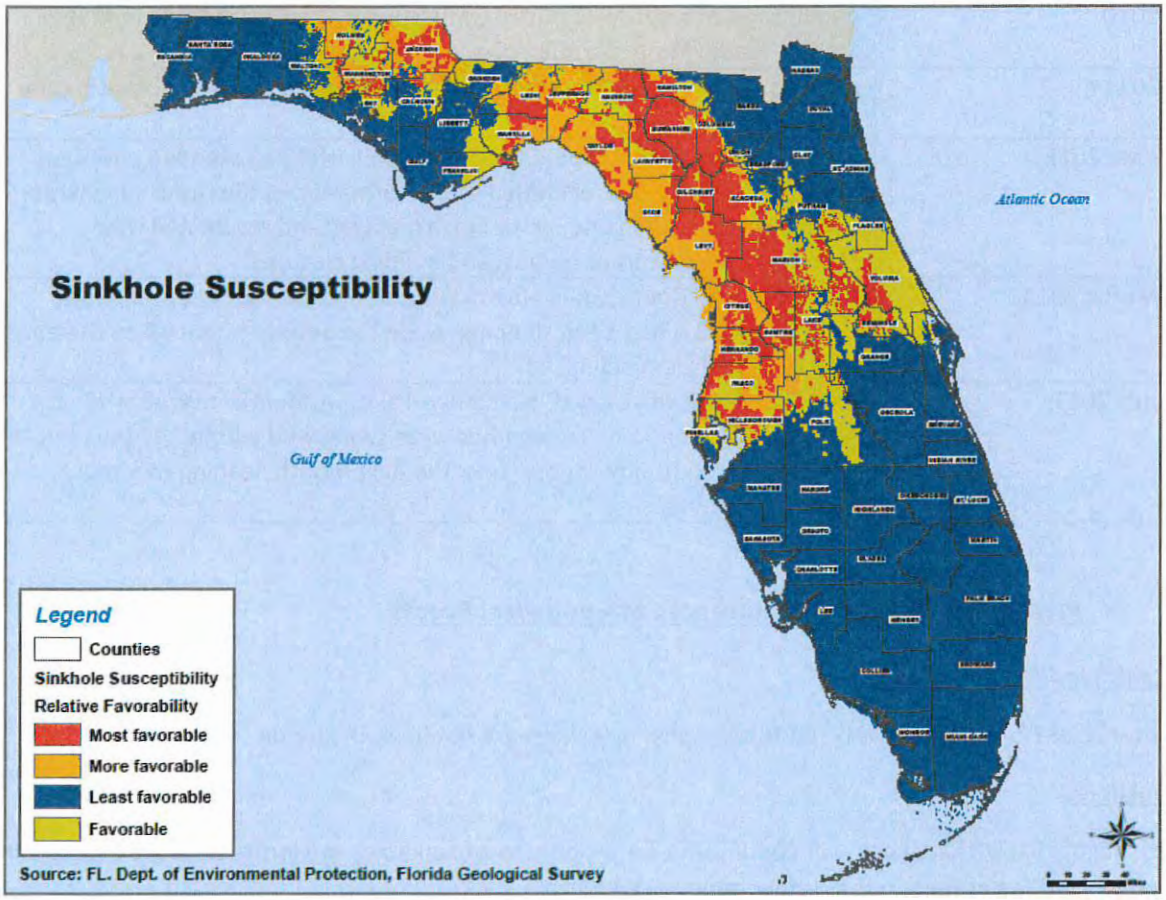
This hazard was determined to occur about every 5-10 years, giving it a Probability ranking of Likely.

Additionally, as Florida's population increases, the potential for individuals to be negatively impacted by a sinkhole increases because more people will live in locations that are favorable for sinkhole development.[158]

[157] http://articles.orlandosentinel.com/2013-08-12/news/os-sinkhole-damage-qa-20130812_1_largest-sinkhole-florida-geological-survey-limestone

[158] Florida Department of Environmental Protection Florida Geological Survey. (2017). *The favorability of Florida's geology to sinkhole formation.* Page 4.

Figure 85: Florida Sinkhole Susceptibility



According to the map from the report, the area most favorable to sinkhole development reach from the Big Bend region to west central Florida.

5. Impact Analysis of Geological Events

Landslides

N/A

Sinkholes

- Public
  - May fall in or drive in to a sinkhole
  - May be injured or killed from structure collapse because of sinkhole
- Responders
  - May be injured or killed when attempting rescue missions
- Continuity of Operations (including continued delivery of services)

- If sinkhole affects structures or critical infrastructure, operations may be interrupted

- Property, Facilities, Infrastructure
  - Critical infrastructure, including structures and roads, may be affected or damaged causing disruption
- Environment
  - Sinkholes are part of the natural environment, but there may be damage to some natural spaces from a sinkhole; for example, a public park may be damaged and result in closure
- Economic Condition
  - Sinkhole damage repair can be very expensive, so a sinkhole may have a significant negative impact for the property owner; a sinkhole would likely not affect the economy of a community
- Public Confidence in Jurisdiction's Governance
  - If there is an increase in sinkhole occurrences and the government does not address the issue, the public may become concerned about what would happen if a sinkhole were to affect their property.

6. 2018 LMS Integration

An analysis of all 67 Florida County LMS Plans and their individual geological hazard rankings is shown below. Only 6 counties profiled Landslides as a hazard and ranked it as a low-risk. 11 counties considered sinkholes to be a high risk hazard to their jurisdiction.

Landslides

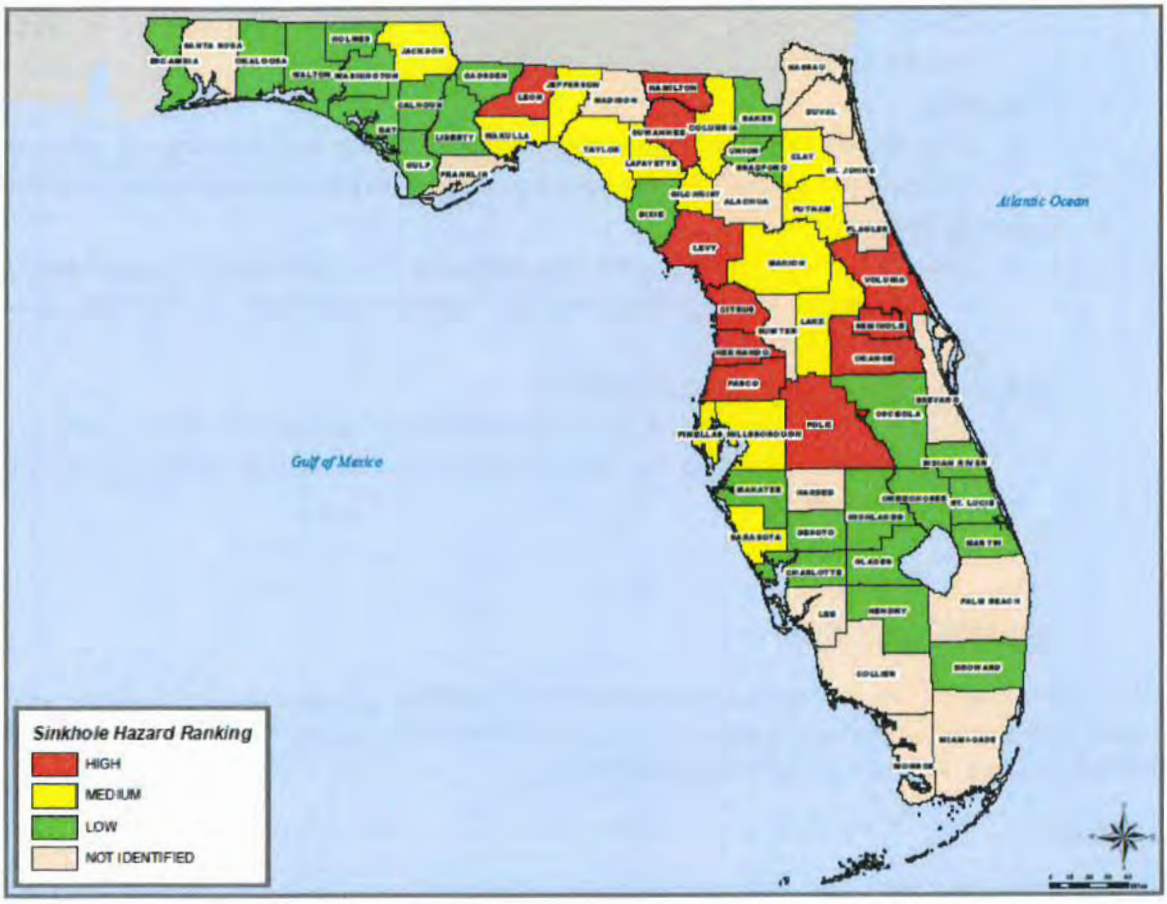
Only six jurisdictions identified landslides as a hazard in their LMS and they were ranked as low-risk. The other 61 LMS plans did not identify landslides as a hazard. Therefore, a map was not created to demonstrate this information.

Sinkholes

Based on the LMS plans, Figure 86 displays the jurisdictional rankings for the sinkhole hazard. Not all counties have identified sinkholes as one of their hazards.

- High-risk Jurisdictions: 11
- Medium-High-risk Jurisdictions: 0
- Medium-risk Jurisdictions: 14
- Low-risk Jurisdictions: 26
- Not identified Jurisdictions: 16

Figure 86: Sinkhole Hazard Rankings by County



7. Vulnerability Analysis and Loss Estimation, by Jurisdiction

The Enhanced SHMP is required to evaluate the vulnerability of jurisdictions and estimate potential losses for each hazard. Below is the Vulnerability Analysis and Loss Estimation of the state, by Jurisdiction, to Geological Events, broken down by Landslides and Sinkholes.

Landslides

Florida is not vulnerable to landslides so no vulnerability analysis or loss estimation will be conducted.

Sinkholes

Sinkhole events are prevalent across all parts of the State of Florida and there is no way of knowing where future sinkholes might appear. Because of this, the entire state is vulnerable to sinkholes. The counties with the most sinkholes in the past will likely continue to be vulnerable to sinkholes in the future. The map shown above in the Probability section shows which counties are more favorable and most favorable

to sinkhole occurrences. Listed below are the counties that have areas designated in the FDEP report as either Favorable, More Favorable, or Most Favorable. Some counties are listed in all three of the sections. Please note that the counties are listed alphabetically, not by level of risk.

- Counties with areas that are "Favorable"
  - Alachua, Bay, Bradford, Brevard, Calhoun, Citrus, Columbia, Dixie, Flagler, Franklin, Gadsden, Gilchrist, Hamilton, Hernando, Hillsborough, Holmes, Jackson, Jefferson, Lafayette, Lake, Leon, Levy, Liberty, Madison, Marion, Orange, Osceola, Pasco, Pinellas, Polk, Putnam, Seminole, Sumter, Suwannee, Taylor, Union, Volusia, Wakulla, Walton, Washington
- Counties with areas that are "More Favorable"
  - Alachua, Calhoun, Citrus, Columbia, Dixie, Gadsden, Gilchrist, Hamilton, Hernando, Hillsborough, Holmes, Jackson, Jefferson, Lafayette, Leon, Levy, Madison, Marion, Pasco, Pinellas, Polk, Sumter, Suwannee, Taylor, Union, Wakulla, Walton, Washington
- Counties with areas that are "Most Favorable"
  - Alachua, Bay, Calhoun, Citrus, Columbia, Dixie, Franklin, Gilchrist, Hamilton, Hernando, Hillsborough, Holmes, Jackson, Jefferson, Lafayette, Lake, Leon, Levy, Madison, Marion, Orange, Pasco, Pinellas, Polk, Putnam, Seminole, Sumter, Suwannee, Taylor, Union, Volusia, Wakulla, Walton, Washington

No loss estimation was conducted. The map shows the geologic favorability for the development of sinkholes. Since this is such an imprecise method of identification, a loss estimation would not have been useful for these purposes.

8. Vulnerability Analysis and Loss Estimation, of State Facilities

The Enhanced SHMP is required to evaluate the vulnerability and estimate potential losses regarding the State and its facilities across the state. The GIS team used the database of all state facilities and their values to provide the loss estimation data.

Landslides

Florida is not vulnerable to landslides so no vulnerability analysis or loss estimation will be conducted.

Sinkholes

State facilities within the areas marked as "favorable," "more favorable," and "most favorable," may be vulnerable to damage due to sinkhole development. The state facility GIS layer was not layered with the sinkhole favorability map above because of the imprecise nature of the favorability map. The data shows the geologic favorability for the development of sinkholes and therefore is not useful to determine whether or not a state facility is actually vulnerable. Furthermore, a loss estimation was not conducted because it would not have been useful for risk assessment purposes because of the imprecise method of identification of areas favorable for sinkhole development.

9. Overall Vulnerability

Each category was given a number and when all 5 categories are added together, the overall vulnerability is a number between 5 and 15.

Based on the Frequency, Probability, and Magnitude summary, the Overall Vulnerability of this hazard was determined to be Medium, with a score of 10.

<table>
<tr><th colspan="5">GEOLOGICAL</th><th>Overall Vulnerability</th></tr>
<tr><th colspan="5">Overview</th><td rowspan="4">MEDIUM</td></tr>
<tr><td colspan="5">Sinkholes are landforms created when overburden subsides or collapses into fissures or cavities in underlying carbonate rocks. Florida is underlain by several thousand feet of carbonate rock, limestone, and dolostone, with a variably thick mixture of sands, clays, shells, and other near surface carbonate rock units, called overburden.</td></tr>
<tr><th>Frequency</th><th>Probability</th><th colspan="3">Magnitude</th></tr>
<tr><td rowspan="2">Likely</td><td rowspan="2">Likely</td><th>Injuries/Deaths</th><th>Infrastructure</th><th>Environment</th></tr>
<tr><td>High</td><td>Medium</td><td>Low</td></tr>
</table>

Winter Storm and Freeze Hazard Profile

1. Winter Storm and Freeze Description

Severe winter weather includes extreme cold, snowfall, ice storms, winter storms, and/or strong winds, and affects every state in the continental United States. Areas where such weather is uncommon, such as Florida, may experience a greater impact on transportation, agriculture, and people from relatively small events compared to other states that experience winter weather more frequently.

Winter storm formation requires below-freezing temperatures, moisture, and lift to raise the moist air to form the clouds and cause precipitation. Lift is commonly provided by warm air colliding with cold air along a weather front. These storms move easterly or northeasterly and use both the southward plunge of cold air from Canada and the northward flow of moisture from the Gulf of Mexico to produce ice, snow, and sometimes blizzard conditions. These fronts may push deep into the interior regions, sometimes as far south as Florida. The National Weather Service will issue Frost Advisories, Wind Chill Advisories, Watches or Warnings, along with Freeze and Hard Freeze Watches and Warnings when cold weather threatens an area.

Frozen Precipitation: Snow, Sleet, and Freezing Rain

As a hazardous winter weather phenomena, the National Weather Service (NWS) defines a Winter Storm a weather event with accumulating frozen precipitation such as snow, sleet, and/or freezing rain.

- Snowfall: steady fall of snow for several hours or more. Heavy snow is defined as either a snowfall accumulating to 4 inches in depth in 12 hours or less, or snowfall accumulation to 6 inches or more in depth in 24 hours or less.
- Sleet: pellets of ice composed of frozen or mostly frozen raindrops or refrozen partially melted snowflakes. Heavy sleet is a relatively rare event defined as the accumulation of ice pellets covering the ground to a depth of 0.5 inch or more.

In states such as Florida, where even the smallest accumulations can cause impacts, lower thresholds are typically used to define significant winter storms and the issuance of Winter Storm Warnings. This is because of a lower capacity to respond to winter storm events.

In North Florida, a Winter Storm Warning is issued when greater than 1" of snow and/or sleet is expected to fall. For Central Florida, any snow or sleet amount over a 1/2" is considered a Winter Storm. An Ice Storm is when ice accumulates on the ground, vegetation, and power lines. Freezing Rain falls as liquid rain, but then freezes on contact with surfaces when the air temperature is below freezing. A Winter Storm Warning is issued in North Florida for ice accumulations over 1/4". This amount is often when trees and power lines begin to feel the weight of the ice. Ice accumulations are usually accumulations of 0.25 inches or greater across the country; however, amounts as little as 0.1 inch in Florida have significant impact on transportation, special needs populations, and agriculture and livestock throughout the state.

These accumulations become heavy and can damage buildings, trees, and even disrupt power and communications systems. A small amount of ice can be dangerous to pedestrians and motorists, with bridges being particularly dangerous because they freeze before other surfaces. A thin layer of ice can cause travel issues on untreated roadways.

Frost, Freeze, and Hard Freeze

Frost is the accumulation of small ice crystals on surfaces, similar to the accumulation of dew in the mornings. If a frost persists for long enough, it can lead to crop damage or loss. Frost is not a threat to the public but is a concern to the agricultural industry particularly that of Florida's citrus growing season. Frost can occur when air temperatures fall below 36 degrees Fahrenheit, the wind is light, and there is sufficient moisture in the air. A Freeze occurs when overnight temperatures reach at least 32 degrees Fahrenheit. A Hard Freeze occurs when the temperature falls below 28 degrees Fahrenheit for four hours or more. While most vegetation can survive a frost, very little vegetation can survive a hard freeze and this is when the most damage to crops occurs. While cold fronts rarely bring snow or sleet to Florida, long lasting cold temperatures occur more often and can last for several days. Nighttime temperatures can drop below freezing for periods well in excess of 8 hours.

Nor'easter

A Nor'easter is a storm over the Atlantic coast, typically moving to the northeast, with northeasterly winds blowing from the ocean across the coast. According to the NWS, these storms can occur at any time of the year, but are more common and stronger between September and April. These storms bring heavy rain, frozen precipitation, high winds, and rough surf, all of which may impact Florida. While Nor'easters don't typically bring winter weather, they have contributed to high winds, coastal erosion, and frozen precipitation in Florida.

Cold Illnesses

Frostbite is damage to skin and tissue caused by exposure to freezing temperatures – typically any temperature below 31F, and can occur in a matter of minutes when bare skin is exposed to extreme cold. Hypothermia occurs when the body loses the ability to regulate temperature. Both of these illnesses are very dangerous and can be life threatening if not treated immediately. Infants and elderly people are most at risk. When strong winds combine with cold temperatures, the heat loss from a person's skin can be accelerated. This is called the wind chill. The wind chill can make it feel like it is much colder outside than what the actual temperature is. In areas unaccustomed to winter weather, near freezing temperatures are considered "extreme cold." During unexpected or prolonged cold periods in Florida, there are often issues with propane gas supplies, and electrical and natural gas systems are pushed to their limits to meet the record demands. Also, many residents of Florida have inadequate heating systems and turn to alternatives such as space heaters and wood fires that increase the likelihood of accidental house fires and deaths from carbon monoxide poisoning.[159]

[159] http://www.nws.noaa.gov/om/winter/index/shtml

Frequency

This hazard was determined to occur about every 5-10 years, giving it a Frequency ranking of Likely.

Magnitude

This hazards Injuries and Deaths Magnitude was determined to be Medium, meaning any injuries, but no deaths are recorded.

This hazards Infrastructure Magnitude was determined to be Low, meaning little to no damage to property occurs.

This hazards Environment Magnitude was determined to be Medium, meaning some damage to the environment occurs.

Potential Effects of Climate Change on Winter Storms and Freezes

Climate change is not expected to increase occurrences or magnitude of winter storms and freezes in Florida. However, climate change does not mean that winter storms and freezes would not continue to occur in Florida. Climate variability will continue to influence daily temperature variability so isolated and prolonged winter storms and freeze events are not unlikely.[160]

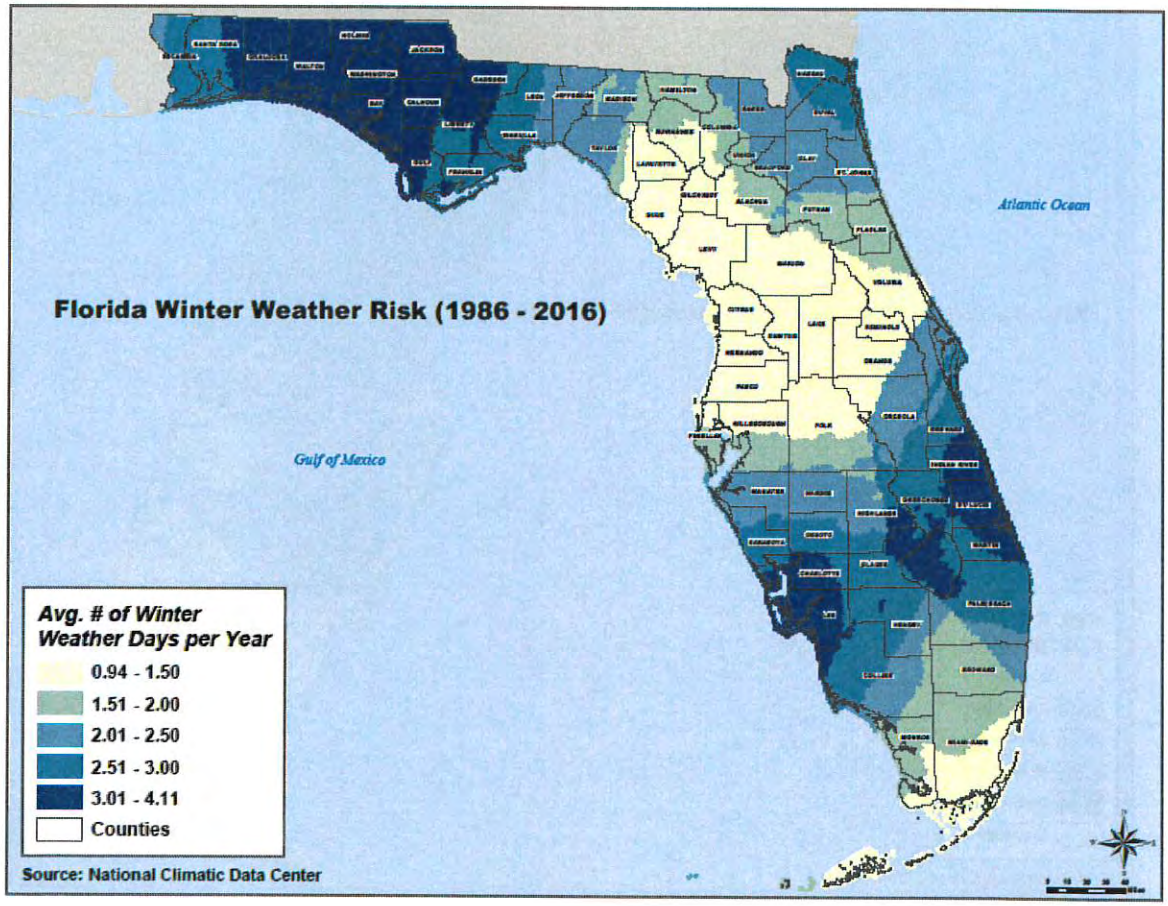
Severe winter storms will not disappear. Specifically, isolated or prolonged winter freeze events in Florida will still occur.

2. Geographic Areas Affected by Winter Storm and Freeze

The northern portion of the state is affected by winter storm and freeze events more frequently than southern Florida. That being said, south Florida can still experience freeze events, as shown in the historical section below.

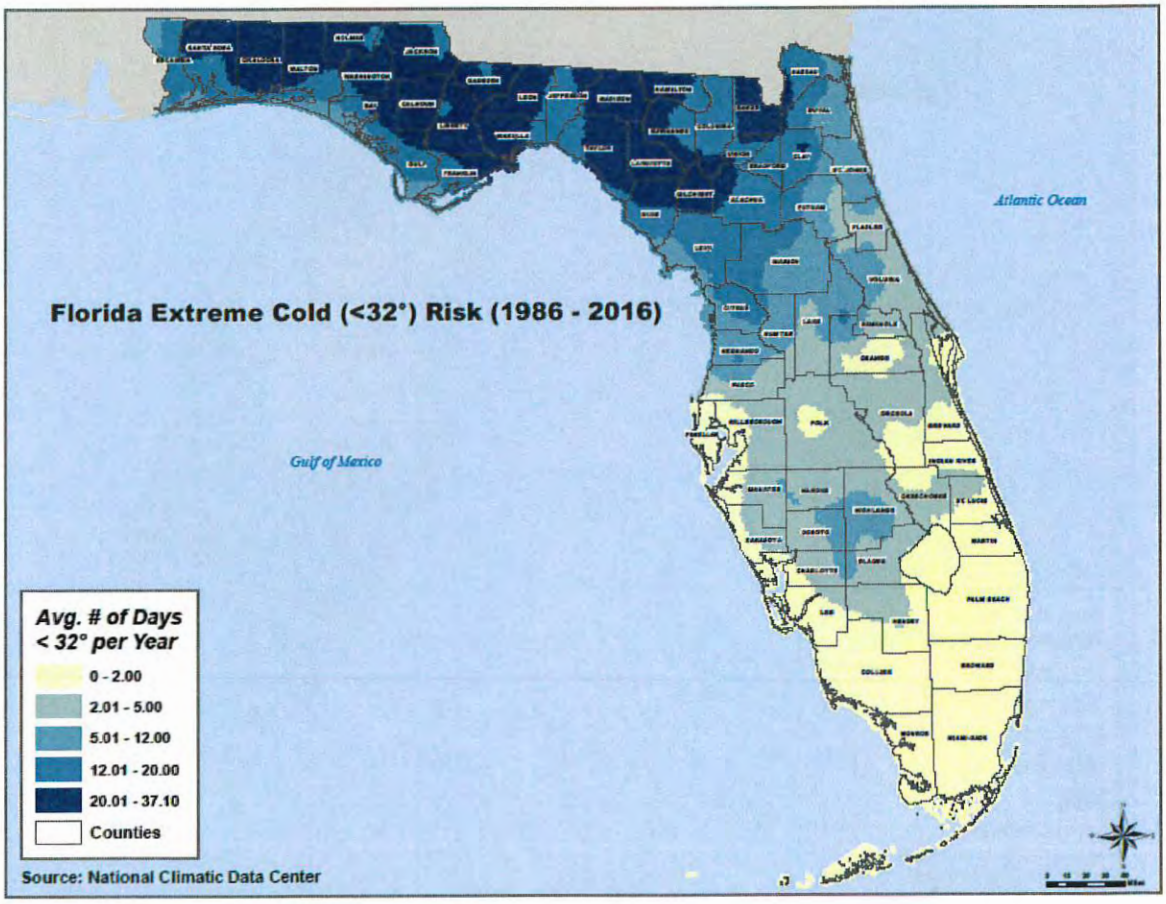
[160] *Ingram and Carter (2012). Southeast region technical report to the National Climate Assessment.* http://gyr.fortlauderdale.gov/home/showdocument?id=3153

Figure 87: Winter Weather Risk, 1986 – 2016



According to this data, most of north Florida, as well as portions of southwest and southeast Florida are likely to receive 2 to 4 days of winter weather. Central Florida and the very southern Florida are likely to experience only 1 to 1 ½ days of winter weather.

Figure 88: Florida Extreme Cold (<32 degrees) Risk, 1986-2016



According to this data, north Florida is likely to experience between 5 and 37 days of Extreme Cold, which is classified as less than 32 degrees. Specifically, the northern portions of the panhandle of Florida are likely to experience between 20 and 37 days with temperatures less than 32 degrees.

3. Historical Occurrences of Winter Storm and Freeze

Of the 69 FEMA-declared events in Florida from 1953 until 2016, there have been seven events that involved severe winter weather. These events all related to freezing and to a large degree focused on the overall impact to the Florida economy. Below is a table of the major disaster declarations related to severe winter weather, as designated by FEMA.

Table 49: FEMA Major Disaster Declarations in Florida, 1953 - 2016[161]

Date	Event	Declaration Number
March 15, 1971	Freeze	DR-304
January 31, 1977	Severe Winter Weather	DR-526
December 24 – 26, 1983	Freezing Temperatures	DR-698
March 18, 1985	Severe Freeze	DR-732
December 23 – 25, 1989	Severe Freeze	DR-851
March 12 – 16, 1993	Tornadoes, Flooding, High Winds, Tides, Freezing	DR-982
December 1, 2000 – January 25, 2001	Severe Freeze	DR-1359

According to the NCDC Storm Event Database, there were 58 winter storm and freeze events in Florida, including Extreme Cold, Frost/Freeze, and Winter Weather/Storm from 2006 to 2016. These events often lasted for longer than one day and affected multiple counties.

While there were no declared winter storm or freeze events in Florida from 2006 to 2016, there were several events that affected Florida.

Table 50: Florida Historical Occurrences, Winter Weather and Freeze, 2006-2016[162]

Date	Event Type	Location	Impacts
November 21, 2006	Snowstorm	Central Florida	Snow fell in parts of Central Florida; this was the first November snow event in the State since 1912.
February 17, 2007	Frost/Freeze	Palm Beach County	Estimated $50 million in crop damages; durations of freezing temperatures ranged from 7-11 hours north of I-4 and 3-5 hours south of I-4.
January 2-3, 2008	Frost/Freeze	Hillsborough, Collier, Hendry counties	Estimated $15 million in crop damages; brief snow flurries reported in St. Johns, Flagler, Volusia, and Brevard counties.

161 https://www.fema.gov/disasters?field_state_tid_selective=47&field_disaster_type_term_tid=9243&field_disaster_declaration_type_value=All&items_per_page=20&=GO

162 https://www.ncdc.noaa.gov/stormevents/listevents.jsp?eventType=%28Z%29+Blizzard&eventType=%28Z%29+Cold%2FWind+Chill&eventType=%28Z%29+Extreme+Cold%2FWind+Chill&eventType=%28Z%29+Freezing+Fog&eventType=%28Z%29+Frost%2FFreeze&eventType=%28Z%29+Heavy+Snow&eventType=%28Z%29+Ice+Storm&eventType=%28Z%29+Sleet&eventType=%28Z%29+Winter+Storm&eventType=%28Z%29+Winter+Weather&beginDate_mm=01&beginDate_dd=01&beginDate_yyyy=2006&endDate_mm=12&endDate_dd=31&endDate_yyyy=2011&county=ALL&hailfilter=0.00&tornfilter=0&windfilter=000&sort=DT&submitbutton=Search&statefips=12%2CFLORIDA

January 21-22, 2009	Frost/Freeze; Extreme Cold	Statewide	1 death; $61.55 million in crop damages.
February 5, 2009	Extreme Cold	Broward County	1 death; crops were damaged by the cold.
January 2, 2010	Frost/Freeze	Lake, Volusia, Orange, Okeechobee, Brevard, Indian River, St. Lucie, Seminole, Martin, and Osceola counties	Estimated $14.5 million in crop damages.
January 4, 2010	Extreme Cold	Broward County	1 death.
January 9, 2010	Extreme Cold	Brevard, Volusia, Orange, Putnam, Marion, Flagler, Seminole, Lake, and Miami-Dade counties	1 injury and 1 death; sleet and snow, freezing rain mixed with a band of light rain from Kissimmee to Palm Bay northward; a slight accumulation of mixed precipitation occurred on vehicles, pool screen enclosures, and plants.
January 10-11, 2010	Frost/Freeze	Collier, Miami-Dade, Hernando, Levy, Polk, Pasco, Citrus, Hillsborough, Hardee, Desoto, Charlotte, Sumter, Highlands, Manatee, Sarasota, and Lee counties	Over $648 million in crop damages and $3 million in property damage.
February 26, 2010	Frost/Freeze	Levy, Hernando, Citrus, Sumter, Highlands, Pasco, Manatee, Polk, Hillsborough, Hardee, Desoto, Charlotte, Sarasota, and Lee counties	Estimated $8.86 million in crop damages.
December 14-15, 2010	Frost/Freeze	Hernando, Hardee, Sarasota, Hillsborough, Levy, Sumter, Citrus, Pasco, Desoto, Manatee, Polk, Highlands, Charlotte, and Lee counties	Estimated $41.23 million in crop damages.
December 27-28, 2010	Frost/Freeze	Indian River, Osceola, Seminole, Lake, Brevard, Volusia, Okeechobee, Orange, Martin, St. Lucie, Palm Beach, Collier, Miami-Dade, and Broward counties	Estimated $300,000 in crop damages; temperatures stayed below freezing for up to 12 hours over the Nature Coast with hard freeze conditions for up to 10 hours; central Florida had around 8 hours of freezing temperatures with as many as 4 hours of hard freeze conditions; southwest

			Florida had up to 4 hours of sub-freezing temperatures.
January 3, 2012	Frost/Freeze	Miami-Dade and Hendry counties	$300,000 in crop damages.
March 4, 2013	Frost/Freeze	Palm Beach County	$3 million in crop damages.
January 7, 2014	Extreme Cold	Leon County	$1.1 million in property damages.
January 28, 2014	Winter Weather	Walton, Gulf, Calhoun, Jackson, Washington, Holmes, Bay, Franklin, Wakulla, Jefferson, Madison, Leon, Gadsden, and Liberty counties	Estimated $70.17 million in property damages; several roads were closed including a large stretch of I-10 in the panhandle; most bridges were closed at one point from Tallahassee westward; during the peak of the event, there was no road access to cross the Apalachicola River; this all led to transportation impacts with significant monetary losses for trucking companies.

The storm of 1993, considered to be among the worst non-tropical weather events in the United States, killed at least 79 people, injured more than 600, and caused more than $2 billion in property damage across parts of 20 states. Florida was affected by this winter storm, and it was a FEMA-declared event for tornadoes, flooding, high winds, tides, and freezing. According to NOAA, 2 people died from exposure to the cold in 2009 and 2 people died in 2010. This does not include additional deaths related to carbon monoxide poisoning from using improper heating sources.[163]

Prolonged freezing temperatures in January 2010 led to agricultural losses of more than $200 million. The USDA declared 59 of 67 Florida counties natural disaster areas for agricultural production as the temperature dropped below 28 degrees for more than 4 hours in a row across most of the state.[164]

4. Probability of Future Occurrences of Winter Storm and Freeze

Based on all the historical evidence, it is anticipated that a freeze may be expected in Florida every one to two years. Hard freezes, where the greatest numbers of winter crops are lost, may be expected on average once every five years based on historic FEMA-declared disasters.

According to the maps above, the panhandle of Florida, as well as portions of southeast and southwest Florida are likely to experience between 2 and 4 days of winter weather each year. Additionally, north Florida, particularly the northern panhandle, is likely to experience at least 5 days and up to 37 days of extreme cold, with temperatures less than 32 degrees.

[163] http://www.nws.noaa.gov/om/hazstats.shtml#
[164] http://www.tbo.com/news/usda-approves-disaster-declaration-for-florida-crops-87897

This hazard was determined to occur about every 5-10 years, giving it a Probability ranking of Likely.

NCDC Database

According to the NCDC database, there were 42 winter storm and freeze events in Florida from 2006 to 2016. The database categorizes these events as cold or extreme cold; frost or freeze; and winter storm or weather. In the given timeframe, there were 5 to 6 times more frost or freeze events than extreme cold and winter storm or weather events. Based on this data, there will be an average of 2-3 frost and freeze events each year and an average 1 extreme cold or winter weather event each year in Florida.

Table 51: NCDC Winter Storm and Freeze, 2006-2016[165]

Type	NCDC Report	Average per year
Cold/Extreme Cold	6	.55
Frost/Freeze	31	2.82
Winter Storm/Weather	5	.45
Total	42	3.82

5. Winter Storm and Freeze Impact Analysis

- Public
  - Injury or death, as well as possible property damage from car accidents because of ice on roads and bridges.
  - Injury or death from exposure to cold weather, either because of being stranded outside, or inside without proper heating systems.
  - Deaths and injuries have resulted from accidents including automobile collisions due to poor driving conditions. Emergency medical response can be severely hindered from the effects of a winter storm event. This is because Floridians are not accustomed to driving in winter weather conditions.
- Responders
  - First responders are increasingly at risk as they respond to traffic incidents and calls for medical attention. They are vulnerable to the same transportation dangers as other citizens, but often have to go out in hazardous conditions when ordinary citizens would not.
- Continuity of Operations (including continued delivery of services)
  - During a winter storm and the days that follow, many people do not travel due to the road conditions. The absenteeism of workers affects the overall continuity of operations of the government.
- Property, Facilities, Infrastructure
  - Loss or damage of crops and agricultural revenue because of frost/freeze events.

[165] https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=12%2CFLORIDA

- Roads and highways are most vulnerable to the effects of winter storms. Roads frequently become iced over, resulting in accidents, injuries, deaths, and traffic congestion. Roads can be heavily damaged due to winter weather events. Potholes and cracks can be found on roadways after a winter weather event, resulting in the need for repairs, causing further economic losses to the local area.
- Electrical transmission lines are highly vulnerable to severe winter weather. Trees frequently fall due to the extra weight of ice accumulating on branches. Trees falling on nearby power lines cause disruption of power service, which results in additional costs for repairs and maintenance.
- Other impacts resulting from winter storms include damage to plumbing, sewers, and waterlines, as well as minor roof damage and house fires resulting from portable heaters.

- Environment
  - Loss or damage to environment, including green spaces, habitats, species because of cold weather, winter weather, and/or frost/freeze events.
- Economic Condition
  - Loss or damage to crops because of freezes result in the loss of tens and sometimes hundreds of millions of dollars. This affects individual farmers and industries, such as the citrus industry in Florida.
  - During a winter storm and the days that follow, many people do not travel due to the road conditions. The absenteeism of workers affects the economy.
- Public Confidence in the Jurisdiction's Governance
  - A high number of motor vehicle accidents, school closures, power outages, or injuries and deaths may cause the public to believe that the government did not adequately prepare for the incident.
  -

6. 2018 LMS Integration

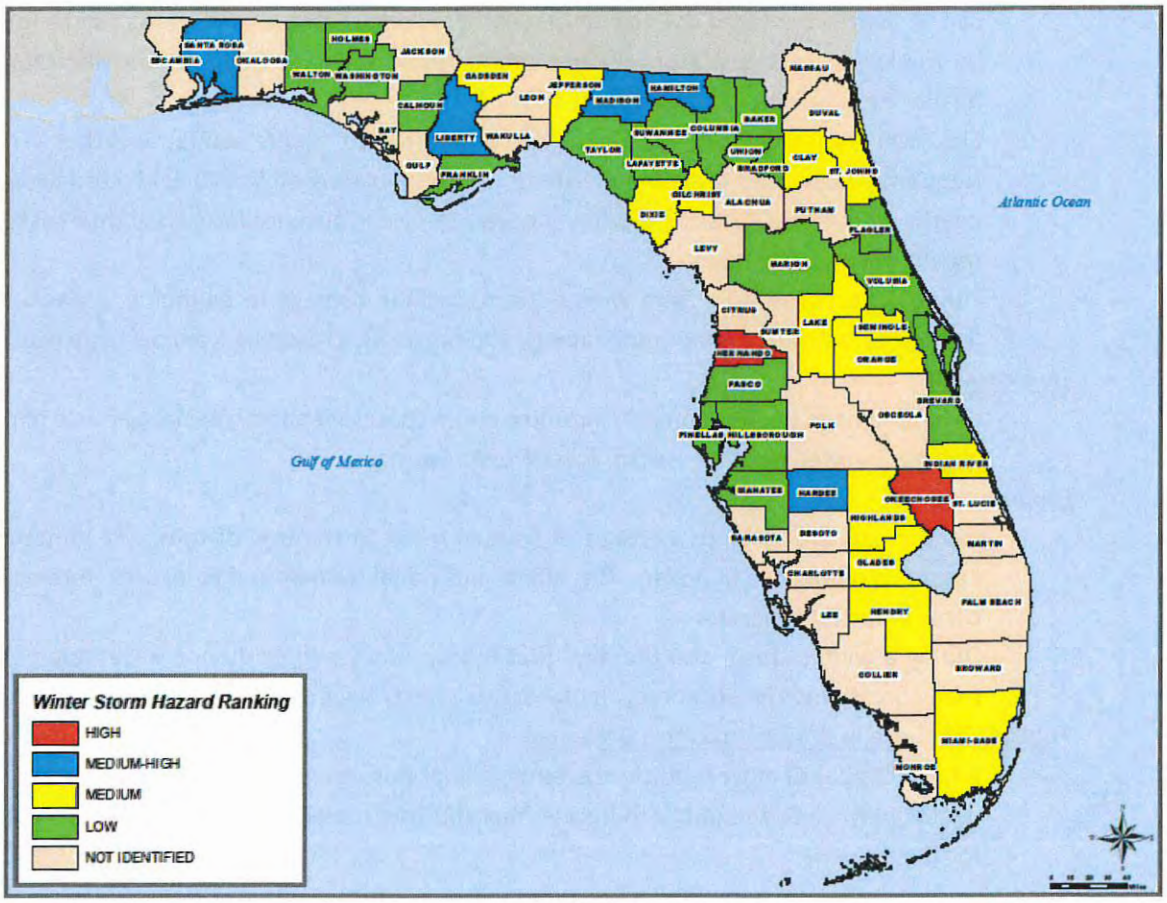
An analysis of all 67 Florida County LMS Plans and their individual winter storms or freeze hazard rankings is shown below. While 2 counties considered winter storms to a high risk in their county, 26 counties did not identify winter storms as a hazard. More counties identified Freezes as a hazard to their jurisdiction, with 8 considering freeze to be a high risk hazard and only 17 counties did not identify freeze as a hazard.

Winter Storms

Based on the LMS Plans, Figure 89 displays the jurisdictional rankings for the winter storms hazard. Not all counties have identified winter storms as one of their hazards.

- High-risk Jurisdictions: 2
- Medium-High-risk Jurisdictions: 5
- Medium-risk Jurisdictions: 14
- Low-risk Jurisdictions: 20
- Not identified: 26

Figure 89: Winter Storm Hazard Rankings by County

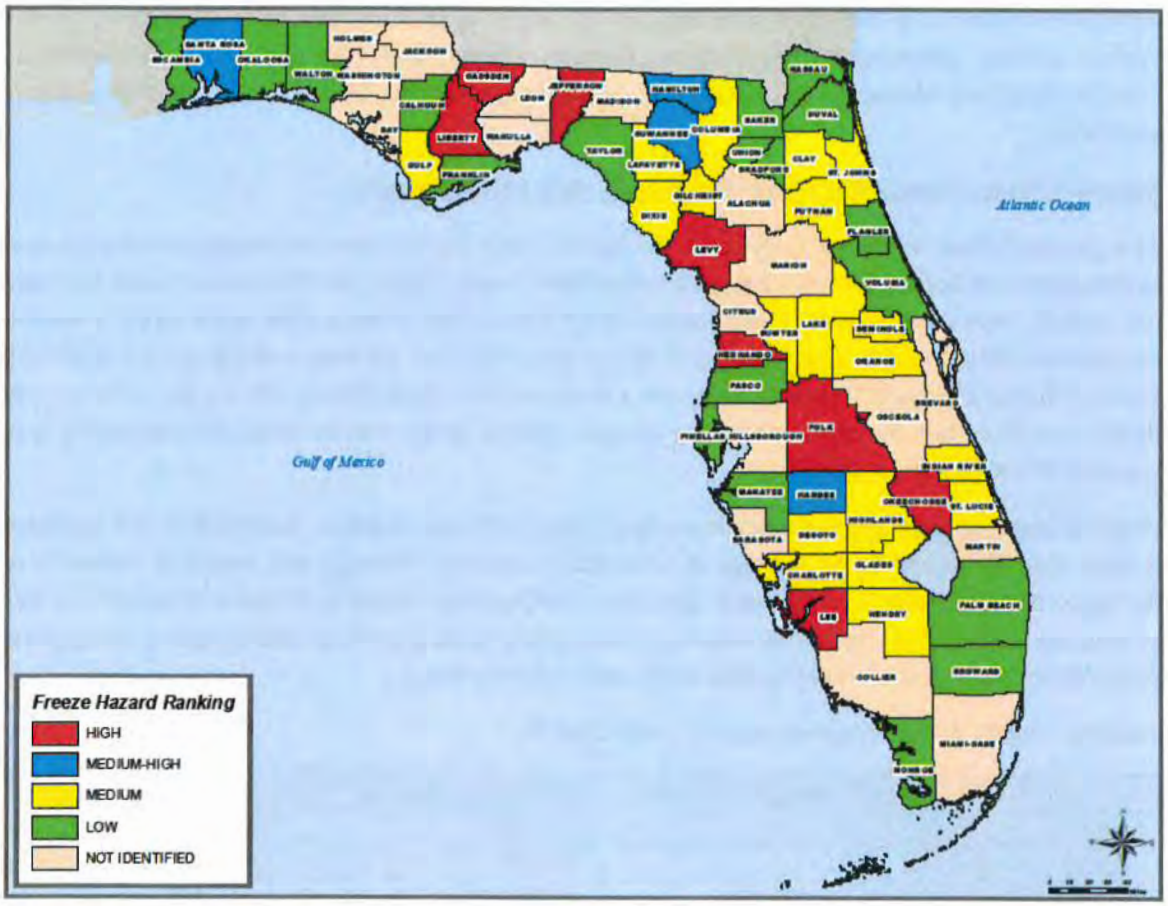


Freezes

Based on the LMS plans, Figure 90 displays the jurisdictional rankings for the freezes hazard. Not all counties have identified freezes as one of their hazards.

- High-Risk Jurisdictions: 8
- Medium-High-risk Jurisdictions: 4
- Medium-risk Jurisdictions: 19
- Low-risk Jurisdictions: 19
- Not identified Jurisdictions: 17

Figure 90: Freeze Hazard Rankings by County



7. Vulnerability Analysis and Loss Estimation, by Jurisdiction

The Enhanced SHMP is required to evaluate the vulnerability of jurisdictions and estimate potential losses for each hazard. Below is the Vulnerability Analysis and Loss Estimation of the state, by Jurisdiction, to Winter Storms and Freezes.

Severe winter weather events do not occur with the same frequency within all parts of Florida. Counties found in northern Florida have experienced more winter weather than central and southern counties.

As explained above, northern counties are likely to experience between 2 and 4 days of winter weather. There are also areas in southwest and southeast Florida that are likely to experience between 2 and 4 days of winter weather each year. Counties likely to experience between 3 and 4 days of winter weather include: Santa Rosa, Okaloosa, Walton, Holmes, Washington, Bay, Jackson, Calhoun, Gulf, Gadsden, Liberty, Charlotte, Lee, Indian River, St. Lucie, Martin, Highlands, and Glades.

Furthermore, as the map above shows, most northern counties are expected to receive between 2 and 37 days of extreme cold, with temperatures below 32 degrees. Specifically, the following northern panhandle counties are likely to receive between 20 and 37 days of extreme cold: Santa Rosa, Okaloosa, Walton, Holmes, Washington, Bay, Jackson, Calhoun, Liberty, Gulf, Gadsden, Leon, Liberty, Wakulla, Franklin, Jefferson, Madison, Taylor, Hamilton, Suwannee, Lafayette, Dixie, Gilchrist, Alachua, Columbia, and Baker.

National Climatic Data Center Winter Storm and Freeze Loss Estimation

As explained before, there will likely be an average of 3 to 4 winter storm and freeze events each year in Florida, with 2 to 3 of those events being a frost or freeze. According to the NCDC data, deaths and injuries are unlikely from these events. There were 4 direct deaths and 1 injury from these types of events in Florida from 2006 to 2016. This averages to about .09 deaths and .02 deaths resulting from each winter storm or freeze in Florida. These fatalities are a direct result of hypothermia and do not include indirect deaths due to carbon monoxide poisoning or other causes, which may increase the probability of cold weather deaths in a given year.

Property and crop damages are much more likely than deaths and injuries. According to the database, it is likely that there will be an average of $100,000 in property damage and over $74 million in crop damages. Because there is a significant agriculture and livestock industry, Florida is vulnerable to winter storms and freezes. The large citrus industry is particularly vulnerable because the primary citrus growing season is throughout the winter months when freeze events occur.

Table 52: Florida Winter Weather Impacts, 2006-2016[166]

	Total 2006 – 2016	Annual Average	Average per Event
Deaths	**4**	**0.36**	**0.9**
Injuries	**1**	**0.09**	**0.02**
Property Damage	$1,100,000	$100,00	$26,178
Crop Damage	$814,873,340	$74,079,394	$19,392,511
Total Damage	**$815,973,340**	**$74,179,394**	**$19,418,689**

8. Vulnerability Analysis and Loss Estimation, of State Facilities

The Enhanced SHMP is required to evaluate the vulnerability and estimate potential losses regarding the State and its facilities across the state. The GIS team used the database of all state facilities and their values to provide the loss estimation data.

The 2018 plan does not change the perspective that state facilities are not vulnerable to winter storms and freezes; the operating capacity of a building may be affected by this particular hazard but not to a significant degree. During the 2018 plan update and revision process, the winter weather-specific estimation of losses has not been calculated, as the impacts to state facilities from severe winter weather are negligible. The past and future vulnerabilities to winter storm events within Florida were reviewed in

[166] https://www.ncdc.noaa.gov/stormevents/choosedates.jsp?statefips=12%2CFLORIDA

an effort to determine the state's overall vulnerability. However, winter storms—similar to droughts—usually do not cause direct structural damage to facilities.

9. Overall Vulnerability

Each category was given a number and when all 5 categories are added together, the overall vulnerability is a number between 5 and 15.

Based on the Frequency, Probability, and Magnitude summary, the Overall Vulnerability of this hazard was determined to be Medium, with a score of 9.

WINTER STORM & FREEZE					Overall Vulnerability
Overview					
Severe winter weather includes extreme cold, snowfall, ice storms, winter storms, and/or strong winds, and affects every state in the continental United States. Areas where such weather is uncommon, such as Florida, may experience a greater impact on transportation, agriculture, and people from relatively small events compared to other states that experience winter weather more frequently.					MEDIUM
Frequency	Probability	Magnitude			
		Injuries/Deaths	Infrastructure	Environment	
Likely	Likely	Medium	Low	Medium	

Seismic Event Hazard Profile

1. Seismic Event Description

A seismic event, or an earthquake, is a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface that creates seismic waves. This shaking can cause buildings and bridges to collapse; disrupt gas, electric, and phone service; and sometimes trigger landslides, and tsunamis or indirectly cause flash floods or fires.

Measures

Earthquakes are measured in two ways, by magnitude and by intensity. Magnitude is defined as one number, while intensity varies based on what is experience in a specific location.

The magnitude is measured on the moment magnitude (Mw) scale and measures how much energy is released from a seismic event, such as the amount of rock movement and the area of the fault or fracture surface. The moment magnitude scale ranges from 0 to 10 and each increase in number is about 32 times greater than the previous number.

Table 53: Moment Magnitude Scale

Moment Magnitude Scale (Mw)	
10	
9	
	Great earthquake; near total destruction, massive loss of life
8	
	Major earthquake; severe economic impact; large loss of life
7	
	Strong earthquake; damage in the $ billions; loss of life
6	
	Moderate earthquake; Property damage
5	
	Light earthquake; some property damage
4	
	Minor earthquake; felt by humans
3	
2	
1	

The intensity of earthquakes is measured using the Modified Mercalli (MM) Intensity Scale, which attributes a number to the level of effects that people experience and the damages that are likely. The intensity scale consists of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and finally - total destruction. The scale is composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, and is designated by Roman numerals. It does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects.

The Modified Mercalli Intensity value assigned to a specific site after an earthquake has a more meaningful measure of severity to the nonscientist than the magnitude. Being far from the epicenter of an earthquake would mean people and structures experience a lower intensity, so the MM value would be lower. Whereas being close to the epicenter of an earthquake would have a higher MM value because people and structures would experience a higher intensity. Structural engineers usually contribute information for assigning intensity values of VIII or above. The Modified Mercalli Intensity Scale is shown below.

Table 54: Modified Mercalli Intensity Scale

Modified Mercalli Intensity Scale	
I.	Not felt except by a very few under especially favorable conditions.
II.	Felt only by a few persons at rest, especially on upper floors of buildings.
III.	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV.	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V.	Felt by nearly everyone, many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI.	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII.	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII.	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX.	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X.	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI.	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII.	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Frequency

This hazard was determined to occur about every 50-100 years, giving it a Frequency ranking of Not Likely.

Magnitude

This hazards *Injuries and Deaths* Magnitude was determined to be Low, meaning no injuries or deaths are recorded.

This hazards *Infrastructure* Magnitude was determined to be Low, meaning little to no damage to property occurs.

This hazards *Environment* Magnitude was determined to be Low, meaning little to no damage to the environment occurs.

Potential Effect of Climate Change

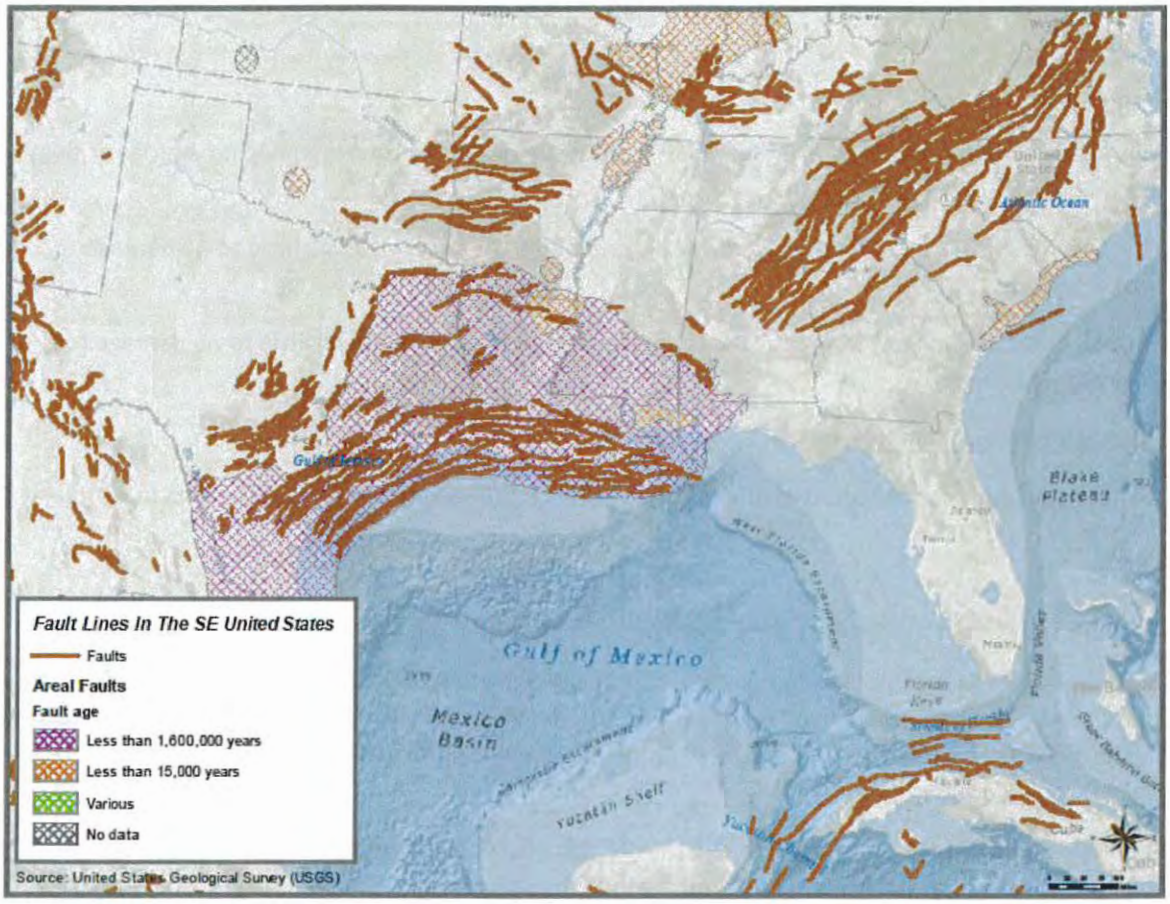
Climate change is not expected to affect the occurrence or magnitude of seismic events in Florida.

2. Geographic Areas Affected by Seismic Events

Seismic activity is rare in Florida and no earthquakes have had an epicenter in Florida. This is because there are no documented active faults in the State. Shaking felt in Florida comes from earthquakes either in the Gulf of Mexico, the Caribbean, or from the small fault line that is northeast of the State near Charleston, South Carolina.

Below is a map of fault lines in the southeast US. The map shows that there are not any known fault lines in Florida and that any seismic activity felt in Florida is likely from the faults to the north, west, or south.

Figure 91: Southeast United States Fault Lines



3. Historical Occurrences of Seismic Events

Earthquakes are very rare in Florida and there are no significant recorded incidents. Additionally, many of the reports of earthquakes from before technological advancements have no proof and the original reports are lost.

Table 55: Florida Historical Occurrences, Seismic

Date	Description
August 31, 1886	Known as the "great earthquake," a severe earthquake hit Charleston, South Carolina. It was so powerful that shaking was felt in St. Augustine and Tampa. There were also several aftershocks in the months after the quake that were felt in Florida.
January 5, 1945	Shaking was felt in Volusia County. Windows in a De Land courthouse shook violently.
October 27, 1973	A shock was felt in Seminole, Volusia, Orange, and Brevard counties with a maximum intensity of MM V.

January 13, 1978	Two shocks were felt in Polk County, each lasting about 15 seconds and one minute apart. It rattled doors and windows, but there were no injuries or damages.
November 13, 1978	A shock was felt in northwest Florida. The seismic station estimated that it originated in the Atlantic Ocean.[167]
September 10, 2006	A strong quake was felt in Florida and other Gulf Coast states. USGS determined it was magnitude 6 quake originating in the Gulf of Mexico, 250 miles southwest of the Apalachicola area.[168]
July 16, 2016	Some felt small shakes in Florida and USGS rated it as a 3.7 magnitude. It was later discovered that the "quake" was actually an experimental explosion in the ocean by the US Navy.[169]

Many reports of Earthquakes felt in Florida are unsubstantiated and only known because of personal accounts of "tremblors." The 1886 Charleston, South Carolina earthquake was felt in Florida. There was a shock felt in 1978 and then no seismic activity in Florida until 2006 when a quake in the Gulf of Mexico was reportedly felt in Florida. Shaking in 2016 was thought to be a rare earthquake affecting Florida, but it was actually shaking felt from explosion tests by the US Navy.

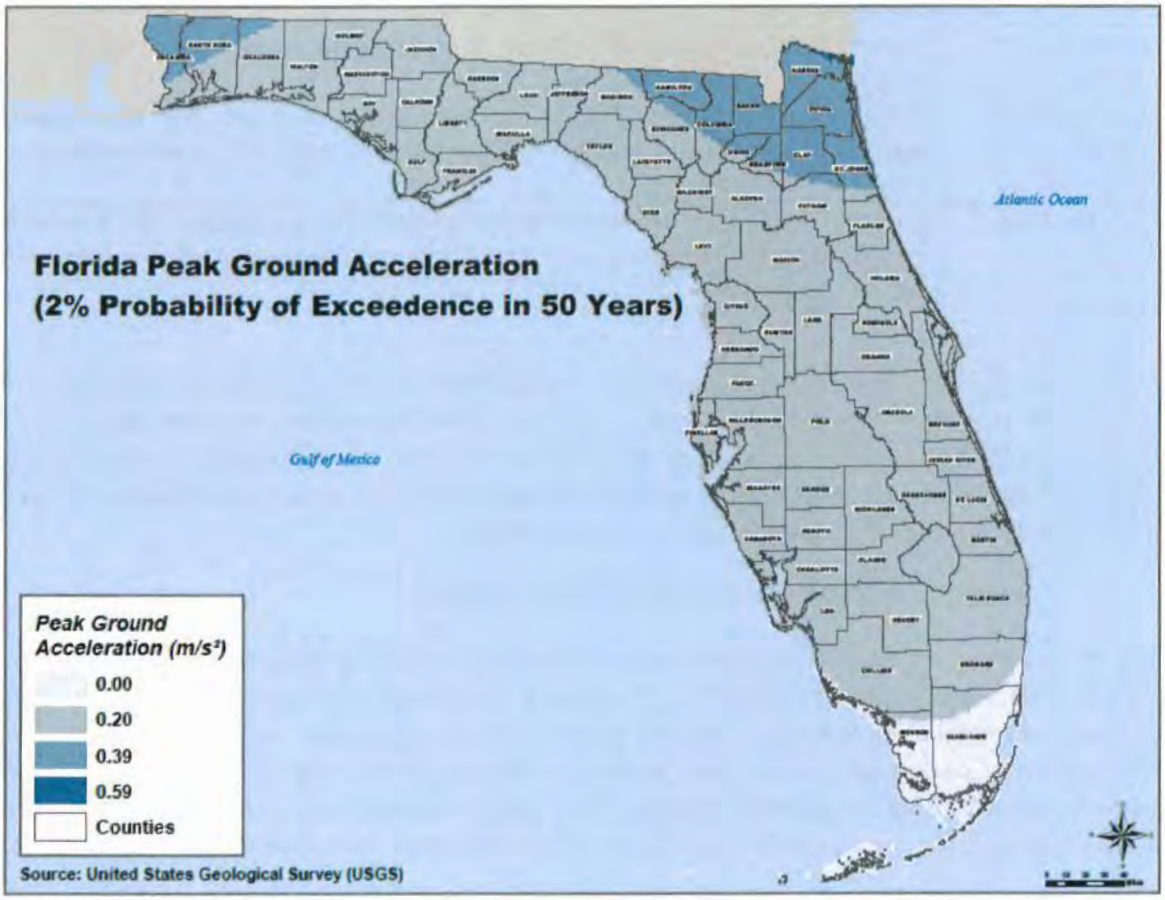
4. Probability of Future Occurrences of Seismic Events

The probability is extremely low that a major earthquake will affect the State of Florida and cause significant damage. According to USGS, Florida is classified as a stable geological area, which means that damage from any shaking or tremors felt from an earthquake, is expected to be minimal. The map below shows zones of peak ground acceleration as a percentage of gravitational acceleration. There is a two percent probability that the given acceleration range will be exceeded in a 50-year period. Peak ground acceleration refers to the maximum shaking that occurs at a specific location during an earthquake.

This hazard was determined to occur about every 50-100 years, giving it a Probability ranking of Not Likely.

[167] http://ufdc.ufl.edu/UF00001039/00001/13x
[168] http://publicfiles.dep.state.fl.us/FGS/FGS_Publications/Forum/forum_oct2006.pdf
[169] https://earthquake.usgs.gov/earthquakes/eventpage/us20006f8n#executive

Figure 92: Florida Peak Ground Acceleration



Generally, a peak ground acceleration of 0.01 m/s^2 is felt by humans and a peak ground acceleration of 0.2 m/s^2 can cause people to lose their balance. As shown in the map above from USGS, most of the state would experience 0.20 m/s^2 peak ground acceleration in the event of an earthquake affecting Florida. Portions of Escambia, Santa Rosa, Okaloosa, Madison, Hamilton, Suwannee, Columbia, Baker, Union, Bradford, Nassau, Duval, Clay, St. Johns, and Putnam counties would perhaps experience 0.39 m/s^2 peak ground acceleration. To be clear, this does not mean that an earthquake that centered near Florida would be felt by all of Florida, but that shaking may be possible to feel.

5. Impact Analysis of Seismic Events

- Public
  - May feel slight shaking, but no injuries will result in shaking from an earthquake
- Responders
  - Unlikely to experience impacts
- Continuity of Operations (including continued delivery of services)
  - Unlikely to cause interruptions to operations

- Property, Facilities, Infrastructure
  - Some windows may be shattered from a large earthquake that sends shocks and shaking to Florida, but this is very unlikely
- Environment
  - Unlikely to impact the environment
- Economic Condition
  - Unlikely to impact the economy
- Public Confidence in Jurisdiction's Governance
  - Unlikely to impact the public confidence in the jurisdiction's governance

6. 2018 LMS Integration

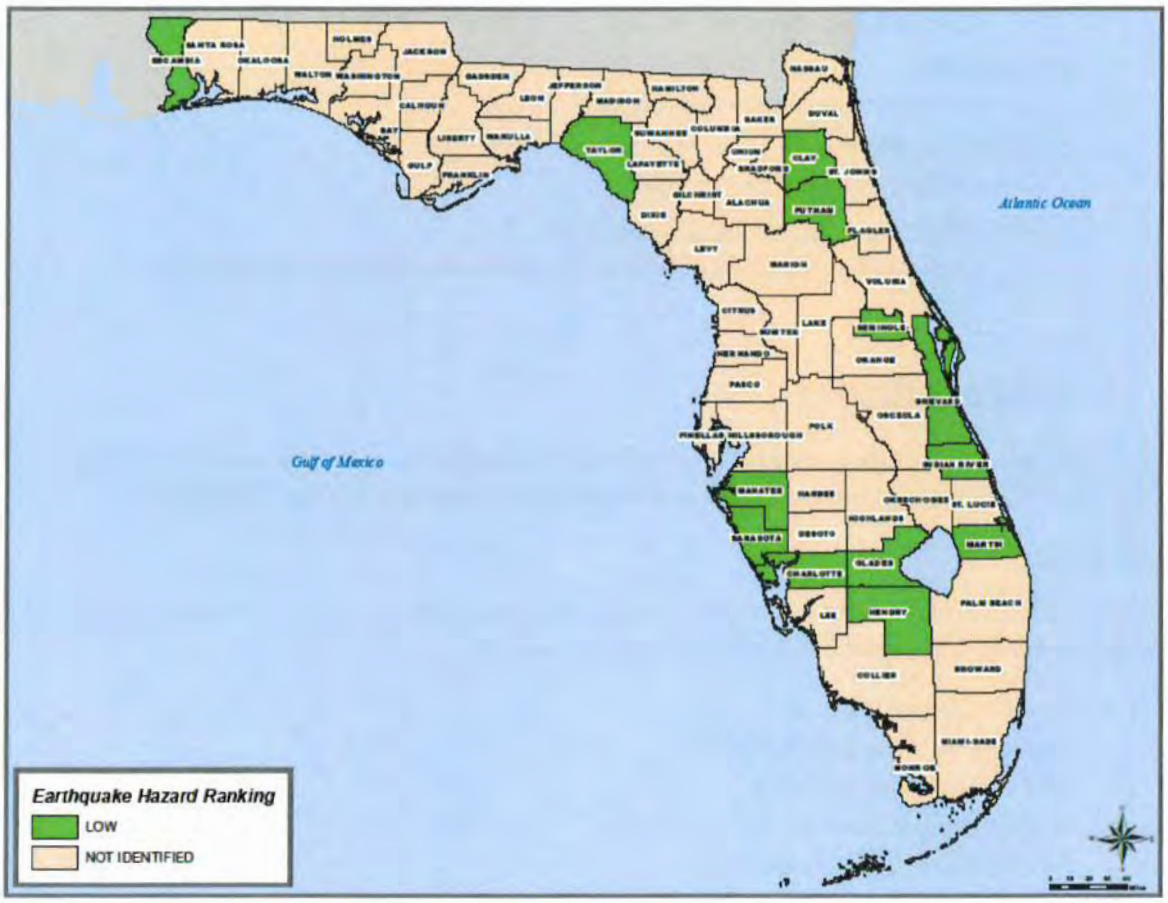
An analysis of all 67 Florida County LMS Plans and their individual seismic hazard rankings is shown below. Only 13 counties profiled Seismic Events as a hazard and all ranked it as a low-risk hazard.

Earthquakes

Based on the LMS plans, Figure 93 displays the jurisdictional rankings for the earthquakes hazard. Not all counties have identified earthquakes as one of their hazards.

- High-risk Jurisdictions: 0
- Medium-High-risk Jurisdictions: 0
- Medium-risk Jurisdictions: 0
- Low-risk Jurisdictions: 13
- Not identified Jurisdictions: 54

Figure 93: Seismic Hazard Rankings by County



7. Vulnerability Analysis and Loss Estimation, by Jurisdiction

The Enhanced SHMP is required to evaluate the vulnerability of jurisdictions and estimate potential losses for each hazard. Below is the Vulnerability Analysis and Loss Estimation of the state, by Jurisdiction, to Seismic Events.

According to the peak ground acceleration map above, most of the state has equally low vulnerability. There are small portions of north Florida that may experience slightly more intense shaking.

There are no losses expected to be caused by a seismic event.

8. Vulnerability Analysis and Loss Estimation, of State Facilities

The Enhanced SHMP is required to evaluate the vulnerability and estimate potential losses regarding the State and its facilities across the state. The GIS team used the database of all state facilities and their values to provide the loss estimation data.

Similarly to the jurisdiction vulnerability and loss estimates, state facilities have a low vulnerability to seismic events and there are minimal to no losses expected.

9. Overall Vulnerability

Each category was given a number and when all 5 categories are added together, the overall vulnerability is a number between 5 and 15.

Based on the Frequency, Probability, and Magnitude summary, the Overall Vulnerability of this hazard was determined to be Low, with a score of 5.

<table>
<tr><th colspan="5">SEISMIC EVENTS</th><th>Overall Vulnerability</th></tr>
<tr><th colspan="5">Overview</th><td rowspan="4">LOW</td></tr>
<tr><td colspan="5">A seismic event, or an earthquake, is a sudden, rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface that creates seismic waves. This shaking can cause buildings and bridges to collapse; disrupt gas, electric, and phone service; and sometimes trigger landslides, and tsunamis or indirectly cause flash floods or fires.</td></tr>
<tr><th>Frequency</th><th>Probability</th><th colspan="3">Magnitude</th></tr>
<tr><td rowspan="2">Not Likely</td><td rowspan="2">Not Likely</td><th>Injuries/Deaths</th><th>Infrastructure</th><th>Environment</th></tr>
<tr><td>Low</td><td>Low</td><td>Low</td></tr>
</table>

Tsunami Hazard Profile

1. Tsunami Description

Tsunamis are among the most devastating of geologic disasters. Tsunamis are powerful waves created as a consequence of another non-meteorological, geologic in nature, hazard such as earthquakes, underwater landslides, volcanic eruptions, or other displacements of large amounts of water under the sea. As the waves travel towards land, they build up to higher heights as the depth of the ocean decreases and appear as walls of water or turbulent waves that resemble hurricane storm surge. The speed at which a tsunami travels depends on the ocean depth rather than the distance from the source of the wave. Deeper water generates greater speed, and the waves slow down when reaching shallow waters. Where the ocean is deep, tsunamis can travel at speeds up to 500 miles an hour. Tsunamis arrive on land with enormous force and recede with nearly equal force.

A tsunami is not a single wave, but rather a series of waves often referred to as a "wave train". There can be as many as 60 miles between peaks of each wave series and be as far as one hour apart.[170] Tsunamis have a much smaller amplitude (wave height) offshore, and a very long wavelength (often hundreds of kilometers long), which is why they generally pass unnoticed at sea, forming only a passing "hump" in the ocean. The number of arrivals and the amplitudes of each wave will vary depending on the coastal properties, the exact travel direction, and other specifics of how the tsunami was generated. They will vary from place to place and event to event. In the largest tsunamis, surge can continue for many hours and more than a day.

Scientists cannot predict when and where the next tsunami will strike, but Tsunami Warning Centers know which earthquakes are likely to generate tsunamis and can issue messages when they think it is possible.

Tsunami Monitoring and Forecasting

There is often no advance warning of an approaching tsunami. However, since earthquakes are often a cause of tsunamis, an earthquake felt near a body of water may be considered an indication that a tsunami could shortly follow. The first part of a tsunami to reach land is a trough rather than a crest of the wave. The water along the shoreline may recede dramatically, exposing areas that are normally submerged. This can serve as an advance warning of the approaching crest of the tsunami, although, the warning only gives a very short time before the crest, which typically arrives seconds to minutes later.[171]

NOAA's Pacific Marine Environmental Laboratory developed Deep-Ocean Assessment and Reporting of Tsunamis (DART) buoys to monitor tsunami systems in real time. These buoys are positioned at strategic locations throughout the ocean globally and play a critical role in tsunami forecasting. NOAA has two tsunami warning centers:[172]

[170] http://news.nationalgeographic.com/news/2007/04/070402-tsunami.html
[171] http://www.tsunami.gov/?page=tsunamiFAQ
[172] http://www.tsunami.gov/?page=tsunamiFAQ

- The National Tsunami Warning Center in Palmer, Alaska, serves the continental United States, Alaska, Puerto Rico, and Virgin Islands and Canada
- The Pacific Tsunami Warning Center in Honolulu, Hawaii, directly serves the Hawaiian Islands and the U.S. Pacific territories and is the primary international forecast center for the warning systems of the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization in the Pacific and the Caribbean and Adjacent Regions

NOAA's National Geophysical Data Center (NGDC) is building high-resolution digital elevation models (DEMs) for select U.S. coastal regions. These combined bathymetric-topographic DEMs are used to support tsunami forecasting and modeling efforts at the NOAA Center for Tsunami Research, Pacific Marine Environmental Laboratory (PMEL). The DEMs are part of the Short-term Inundation Forecasting for Tsunamis (SIFT) system currently being developed by the PMEL for the NOAA tsunami warning centers, and are used in the Method of Splitting Tsunami (MOST) model developed by the PMEL to simulate tsunami generation, propagation, and inundation.

Misnomers

Tsunamis are often referred to as tidal waves; however, oceanographers discourage this name because tides have little to do with these giant waves.[173]

There is another phenomenon often confused with tsunamis called rogue waves. There remains debate as to whether these waves are related to tsunamis. They are included in this section as the mitigation plans address the threat in the same relative manner. Rogue waves are unpredictable, little is known about their formation, but may be caused by regularly-spaced ocean swells that are magnified by currents or the atmosphere.

Frequency

This hazard was determined to occur about every 50-100 years, giving it a Frequency ranking of Not Likely.

Magnitude

This hazards Injuries and Deaths Magnitude was determined to be Low, meaning no injuries or deaths are recorded.

This hazards Infrastructure Magnitude was determined to be Low, meaning little to no damage to property occurs.

This hazards Environment Magnitude was determined to be Low, meaning little to no damage to the environment occurs.

Potential Effect of Climate Change

Climate change is not expected to affect the occurrence of tsunamis in Florida.

[173] http://oceanservice.noaa.gov/facts/tsunami.html

2. Geographic Areas Affected by Tsunami

Tsunami events occur most often in the Pacific Ocean, but they are a global phenomenon and all are potentially dangerous, though they may not damage every coastline they strike. Analyzing the past 150 years of tsunami records shows that the most frequent and destructive tsunamis to affect the U.S. have occurred along the coasts of California, Oregon, Washington, Alaska, and Hawaii.[174]

Overall, Florida has experienced few destructive tsunami or rogue wave events, but there were several small events.

Mitigate FL found that there are two ways of identifying geographic locations that could be affected by a tsunami event. The first way is to consider the fact that there is scientific evidence that shows that there is the potential for a geological event, such as a massive landslide, to take place with Cumbre Vieja in the Canary Islands. If this event were to occur, a large-scale tsunami could affect the United States' eastern coastline, and it is expected that the eastern coastline of the State of Florida would suffer extensive damage and loss of life.

Earthquakes are frequently the cause for tsunami events, and because there is no way of knowing exactly when and where future earthquake events might take place, Mitigate FL has concluded that all geographic areas of Florida that border the Atlantic Ocean or Gulf of Mexico are at risk. However, sediment deposits in the Gulf of Mexico and Great Bahama Bank may lead to underwater landslide activity. The following vulnerabilities are organized by threat to the Atlantic Coast, or Gulf Coast and Keys and list the potential causes of a tsunami that would put the state at risk:[175]

- Florida's Atlantic Coast
- Puerto Rico Trench
- Cumbre Vieja Volcano in Canary Islands
- Azores-Gibraltar Fracture Zone
- Florida's Gulf Coast and Keys
- Puerto Rico Trench (minor effect as wave wraps around islands)
- Large Meteorite into Gulf of Mexico

3. Historical Occurrences of Tsunami

There have been 4 reported tsunami events in the history of Florida. All 4 of these tsunamis occurred on the Atlantic Coast. Below are the causes of these tsunamis.[176]

- 1 was caused by an Atlantic Coast earthquake

[174] http://nws.weather.gov/nthmp/documents/GoM-Final01regionalAssessment.pdf
[175] http://www.rsmas.miami.edu/news-events/press-releases/2016/study-models-tsunami-risk-for-florida-and-cuba
[176] http://nws.weather.gov/nthmp/documents/Tsunami_Assessment_Final.pdf

- 1 was caused by a non-Atlantic earthquake
- 2 were caused by a Caribbean earthquake

While no known tsunamis have ever affected the Florida Gulf Coast, a tsunami in that location is not impossible. Additionally, while tsunamis have historically affected the Caribbean many times, it is unlikely that those tsunamis will also affect Florida.

While it wasn't officially a "tsunami," there was a tsunami-like event on July 7, 1992 when a large "rogue wave" suddenly appeared along the coast in the Daytona area. The wave was reportedly about 10 feet above normal waves and stretched 27 miles long, from Ormond Beach to New Smyrna Beach. There was one death, over 20 people injured, and damage to about 100 cars parked near the coastline. The best theory is that the wave was caused by winds from a storm front.[177]

4. Probability of Future Occurrences of Tsunami

Based on a historical analysis, and the frequency of prior tsunami events from around the world, it is Mitigate FL's conclusion that the probability of future tsunami events affecting the State of Florida is low.

Since earthquakes cause most tsunamis and Florida is in a seismically stable region, there is a low probability that a tsunami will affect Florida. However, underwater landslides can also trigger tsunamis. Such landslides are unlikely, but not impossible.[178]

This hazard was determined to occur about every 50-100 years, giving it a Probability ranking of Not Likely.

5. Impact Analysis of Tsunami

- Public
  - There may be injury or death
- Responders
  - Rescue missions may be life-threatening if buildings are not structurally stable or if rescuing from waters of unknown depth
- Continuity of Operations (including continued delivery of services)
  - If a structure were severely damaged or flooded, operations would be disrupted
- Property, Facilities, Infrastructure
  - If a major tsunami were to occur in Florida, many structures and critical infrastructure would be severely damaged from the force of the waters and from flooding effects
- Environment
  - The coast could be altered, including intra-coastal areas, beaches, mangroves, etc.
- Economic Condition
  - If a major tsunami were to occur in Florida, there would be many businesses damaged and forced to close and employee absenteeism would also be a challenge
- Public Confidence in Jurisdiction's Governance

[177] https://www.deseretnews.com/article/235629/ROGUE-WAVE-CRASHES-ASHORE-IN-FLORIDA.html
[178] http://dep.state.fl.us/geology/geologictopics/hazards/tsunamis.htm

- If a major tsunami were to occur in Florida and response and recovery efforts were not fast enough, the public may lose confidence in the jurisdiction's governance

6. 2018 LMS Integration

Mitigate FL focused on producing a statewide vulnerability analysis based on estimates provided by the Local Mitigation Strategies (LMS). With 67 multi-jurisdictional Local Mitigation Strategy plans, the local risk assessment data provided a solid baseline for the overall state vulnerability analysis. For counties that analyzed tsunamis, all reported low vulnerability and many included the analysis within the "Storm Surge" or "Coastal Flooding" portion of their plan. Due to this fact, it was not possible to acquire a vulnerability score for each county. Only Santa Rosa and Indian River counties identified Tsunami as a hazard in their LMS.

7. Vulnerability Analysis and Loss Estimation, by Jurisdiction

The Enhanced SHMP is required to evaluate the vulnerability of jurisdictions and estimate potential losses for each hazard. Below is the Vulnerability analysis and Loss Estimation of the state, by Jurisdiction, to Tsunamis.

Historically, large-scale tsunami events have not been a major threat to the State of Florida; however, that exposure has increased as more people move into the state in areas of close proximity to the coast.

Approximately 33 percent of the total state population lives within 20 miles of the coast, and that number is increasing. The majority of the state's residents are not educated on the warning signs or effects of a tsunami and would be put at a higher risk of exposure should a large-scale event occur.

The original plan did not perform a loss estimate on a statewide level for tsunamis. In the past, storm surge or coastal flood data was used in place of tsunami data because tsunami data was unavailable. The Florida 2018 Hurricane Exercise included an inject event that was an earthquake, which caused a landslide in the Gulf of Mexico, which caused a tsunami to affect the Gulf Coast of Florida. When the GIS and Meteorology team analyzed this hypothetical scenario, it was determined that the past assumption that storm surge or coastal flood data could be used as an equivalent of tsunami data was incorrect. As explained above, tsunami data for Florida is not available because NOAA has not yet completed the models.

8. Vulnerability Analysis and Loss Estimation, on State Facilities

The Enhanced SHMP is required to evaluate the vulnerability and estimate potential losses regarding the State and its facilities across the state. The GIS team used the database of all state facilities and their values to provide the loss estimation data.

In the past, storm surge or coastal flood data was used in place of tsunami data because tsunami data was unavailable. The Florida 2018 Hurricane Exercise included an inject event that was an earthquake, which caused a landslide in the Gulf of Mexico, which caused a tsunami to affect the Gulf Coast of Florida. When the GIS and Meteorology team analyzed this hypothetical scenario, it was determined that the past assumption that storm surge or coastal flood data could be used as an equivalent of tsunami data was

incorrect. As explained above, tsunami data for Florida is not available because NOAA has not yet completed the models.

9. Overall Vulnerability

Each category was given a number and when all 5 categories are added together, the overall vulnerability is a number between 5 and 15.

Based on the Frequency, Probability, and Magnitude summary, the Overall Vulnerability of this hazard was determined to be Low, with a score of 5.

<table>
<tr><th colspan="5">TSUNAMI</th><th>Overall Vulnerability</th></tr>
<tr><th colspan="5">Overview</th><td rowspan="4">Low</td></tr>
<tr><td colspan="5">Tsunamis are powerful waves created as a consequence of another non-meteorological, geologic in nature, hazard such as earthquakes, underwater landslides, volcanic eruptions, or other displacements of large amounts of water under the sea. As the waves travel towards land, they build up to higher heights as the depth of the ocean decreases and appear as walls of water or turbulent waves that resemble hurricane storm surge.</td></tr>
<tr><th>Frequency</th><th>Probability</th><th colspan="3">Magnitude</th></tr>
<tr><th></th><th></th><th>Injuries/Deaths</th><th>Infrastructure</th><th>Environment</th></tr>
<tr><td>Not Likely</td><td>Not Likely</td><td>Low</td><td>Low</td><td>Low</td></tr>
</table>

Transportation Incident Hazard Profile

1. Transportation Incident Description

Transportation systems are designed to move people, goods, and services efficiently, economically, and safely from one point to another. As the movement of people, goods, and services increases due to population growth and technological innovation, the need to plan for events becomes increasingly important. As one of the critical infrastructure sectors, the Department of Homeland Security (DHS) categorizes the transportation sector into the following seven modes:[179]

- Aviation
- Highway and Motor Carrier
- Maritime
- Mass Transit and Passenger Rail
- Pipeline Systems
- Freight Rail
- Postal and Shipping

Florida has a large transportation network that consists of airports, major highways, passenger railroads, marine ports, and pipelines. These transportation systems provide lifeline services for communities and are vitally important for response and recovery operations. The vast network of public and private critical infrastructure owners and operators, the infrastructure and services they manage, and the extensive interdependencies among the transportation modes and other sectors indicate the need for coordinated planning to manage all hazards efficiently and effectively.

Figure 94: Florida Department of Transportation Network

[179] https://www.dhs.gov/sites/default/files/publications/nipp-ssp-transportation-systems-2015-508.pdf

The identification of critical transportation infrastructure requires consideration of Federal, State, regional, and local jurisdictions, their interests and a variety of hazards. At the national level, critical infrastructure in each of the four subsectors—aviation, maritime, surface, and postal and shipping—contribute to national security, economic stability, and public health and safety. At the regional, State, and local levels, the necessity of infrastructure is primarily determined by the business, lifestyle, and emergency needs of the community.

To secure transportation systems from risks such as natural disasters and man-made threats, states can conduct assessments of physical, human, and cyber elements of critical infrastructure. Risks to critical transportation infrastructure include natural disasters as well as manmade physical and cyber threats. Man-made threats include terrorism, vandalism, theft, technological failures, and accidents. Cyber threats to the Sector are of concern because of the growing reliance on cyber-based control, navigation, tracking, positioning, and communications systems, as well as the ease with which actors can exploit cyber systems serving transportation. While engineered hazards such as road curve geometry can be addressed through design, hazards such as terrorist attacks and extreme weather can be difficult to predict and mitigate.

Terrorism

Terrorist attacks, whether physical or cyber, can significantly disrupt vital transportation services and cause long-term sociological and economic consequences. The risk of a terrorist attack on transportation infrastructure is typically assessed using attack scenarios to evaluate the threats, vulnerabilities, and consequences. Transport vehicles are abundant, moving virtually unnoticed within industrial locations and major population centers; across borders; and in the case of mail and express package services, to nearly every household, business, and government office in the country. As seen on September 11th, 2001, modes of transportation, such as airplanes, can be used as the weapons themselves. The very nature of the transportation enterprise is to be open, efficient, and accessible which can make it a target for terrorist attacks. For more on terrorism please see the *Terrorism Incidents Profile* on page 367.

Natural Disasters and Extreme Weather

Global transportation infrastructure today is confronted with significant vulnerabilities, including the evolving threats of our changing climate. Natural disaster risks to Florida transportation systems include wildfires, flooding, severe storms, tropical cyclones, and drought, all of which have the potential for widespread disruption of transportation services. Risks from natural disasters have a varying regional or local relevance because of prevailing weather patterns, geological trends, topographical features, and population density.

In Florida, heavy rainfall events can disrupt transportation services and damage infrastructure and facilities. During or following periods of heavy rainfall, inundation and washouts can block transportation routes, damage facilities, and interrupt power supplies. Tropical cyclones can damage critical infrastructure such as roads and bridges causing delays in critical response, services, and the ability to move throughout the state. Tornados have similar effects while also creating dangerous situations with people on the roads.

Fog

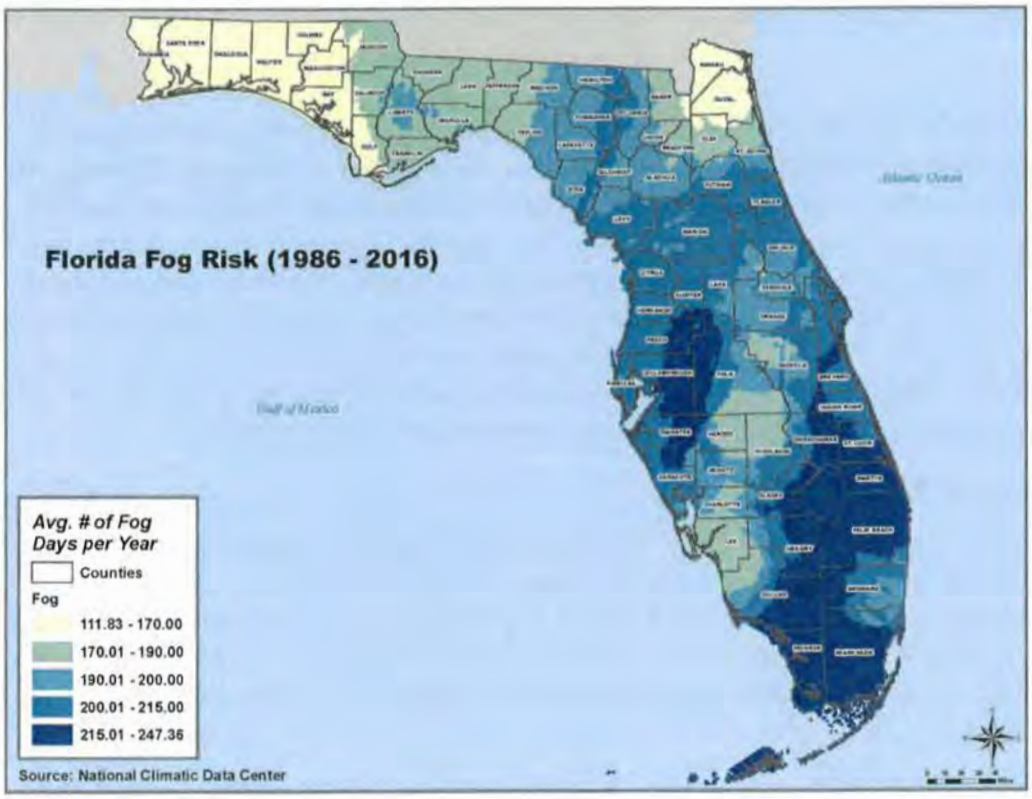
Fog is a cloud form at the surface of the earth made of tiny water droplets suspended in the air. The greatest problem with fog is visibility. Heavy fog is defined as visibility below one quarter of a mile. A

Dense Fog Advisory means that dense fog has reduced visibility to 1/4 mile or less within the advisory area. These conditions make travel difficult.[180]

A Freezing Fog Advisory is when fog develops and surface temperatures are at or below freezing. The tiny liquid droplets in the fog can freeze instantly to any surface, including vehicles and road surfaces. Freezing fog makes driving, boating, flying and other forms of transportation particularly hazardous. Visibilities are typically at or below 1 mile.

Fog, particularly when dense, can be hazardous to drivers, mariners and aviators, contributing to numerous travel accidents every year. Restrictions in visibility resulting from fog can also impact takeoff and landing procedures and requirements for pilots, and can be the cause of weather-related aviation delays.

Figure 95: Florida Fog Risk, 1986-2016



Aging Infrastructure

The condition of Florida's transportation infrastructure is also a concern because of the advanced age and deterioration of many structures throughout the state's transportation network. Aging infrastructure threatens the resilience of these systems and can multiply risks from other factors such as man-made or natural disasters. The impact of a loss of a key asset, such as a bridge, poses an immediate threat and can

[180] http://www.nws.noaa.gov/om/fog/ww.shtml

have cascading impacts to passenger and freight movement, as well as potentially large-scale impacts such as supply chain disruption.[181]

Deterioration of the nation's infrastructure jeopardizes public safety, threatens quality of life, and drains the U.S. economy. Most experts agree that America's infrastructure needs to be upgraded. More than half of America's natural gas transmission pipelines were installed before 1970; the same holds true for pipelines that carry hazardous liquids such as gasoline, diesel, and jet fuel. Pipelines are just a fraction of the nation's vast network of transportation infrastructure — the roads, cables, wires, conduits, drains, satellites, and switches that enable the flow of everything from sewage to gas. The pipelines within Florida are owned by numerous companies and have differing levels of condition, making the system vulnerable to accidents and failure. Meanwhile, the government owned infrastructure — roads, bridges, rail, and mass transit — is under severe financial strain because maintenance costs have increased.

Cyber

Cyber-based technologies in transportation operations enable greater economies and efficiencies, improve customer service, enhance operational controls, and provide better security capabilities. Consequently, transportation companies are increasingly dependent on cyber systems for business, security, and operational functions. Cyber technologies upon which transportation services rely include positioning, navigation, tracking, shipment routing, industrial system controls, access controls, signaling, communications, and data and business management. These technologies are often interconnected through networks and remote access terminals, which may allow malicious actors easier access to key areas. For more information please see the *Cyber Incidents Profile* on page 314.

Types of Transportation

The Florida Department of Transportation (FDOT) is the lead agency in committing to a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity, and preserves the quality of the environment and communities. FDOT has implemented the Strategic Intermodal System (SIS), the state's highest priority for transportation investments. SIS also has a focus for implementing the Florida Transportation Plan (FTP) which is the state's long-term transportation vision and policy. SIS is a transportation system that:[182]

- Is made up of facilities and services of statewide and interregional significance;
- Contains all forms of transportation for moving both people and goods, including linkages that provide for smooth and efficient transfers between modes and major facilities, and;
- Integrates individual facilities, services, modes of transportation and linkages into a single, integrated transportation network.

The system was established to efficiently serve the mobility needs of Florida citizens, businesses, and visitors and to help Florida become a worldwide economic leader, enhance economic prosperity and competitiveness, enrich quality of life, and reflect responsible environmental stewardship.

SIS is a network of high-priority transportation facilities including the state's largest and most significant commercial service airports, spaceports, deep-water seaports, freight rail terminals, passenger rail and

[181] http://knowledge.wharton.upenn.edu/article/americas-aging-infrastructure-what-to-fix-and-who-will-pay/
[182] http://www.fdot.gov/info/moredot/mvv.shtm

intercity bus terminals, rail corridors, waterways, and highways. These state facilities carry more than 99% of all commercial air passengers and cargo, virtually all waterborne freight and cruise passengers, almost all rail freight, 89% of all interregional rail and bus passengers, 55% of total traffic, and more than 70% of all truck traffic on the state highway system.[183]

Aviation

Florida has long been the world's premier gateway to space, the air traffic hub of the Americas, a major hub for flight training, and home to leading manufacturers of all types of aircraft and aircraft components. Florida is fortunate to be served by one of the most comprehensive and progressive airport systems in the country. Florida's aviation sector drives a large portion of the state's economy. In 2010, aviation made up more than 8.5% of Florida's Gross State Product (GSP). One of the largest drivers of the state's economy is international trade, with air cargo accounting for more than one third of Florida's international trade dollars. The second largest is tourism and over half of all visitors to the state arrive by air.

Florida has 21 commercial airports throughout the state, 107 general aviation airports and 12 military airfields. In 2015, 161 million airline passengers flew through Florida airports.[184] FDOT and the Federal Aviation Administration (FAA) coordinate efforts to ensure safe air travel and mitigate against potential hazards. In 2005, FDOT in cooperation with the FAA and Florida's Public Airports developed the Florida Aviation System Plan (FASP). They focused the plan on traditional aviation system planning elements, but also included an analysis of the intermodal aspects of the state transportation system. The FASP also includes a strategic planning element, identifying seven strategic goals considered essential.[185]

Air transportation hazards can include crashes and issues with the airplanes themselves but can also include potential hazards at the airport or within the surrounding areas. Causes and contributors to airplane accidents could include faulty parts and defects, operational or pilot error, system malfunctions, and outside forces such as extreme weather. Airports and the surrounding areas could also potentially cause additional hazards. One such hazard is bird strikes, and while unlikely to cause a crash, birds can cause flight delays and emergency landings.[186] Terrorist attacks could be targeted at major airports or involve the use of airplanes as a weapon. Degraded runways and equipment also pose a significant threat to the aviation infrastructure.[187]

Airplane crashes could lead to cascading hazards, as a crash could lead to wildfires, dam or levee damage leading to flooding, roadway blockage and damage, and utility damage from downed power lines leading to outages and potential accidents. Air transportation hazards could also lead to damage or destruction of goods and freight and loss of life.[188]

Florida is also a premier aerospace and space location, and is a top state for aerospace manufacturing. The industry companies excel in areas from aircraft parts and assembly, to intelligence, surveillance and

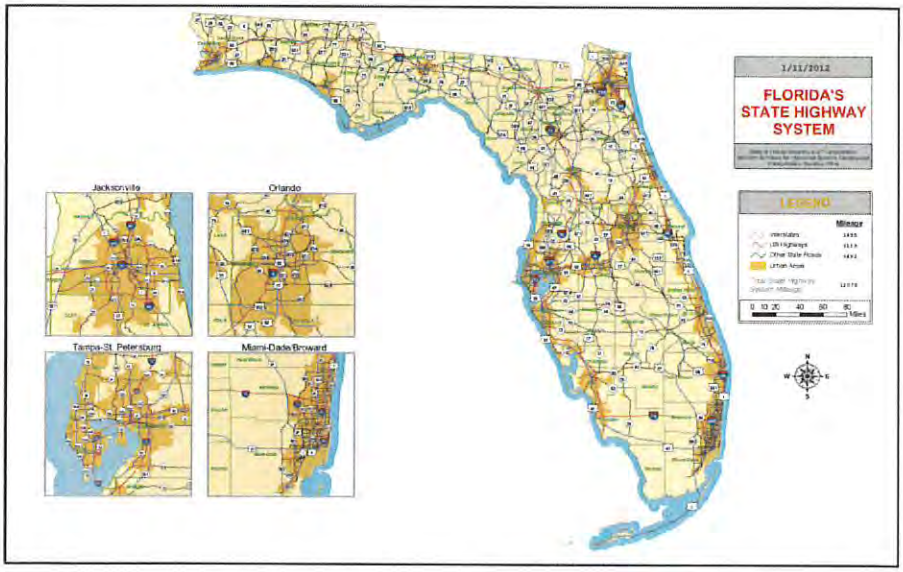
[183] http://www.fdot.gov/planning/sis/about.shtm
[184] https://www.faa.gov/
[185] http://www.fdot.gov/planning/fastfacts.pdf
[186] http://www.bne.com.au
[187] http://www.fdot.gov/aviation/planning.shtm
[188] http://www.fdot.gov/aviation/pdfs/Welcome%20to%20Fl%20Aviation112010.pdf

reconnaissance, and missiles. Florida also offers tremendous space launch assets. Florida has two spaceports and conducted 17 spaceport launches in 2015.[189]

Highway and Motor Carrier

This mode of transportation includes highways, roadways, bridges, trucks, commercial freight vehicles, motor coaches, and school buses.[190] Florida has 122,659 miles of highway, over 273,000 miles of total public roadways, 12,262 bridges, and over 30 public transit systems. In fiscal year 2015, 207 billion automobile miles were traveled within the state. This includes private vehicles, passenger transportation, freight, and hazardous materials transportation. The public transit system had 271 million passengers in 2014.[191] Consequently, today's roadways are dangerously overcrowded, turning the focus to identifying serious roadway hazards.

Figure 96: Florida State Highway System



Accidents are the highest risk on roadways and according to the Florida Department of Highway Safety and Motor Vehicles there were 374,342 accidents in 2015 with 2,939 fatalities.[192] Accidents involving freight could lead to loss of revenue for businesses and wages for drivers as well as affect the consumers waiting on the cargo being transported. Hazardous material is routinely transported along Florida's road system and can affect the environment and surrounding population in the event of a spill. For more information regarding the transportation of hazardous materials please see the *Hazardous Materials Incidents Profile* on page 328. Florida's 12,262 bridges within the state can malfunction or be degraded to the point of structural instability, causing not only roadway hazards but waterway hazards as well.[193]

[189] https://www.nasa.gov/
[190] http://www.floridatransportationindicators.org/index.php?chart=13d
[191] http://www.fdot.gov/planning/fastfacts.pdf
[192] https://flhsmv.gov/pdf/crashreports/crash_facts_2015.pdf
[193] http://www.smartmotorist.com/traffic-and-safety-guideline/roadway-hazards.html

Florida's roads boost significant economic growth and social mobility.[194] By dramatically expediting and substantially reducing costs for the transportation of goods, the roadway and freeway system changed the way the state does business, enabling national supply chains to efficiently make and deliver products. Good, efficient roads make commuting feasible, however, aging roads can lead to hazards and accidents. The Federal Highway Administration's most recent survey points out that almost 20% of U.S. roads are in poor condition. This includes roads and bridges that need to be repaved, are crumbling, or have significant damage. [195]

Maritime

Florida has a total water area of 4,308 square miles with more than 11,000 miles of rivers, streams and waterways.[196] The state has 1,197 statute miles of coastline and 2,276 statute miles of tidal shorelines. This includes 825 miles of beaches. The map below shows Florida's waterways.[197]

Figure 97: Florida Waterways

There are 15 seaports within the state that accommodate cruise lines, military ships, passenger and private vessels, and freight vessels.[198] Florida's 15 public seaports play a critical role in the lives of citizens and continue to drive Florida's economy. From what we wear to what we eat, from building materials to automobiles, almost everything we use in our daily lives flows through Florida ports. In 2015, 15.2 million cruise passengers made port in Florida and many more made port on private vessels. Currently, Florida seaports generate nearly 900,000 direct and indirect jobs and contribute $117.6 billion in economic value

[194] https://www.nhtsa.gov/
[195] https://www.fhwa.dot.gov/
[196] http://geology.com/lakes-rivers-water/florida.shtml
[197] http://www.stateofflorida.com/facts.aspx
[198] http://flaports.org/about/the-florida-system-of-seaports/

to the state through cargo and cruise activities. Florida maritime activities account for approximately 13% of Florida's GDP while contributing $4.2 billion in state and local taxes.

The Maritime Administration (MARAD) is the agency within the U.S. Department of Transportation regarding waterborne transportation. Its programs promote the use of waterborne transportation and its seamless integration with other segments of the transportation system, and the viability of the U.S. merchant marine. MARAD works in many areas involving ships and shipping, shipbuilding, port operations, vessel operations, national security, environment, and safety. [199]

FDOT and MARAD, along with Customs and Border Patrol (CBP)[200] monitor the maritime transportation system in Florida, including waterborne transportation, landside infrastructure, the shipbuilding and repair industry, and labor. They integrate the economy with a vast network of systems that moves large quantities of consumer goods, people, agricultural products, energy, and raw materials.

The United States Coast Guard (USCG) and CBP work together to ensure secure borders. U.S. Customs and Border Protection as part of their comprehensive effort to improve security at the nation's borders while enhancing legitimate travel, including private boaters, established the Local Boater Option (LBO). This means boaters can register with CPB, and then phone-in entry into the U.S. from a foreign country, instead of reporting in person. This reduces the number of undocumented individuals coming to Florida shores and works to reduce drug smuggling operations into the state. On an average day the USCG conducts search and rescue operations, saves lives and property in peril, conducts waterborne patrols of critical maritime infrastructure, seizes drugs, conducts security boarding in and around Florida ports, and interdicts undocumented migrants.[201]

Florida Fish and Wildlife Conservation Commission (FWC) oversees and coordinates statewide regulatory waterway markers to ensure compliance with the uniform marking system and to improve compliance of state boating and resource protection zones for the long term well-being and benefit of all waterway users and the fish and wildlife resources. FWC regulates licenses and permits related to boating and fishing, and manages waterways within the state.[202]

Mass Transit and Passenger Rail

Mass Transit and Passenger Rail includes terminals, operational systems, and supporting infrastructure for passenger services by transit buses, trolleybuses, monorail, heavy rail—also known as subways or metros—light rail, passenger rail, and vanpool or rideshare.[203] Florida has a complex public transportation network with over 270 million public transit riders within the state annually.[204] Public transportation in Florida is a crucial part of the solution to the state's economic, energy, and environmental challenges – helping to bring a better quality of life and economic prosperity. In increasing numbers, people are using public transportation, and local communities are expanding public transit services. The Florida Public Transportation Association (FPTA) is one of the most active state transit associations in the nation. FPTA

[199] https://www.marad.dot.gov/
[200] https://www.cbp.gov/
[201] http://www.uscg.mil
[202] http://myfwc.com/
[203] https://www.dhs.gov/transportation-systems-sector
[204] http://www.fdot.gov/planning/fastfacts.pdf

is a nonprofit association whose members include every major public transit agency in Florida as well as interested citizens and businesses.[205]

Florida has 2,908 main rail corridor miles, owned by 15 operating railroads and terminal or switching companies, as well as 81 miles owned by the State of Florida. The largest operator in the State is CSX Transportation, which owns more than 53% of the statewide track mileage.[206]

On average there is a train collision or derailment every two hours and a hazardous materials transportation incident every two weeks throughout the country. The Federal Railroad Administration (FRA) was created by the Department of Transportation Act of 1966 and is one of ten agencies within the U.S. Department of Transportation concerned with intermodal transportation. The FRA's mission is to enable the safe, reliable, and efficient movement of people and goods, now and in the future.[207]

Railroad hazards could include train collisions, derailments, accidents involving cars or pedestrians, rail worker accidents, and hazardous materials spills. Natural hazards also cause issues for railways including freezing tracks and malfunction with train car operations such as brakes. Dense fog could cause visual obstructions, animals on the tracks could lead to derailments and all accidents can lead to the damage or destruction of freight, property, and loss of life. These accidents could also be caused by equipment failure, operator error, signal failure, and track damage or failure.[208]

Florida also has an extensive bus system with over 60,000 registered buses throughout the state.[209] Public transportation provides access to job opportunities for Floridian's as well as a transportation option to get to work, school, visit friends, or go to a doctor's office. Public Transportation saves America about 4.2 billion gallons of gasoline each year. According to FPTA, Florida currently ranks third among all states in total gasoline consumption. The 4.2 billion gallons of gasoline saved by the transit industry represents Florida's entire gasoline consumption for about seven months.

Pipeline Systems

Energy pipelines are a fundamentally safe and efficient means of transporting materials key to the U.S. energy supply but, given that they often carry toxic, volatile, or flammable material, energy pipelines have the potential to cause injury and environmental damage.[210] There are a total of 34,019 miles of pipeline within Florida:[211]

- 552 miles Intrastate Natural Gas Transmission
- 4,510 miles Interstate Natural Gas Transmission
- 203 miles Propane
- 80 miles Liquid Hazardous Materials
- 43 miles Oil
- 36 miles Refined Petroleum Products

[205] https://floridatransit.org/about-us
[206] https://www.fra.dot.gov/Page/P0002
[207] https://www.aar.org/data-center/railroads-states#state/FL
[208] http://www.fdot.gov/rail/PlanDevel/Documents/FinalInvestmentElement/G-Chapter2-FreightRail.pdf
[209] https://www.statista.com/statistics/196342/total-number-of-registered-buses-in-the-united-states-by-state/
[210] http://hazardmitigation.calema.ca.gov/plan/state_multi-hazard_mitigation_plan_shmp
[211] http://www.fdot.gov/planning/fastfacts.pdf

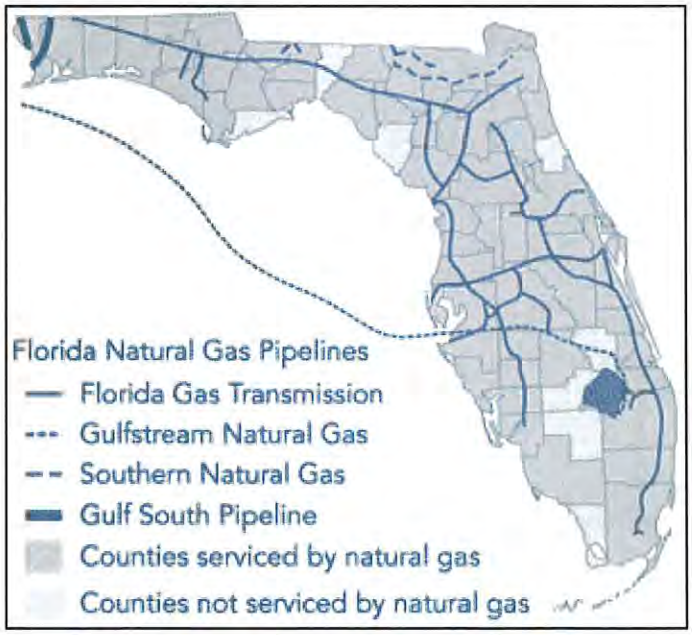
- 28,567 miles Natural Gas Distribution Systems

FDOT and the Pipeline and Hazardous Materials Safety Administration (PHMSA) work together to protect people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to citizens' daily lives. To do this, PHMSA establishes national policy, sets and enforces standards, educates, and conducts research to prevent incidents. PHMSA also prepares the public and first responders to reduce consequences if an incident does occur.[212]

Increased urbanization is resulting in more people living and working closer to existing transmission pipelines. Growth in population, urbanization, and land development near transmission pipelines, together with the addition of new facilities to meet demands, may increase the likelihood of pipeline damage due to human activity and the exposure of people and property to pipeline failures. Compounding the potential risk is the age and gradual deterioration of the transmission pipeline system due to natural causes. [213]

Causes and contributors to pipeline failures include construction errors, material defects, internal and external corrosion, pressure buildups, operational errors, control system malfunctions, and outside force damage. Natural hazards such as sinkholes or land subsidence, earthquake or seismic activity, and flooding can all put pressure on existing pipelines resulting in bursts, spills, or leaks of natural gas, oil, and hazardous substances. For more information on pipelines also see the *Hazardous Materials Incidents Profile* on page 328. The map below shows the major pipelines and the companies that own them.

Figure 98: Florida Natural Gas Pipelines



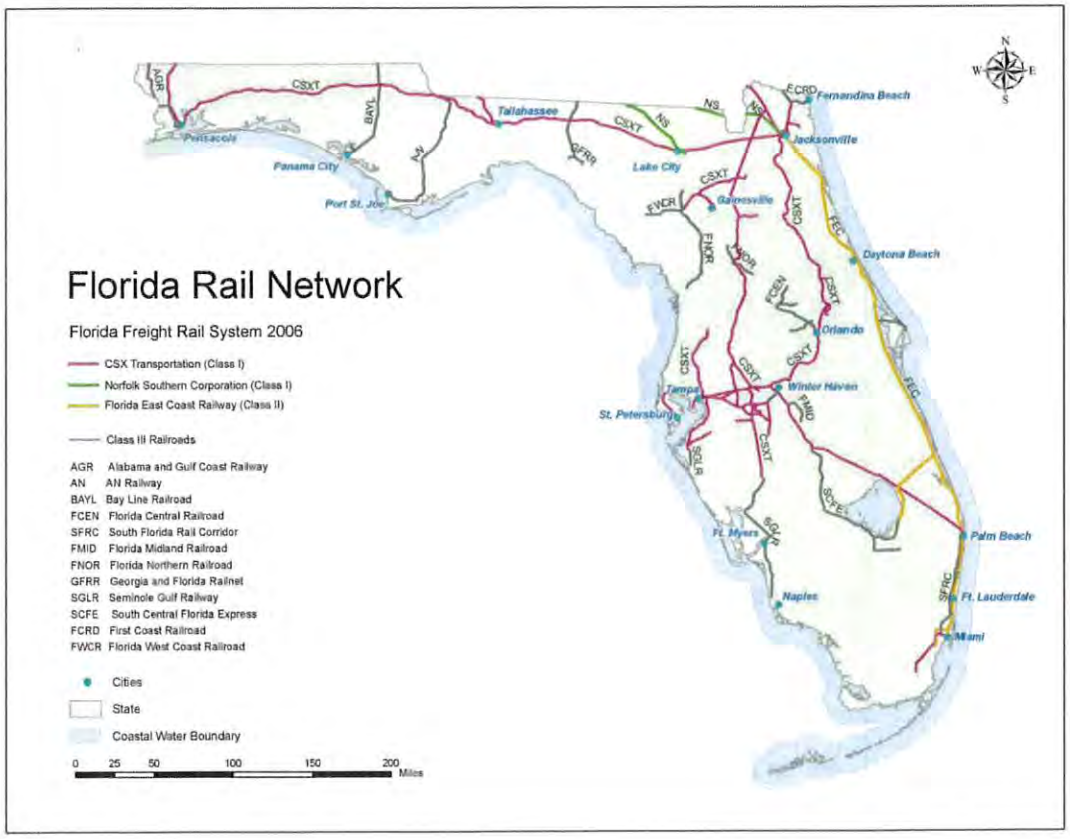
[212] https://www.phmsa.dot.gov/about/mission
[213] https://s3images.americangeosciences.org/agi/statefactsheets/FL_GeoscienceInYourState_AGI.pdf

Freight Rail

Recognizing the increasing demand for rail services and the importance of rail in the state's overall mobility, Florida has been one of the nationwide leaders in promoting public-private partnerships and supporting the rail system. Of the 2,908 miles of rail lines in Florida, all but 81 miles are owned by the State's 15 freight railroads and the entire track is controlled by the freight railroads. Freight rail companies are the shippers that depend on rail to transport their goods in the global marketplace, to stock their shelves with the latest products for Florida residents and visitors, and to haul construction materials to keep pace with the rapid population growth.

There are 15 freight railroads operating in Florida. These railroads carried about 1.2 million carloads and 805,260 intermodal units (trailers and containers) and 119 million tons of freight, effectively removing almost six million heavy trucks from the roadways. The map below shows the freight rail companies in the state.

Figure 99: Florida Freight Rail Network



Below are the seven Florida industries which depend on a strong freight rail system. These industries are:[214]

Phosphates and Fertilizers

Mineral deposits in West Central Florida make the state a world leader in the production of phosphate rock. With the exception of Hamilton County in northern Florida, the state's phosphates production is concentrated in Polk, Hillsborough, and Hardee counties. Florida accounts for just over half of the nation's production of phosphate fertilizers. The phosphates and fertilizers produced in Florida are shipped nationwide and to markets throughout the world, with China, India, Australia, and Brazil ranking among the leading foreign destinations.

Distribution and Retail

The distribution and retail trade industry is comprised of several key economic sectors – wholesale trade, retail trade, and transportation and warehousing. Florida's distribution and retail trade industry depends on the efficient movement of goods to keep costs down and to remain competitive. Rail is crucial for long hauls that bring goods into the state from distribution hubs such as Chicago, Atlanta, and Dallas-Fort Worth, as well as from more distant gateways, including the west coast ports which are the leading point of entry for consumer items entering the United States from Asia.

Food and Agriculture

Rail plays a crucial role in Florida's food and agriculture industries. Perhaps the most famous freight rail shipments are the Tropicana "Orange Juice Trains," originating in Bradenton and Fort Pierce. The railcars are specially designed refrigerated boxcars, each capable of carrying four truckloads worth of product. Rail also plays a critical role in allowing Florida sugar to compete against foreign imports. U.S. Sugar uses rail to haul sugar cane from the fields into the processing plants.

Paper and Fiber

Much of Florida's Panhandle is forested, lying within the yellow pine growing region that stretches from East Texas to Georgia, one of the country's most prodigious areas for forestry. As such, Florida has a substantial paper and fiber industry that has been one of the pillars of the North Florida economy for decades. Rail remains popular for long hauls following the processing of timber into paper and wood products and also as the best option for hauling lumber long distances.

Automotive Distribution

The expanding population stimulates demand for retail sales of automobiles while the millions of tourists visiting the state on an annual basis depend on rental cars for mobility. The combination of retail sales and rental cars makes Florida the second largest market for new vehicles in the country, only surpassed by the much more populous state of California. Whether new or used, meeting Floridians demand for vehicles requires thousands of truck and rail trips annually as part of a system to transport vehicles to dealers and wholesalers

[214] http://www.fdot.gov/rail/Publications/Plans/2006/flrail06.pdf

Energy

The transport of fuels (i.e., coal and petroleum) by rail is one of the leading inputs in the energy industry. Rail, joined by coal and petroleum commodity purchases, construction, and business services is a principal cost factor in electricity production that affects the overall price of energy. Rail is the primary mode of transportation to bring coal into Florida.

Construction

Rail is involved in the movement of many of the materials essential to the Florida construction industry, including metals, lumber, and cement. The largest tonnages though are for movement of aggregate rock such as crushed limestone from the Miami-Dade area to construction markets in Orlando, Jacksonville, and out-of-state markets.

Postal and Shipping

Postal and Shipping in the United States moves roughly 720 million letters and packages each day and includes large integrated carriers, regional and local courier services, mail services, mail management firms, and chartered and delivery services.

The United States Postal Service delivers more mail to more addresses in a larger geographical area than any other post in the world. The Postal Service delivers to more than 156 million addresses in every state, city and town in the country. Everyone living in the United States and its territories has access to postal products and services and pays the same for a First-Class postage stamp regardless of their location.

Frequency

This hazard was determined to occur annually, giving it a Frequency ranking of Very Likely.

Magnitude

This hazards Injuries and Deaths Magnitude was determined to be High, meaning any deaths are recorded.

This hazards Infrastructure Magnitude was determined to be Medium, meaning significant damage to property occurs.

This hazards Environment Magnitude was determined to be Medium, meaning some damage to the environment occurs.

Climate Change and Transportation Infrastructure

A changing climate can modify the types and quantity of food we eat, where we live, the types of available jobs, and how people and goods move. The transportation infrastructure has potential vulnerabilities to rising sea levels, rising temperatures, more intense storms, and extreme drought. The table summarizes climate change factors and the effects they could have on transportation infrastructure.[215]

[215] https://ntl.bts.gov/lib/52000/52800/52855/Transportation_System_Resilience_Extreme_Weather_and_Climate_Change.pdf

Table 56: Transportation Infrastructure Climate Change Impacts

Climate Change Factor	Transportation Effect
Increased storm frequency and severity • Higher drought probability • More extreme precipitation	• Maintenance costs will rise • Costs for erosion and flood control prevention will rise
Change in ocean temperature • Loss of ocean protection from storm surge and damage • Coral reef damage and losses	• Coastal infrastructure will be more vulnerable to extreme and severe weather events • Reduction in commercial fishing
Rising temperatures • More days with temperatures above 95 degrees • Increased risk of wildfire	• Transportation infrastructure degrading • Increased maintenance costs • Increased energy costs for transportation facilities
Rising sea levels and storm surges • Reduced amount of protective barrier islands and coastal wetlands • Loss of coastal land	• Coastal infrastructure degrading • Impacts to supply chains • Rail and road infrastructure damage

2. Geographic Areas Affected by Transportation Incidents

Transportation incidents can occur anywhere within the State of Florida. Areas of high traffic are particularly vulnerable to transportation hazards. Large urban areas with large populations and different forms of transportation are considered high traffic areas, meaning the risk is elevated. Due to the large number of railways, roadways, airports, pipelines, and seaports, the entire State of Florida is at risk for transportation hazards. These hazards also involve the transportation of hazardous materials which carry their own risks and can be found in the *Hazardous Materials Incidents Profile* on page 338.

3. Historical Occurrences of Transportation Incident

Due to the vast number of transportation routes, transportation incidents are fairly common. Below are some of the major incidents that have occurred in Florida.

The ValuJet crash in the Everglades in May 1996 is an example of how a mass casualty incident can overtax the resources of even the largest and most urbanized local government within the state. Shortly after takeoff from the Miami airport, a fire broke out on the plane due to the unsafe handling procedures of hazardous canisters. After attempting to turn back, the plane crashed into the muck in the Everglades, killing all 110 people on board. The first responders had difficulties reaching the crash site due to the remote location and hazardous conditions and spent days working to retrieve evidence.[216]

In April 2002, an Amtrak train derailed carrying 468 passengers near Jacksonville, Florida. Of the many cars, 21 derailed and flipped, killing 6 people, critically injuring more than 100, and trapping dozens more.

[216] Gabino, H. (2016, May 11). The Day A Plane With 110 People Disappeared In The Everglades. The Miami Herald. Retrieved from http://www.miamiherald.com/news/local/community/miami-dade/article76767282.html

The State Emergency Response Team (SERT) worked with local rescue efforts to free passengers and clear the tracks.[217]

In January 2012, an automobile pileup on I-75 in Alachua County left 11 people dead and 21 injured. The cause of the early morning crash was attributed to dense fog and smoke from a nearby marsh fire. The decreased visibility led to a crash involving over a dozen cars and six tractor trailers and closed I-75 north and southbound for hours. First responders worked tirelessly to reach victims and survivors whose vehicles were spread over a mile down the highway.[218]

In May 2017, a 22 foot private vessel travelling off the coast of Dania Beach took on water and capsized. Two people on board were killed and one was rescued from the water. The local Coast Guard and rescue officials heard the call of a boat in distress and immediately were deployed. Private vessel accidents are common along the Florida coast for a multitude of reasons including inebriation, operator error, and system malfunction.

4. Probability of Future Transportation Incident

There is no sure way to predict future transportation incidents as most typically occur without warning. The probability of a major transportation event in the State of Florida is perceived to be high. The Florida Department of Transportation (FDOT) is part of an ongoing assessment of the state's vulnerability and coordinates efforts to prepare for, prevent, mitigate, respond to, and recover from transportation events that affect the state. In coordination with other transportation agencies such as the FAA, PHMSA, USCG, and CBP, FDOT ensures the safe travel and transportation of people and goods throughout the state.

This hazard was determined to occur annually, giving it a Probability of Very Likely.

5. Transportation Incident Impact Analysis

- Public
  - Mass casualties.
  - Injury or death.
  - Delays.
- Responders
  - Danger in reaching victims/survivors.
  - Injury or death during rescue efforts.
- Continuity of Operations (including continued delivery of services)
  - Normal transportation operations may not return to return to normal for a significant time due to repairs.
  - Goods cannot be delivered or accepted.
- Property, Facilities, Infrastructure

[217] Six Die As U.S. Train Derails. (n.d.). Retrieved from The Daily Mail website: http://www.dailymail.co.uk/news/article-110476/Six-die-US-train-derails.html

[218] Stutzman, R., & Jacobson, S. (2012, January 31). Florida's Deadley Pileup: Death Toll Raised to 11 As New Victim Found In Truck. The Orlando Sentinel. Retrieved from http://articles.orlandosentinel.com/2012-01-31/news/os-florida-highway-deaths-killed-i-75-20120130_1_deadly-pileup-smoke-and-fog-first-crash

  - Potential damage to infrastructure and public transportation programs
  - Shutting down affected highways, railways, airports, etc.
- Environment
  - Hazardous material spills
  - Pipeline burst/leak
- Economic Condition
  - Cost for repairs and down time.
  - Could cause loss in revenue or wages.
    - Loss in shipping revenues.
    - Loss of tourism.
- Public Confidence in Jurisdiction's Governance
  - Citizens may lose trust in particular public transportation services.
  - Tourists may reconsider visiting Florida.

6. 2018 LMS Integration

The following counties profile Transportation Incidents:

- Brevard
- Collier
- Glades
- Hendry
- Indian River
- Lee
- Leon
- Martin
- Osceola
- Palm Beach
- Pinellas
- Seminole

7. Vulnerability Analysis and Loss Estimation, by Jurisdiction

Due to the nature and unpredictability of technological hazards, all property and infrastructure in the State of Florida is at risk to these events. Large counties and those with significant tourism are particularly at risk. Counties with large transportation hubs such as airports or ports are also at a higher risk.

8. Vulnerability Analysis and Loss Estimation of State Facilities

Due to the nature and unpredictability of technological hazards, all property and infrastructure in the State of Florida is at risk to these events. Large transportation hubs such as airports or ports are at a higher risk.

Though Florida recognizes that state facilities are vulnerable to transportation incidents, there is a lack of data to quantify the vulnerability of facilities to these hazards compared to natural hazards.

9. Overall Vulnerability

Each category was given a number and when all 5 categories are added together, the overall vulnerability is a number between 5 and 15.

Based on the Frequency, Probability, and Magnitude summary, the Overall Vulnerability of this hazard was determined to be High, with a score of 13.

<table>
<tr><th colspan="4">TRANSPORTATION INCIDENTS</th><th rowspan="2">Overall Vulnerability</th></tr>
<tr><th colspan="4">Overview</th></tr>
<tr><td colspan="4">Transportation systems are designed to move people, goods, and services efficiently, economically, and safely from one point to another. As the movement of people, goods, and services increases due to population growth and technological innovation, the need to plan for events becomes increasingly important. Florida has a large transportation network that consists of airports, major highways, passenger railroads, marine ports, and pipelines. These transportation systems provide lifeline services for communities and are vitally important for response and recovery operations. The vast network of public and private critical infrastructure owners and operators, the infrastructure and services they manage, and the extensive interdependencies among the transportation modes and other sectors indicate the need for coordinated planning to manage all hazards efficiently and effectively.</td><td rowspan="4">HIGH</td></tr>
<tr><th rowspan="2">Frequency</th><th rowspan="2">Probability</th><th colspan="3">Magnitude</th></tr>
<tr><th>Injuries/Deaths</th><th>Infrastructure</th><th>Environment</th></tr>
<tr><td>Very Likely</td><td>Very Likely</td><td>High</td><td>Medium</td><td>Medium</td></tr>
</table>

Cyber Incident Hazard Profile

1. Cyber Incident Description

Cyber incidents are becoming more common and more costly in our society. Because of this, Cyber Incidents will be profiled as a hazard to the state of Florida. The word Cyber refers to anything that contains, is connected to, or controlled by computers and computer networks. A computer is a machine that can take instructions and perform computations based on those instructions. Cyber technology refers to the computers and computer networks and the information and services we rely upon. For example, critical infrastructure relies on such computers and the Internet. Critical infrastructure includes sectors such as communications, energy, financial services, health care, transportation, and water and wastewater systems, among others. A Cyber Incident then, refers to an incident involving computers, networks, and information or services that affect daily operations of critical infrastructure.

A Cyber Incident differs from traditional hazards such as a flood, which makes it difficult to plan for, respond to, recover from, and mitigate against. For example, there is often a lack of physical presence or evidence of a cyber-incident, making it difficult to understand the scope of the incident. Furthermore, the scope will likely cross municipal jurisdictions because of the nature of cyber technology. There are also fewer resources for cyber incidents due to a lack of awareness and knowledge of the cyber threat.[219]

Cyber Threat refers to the possibility of a malicious attempt to damage or disrupt a computer network or system.[220] This is a global threat because of the nature of cyber technology and the wide scope of cyber incidents. In fact, in 2013 the United States intelligence community assessed cyber threats as the top global threat, followed by terrorism.[221]

This makes it clear that cybersecurity is directly linked to our national defense.[222] According to DHS's National Infrastructure Protection Plan (NIPP), cybersecurity is defined as the

> *"prevention of damage to, unauthorized use of, or exploitation of, and if needed, the restoration of electronic information and communication systems and the information contained therein to ensure confidentiality, integrity, and availability; includ(ing) protection, restoration, when needed, of information networks and wireline, wireless, satellite, public safety answering points, and 911 communications systems and control systems."* [223]

Put more simply, cybersecurity is protecting the machines connected to networks and the Internet and the information stored, accessed, or transmitted. A cybersecurity incident then, refers to a data breach. A data breach is when a name plus another record (i.e. financial, medical, credit card) is put at risk, either electronically or in a hard copy.

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[219] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 2.7 – 2.8
[220] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136*. Page 2.4
[221] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136*. Page 2.4
[222] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136*. Page 1.12
[223] https://www.dhs.gov/sites/default/files/publications/national-infrastructure-protection-plan-2013-508.pdf

There are many causes of a data breach or a cyber-incident. A cyber incident could be a malicious attack or it could stem from a system glitch or human error. In 2014, the average cost of a data breach to an organization in the United States was $6.53 million.[224] With so much at stake, it is important to be prepared for a cyber-incident. Cyber Preparedness is defined as the process of ensuring that an agency has developed, tested, and validated its capability to protect against, prevent, mitigate, respond to and recover from a significant cyber incident.[225]

Though a cyber-incident is different than traditional hazards, all phases of emergency management are still applicable. For instance, Mitigation, Prevention, and Preparedness occur before a cyber-incident happens, by implementing policies and increasing awareness. Response is attempting to stop the cyber incident or a data breach. Recovery, and sometimes Mitigation, are after the cyber incident and involve restoring networks, replacing damaged equipment, and eliminating vulnerabilities that allowed the breach.[226]

Cyber Attacks

Some cyber incidents are cyber-attacks, meaning they have a malicious intent. The most significant risk for exposure to attack stems from human error. Any computer system that is accessible from the Internet is a potential target. The goal of a cyber-attack is the theft of proprietary, personal, or financial information. Additionally, cyber warfare and cyber espionage, carried out by other nation states, are possible goals in today's society.[227]

There are three levels of cyber-attacks: unstructured, structured, and highly structured.

Unstructured attacks have little to no organization and no significant funding. These are usually carried out by amateurs who use pre-made tools to take advantage of well-known flaws. These pre-made tools are easily downloadable from the Internet. These attacks are the most common type of threat but they are also easily spotted by network security.[228]

Structured attacks involve more organization and planning and have decent financial backing. These attacks also have specific targets and are intended to disrupt operations to a specific organization or sector. Additionally, these attacks are conducted over long periods of time to avoid detection. The impacts from a structured attack can range from minimal to significant. Potential perpetrators include insider threats, like a disgruntled employee; industrial competitors, like rivals stealing company secrets; organized crime groups, like Columbian drug traffickers; hacktivists motivated by a specific cause, like Anonymous; or blackmail and ransom hackers, using extortion to receive money.[229]

Highly structured attacks involve extensive organization, planning and funding. Attackers conduct reconnaissance and then use multiple attacks to achieve their goal. Sometimes these attacks even include

[224] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 1.25
[225] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.4
[226] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 2.29 – 2.31
[227] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 1.12
[228] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.7 – 2.13
[229] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.14 – 2.23

physical attacks along with a cyber-attack. Possible attackers conducting highly structured attacks include ideological groups, cyber terrorists, and nation states.[230]

Malware

Cyber-attacks are conducted using different types of malware. Malware is *mal*icious soft*ware* that can infect a computer or network and cause harm. Malware can destroy all data, damage networks, or steal information. Malware must be introduced to a computer or network using methods such as removable media, phishing, and drive by downloads. This can be completed using tools such as a virus, worm, trojan, or adware.[231]

A Virus spreads malicious code by copying itself and infecting host computers through downloads, email attachments, or removable media. The virus then corrupts or deletes data on your computer or erases the hard drive.

A Worm is a malicious computer program that replicates itself to spread to other computers. It relies on security failures and utilizes the computer network to spread itself. Worms can cause harm to the network, consume bandwidth, install backdoors (for access later), and allow the creation of botnets.

A Trojan is a malicious program that is disguised as legitimate software. It looks useful to an unsuspecting user but is actually harmful when executed. After installed, the trojan waits silently on the infected machine and invisibly carries out its misdeeds with remote administration capabilities. Trojans can control the mouse and keyboard, format drives, log keystrokes, play sounds, record sound and video, and use the Internet connection to perform Denial of Service attacks. [232]

Methods

Attackers use several methods to complete their goals. The following will be discussed here: social engineering, botnets, Denial of Service (DoS), Zero day exploits, Web-based, malicious insider, and unintentional actions or errors.

Social engineering is a very common method to conduct attacks that involves manipulating legitimate users and convincing them to perform actions or give confidential information using email, phone, in person encounters, dumpster diving, or insider threats. People are often the weakest link in the cyber security chain and social engineering takes advantage of that. There are several types of social engineering but phishing is one of the most common. Phishing is when an attacker sends an email that appears to originate from a legitimate source, such as a bank, advising that verification of account information is needed immediately to prevent serious consequences. The email usually contains a link to a fraudulent website with a form for customers to enter their information. Similarly, spear phishing is when an attacker sends a phishing email to a specific organization or person. Whaling is when attackers attempt to spear phish a high priority target, such as a CEO.[233]

Botnets are another method to conduct an attack. A "bot" is malware that allows attackers to take control of the computer. A "botnet" then, is a ro*bot net*work of infected computers used to conduct malicious

[230] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.23
[231] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.10 – 2.12
[232] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.32 – 2.33
[233] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.38 – 2.40

activities. A botnet is created when one bot infects several computers and then networks them together. Botnets can be used for Denial of Service attacks, malware distribution, and covert intelligence gathering. Owners of computers that are part of a botnet often have no idea their computer has been compromised. A botnet can include thousands or millions of bots and may remain quietly operational for years. This method is successful because it distributes the activities to several computers, making it more difficult to track and block.[234]

Denial of Service attacks are simply what they sound like, the attackers attempt to prevent legitimate users from accessing information or services of a computer system or network by overwhelming the system with more traffic than it can handle. When you type an address into your web browser, you are sending a request to that site's computer server to view the page. The server can only process a certain number of requests at one time, so when it is overloaded, the website does not work. A Denial of Service (DoS) attack occurs when an attacker overwhelms the server with false requests so that the server cannot process the legitimate requests. A Distributed DoS or DDoS attack occurs when attackers use multiple computers and multiple Internet connections to conduct the attack. This greatly increases the magnitude of false requests that can be sent, meaning a larger DDoS attack. Attackers sometimes use botnets, as discussed above, to carry out DDoS attacks. These types of attacks can be used against a wide variety of targets, from retail websites to nation states.[235]

A Zero Day Exploit is an attack that takes advantage of a security risk on the same day that the risk becomes known to the public. Because there is no known solution to the risk yet, attackers are able to conduct attacks without being stopped. These exploits can be purchased from those who find these security risks and choose not to report to them to the company, but rather sell the information to would-be attackers. Attacks such as these have been used to target programs like Microsoft Word, PowerPoint, Excel, Adobe, and Flash Player.[236]

Web-based attacks involve websites redirecting the browser to a malicious website where malicious software downloads to the computer. These attacks are known as drive by downloads and involve malicious code downloading in the background of a computer just from visiting a certain site, without clicking on anything. These attacks require no action from the target and they often have no idea their computer has been infected.

Another method is to use a Malicious Insider to conduct an attack. A malicious insider is a person with special advantage, influence, or proprietary knowledge, and uses it for malicious intent. These could be current or former employees, or even contractors or vendors. Malicious insiders risk the theft of confidential information and the sabotage of systems.

As stated earlier, humans are the weakest link in cyber security. Unintentional actions or errors can provide an opportunity for attackers to steal information and gain unauthorized access. For example, unintentional acts or failures directly compromise the security of a computer network or a resource

[234] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 1.34 – 1.35
[235] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.20; FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 2.36 – 2.37
[236] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 2.22

dependent on the network. This includes not properly updating software or a network and the failure to remove or change system permissions after personnel changes.[237]

Vulnerabilities

Because our society is increasingly reliant upon cyber technology and the Internet, new vulnerabilities are presenting themselves. There are vulnerabilities at the personal, local and national scale. For example, an individual person may have their identity stolen. Additionally, hackers may take a local 911 system offline for an extended period of time. Finally, there could be a multi-state power outage or a hack of a large company that affects many across the nation, such as the Yahoo or Target breaches.

More specifically, critical infrastructure often relies upon cyber technology and the Internet, making critical infrastructure vulnerable to cyber incidents. Additionally, many critical infrastructure systems are interconnected, so even if a particular critical sector is not reliant upon cyber technology, it may be reliant upon a critical sector that is reliant upon cyber technology. These possible cascading impacts are very important to consider when planning for hazard mitigation. This can be complicated though, as not all critical infrastructure sectors are controlled by the government, some include privately owned companies, like a private energy company, financial institution, or hospital. Sometimes the priorities of privately owned organizations differ from those of the government. For example, while the government is concerned with protecting all critical infrastructure from cyber-attacks, these privately owned organizations may be more concerned with profits or public reputation. Furthermore, the interconnectivity of sectors expands the scope from one geographical area to large regional areas that likely cross political jurisdictions, making planning more complicated.[238]

Another vulnerability is that the Internet was designed with efficiency and access concerns, not specifically with security considerations. Now that cyber technology and Internet capabilities have expanded, vulnerabilities are appearing. For example, many critical infrastructure systems are controlled remotely using systems called Supervisory Control and Data Acquisition (SCADA) or Distributed Control Systems (DCS). These systems are used to manipulate functions and services of systems remotely so people do not have to deploy to sites in the field where equipment is located, but can instead alter systems, like adjusting pressure or flow, from their offices.[239] This is a concern because these systems can be hacked and controlled by enemies.

SHODAN is a search engine to find Internet connected devices. From 2012 to 2014, a research project to increase awareness of the vulnerabilities, Project SHINE, attempted to find SCADA and DCS systems. The project found hundreds of thousands of SCADA and DCS devices and systems. When the project ended in 2014, it wasn't because they had found all the devices, it was because they saw no end in sight with hundreds and sometimes thousands of devices being added every day.

Some of these devices and connections are not secure, meaning they can be hacked. Policies and procedures need to be adopted by all critical infrastructure sectors using Internet connected devices. Many times owners keep the default username and password, which are very easy to hack. The Project SHINE report concluded that critical infrastructure and cyber security professionals must not continue to

[237] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 2.40 – 2.43
[238] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 1.15 – 1.16
[239] FEMA. (2016). *Essentials of Community Cybersecurity AWR 136.* Page 1.12

use "compliance-based security," but focus on an "attitude of safety, vigilance, and performance awareness."[240]

Cybersecurity and Cyber Preparedness

Presidential Policy Directive (PPD) 8 aimed at strengthening the security and resilience of the US through systematic preparation for the threats that pose the greatest risk to the security of the Nation, including acts of terrorism, cyber-attacks, pandemics, and catastrophic natural disasters.[241]

PPD 41 gives principles for the Federal Government response to any cyber incident. It also recognizes that cyber incidents are occurring more frequently and that responding to cyber incidents that pose a significant threat requires deliberative planning, coordination and exercising of the response plan.[242]

The US also has a National Cyber Incident Response Plan that was published in December 2016 after PPD 41 was issued, detailing the response activities and responsibilities of federal agencies during a significant cyber incident.[243]

The State of Florida has several cyber security mechanisms. One is the Florida Computer Crime Center (FC3), which conducts cyber investigations, trainings, research, and prevention. The FC3 also developed the Florida Infrastructure Protection Center (FIPC) to anticipate, prevent, react to, and recover from acts of terrorism, sabotage, and cyber crime. There are three components to the FIPC: the "Secure Florida" Education and Awareness campaign, the Central Analysis and Warning Point to monitor and analyze information, and the Computer Incident Response Team (CIRT). The CIRT is always on-call to respond to critical cyber incidents in Florida.[244]

The Florida Infrastructure Protection Center (FIPC) has evolved into a group of services, which range from investigations, awareness training, intelligence, and domestic security. All FDLE regions have sworn agents that conduct high-tech investigations into computer crimes. Additionally, FDLE has strong cyber intelligence efforts within the Cyber Intelligence Unit and the Domestic Security Critical Infrastructure Unit is expanding as well. The Secure Florida group within the FIPC conducts business and consumer education awareness and efforts.

The Computer Incident Response Teams (CIRT) are used in two ways. For example, an individual criminal incident, such as the unauthorized access into a computer system and theft of data, are investigated as criminal cases by the Regional Network Intrusion Unit or the Cyber Crime Unit. Larger scale cyber incidents, such as those that affect several organizations and systems within Florida's critical infrastructure system, are investigated by the Domestic Security Working Group, which is composed of several agencies including AST, the FBI, the Florida National Guard, FDEM, and other stakeholders.

Additionally, the Agency for State Technology (AST)[245] developed a Statewide Strategic Information Technology Security Plan. This plan is designed to ensure state data is secure and outlines their roadmap

[240] https://scadahacker.com/library/Documents/ICS_Vulnerabilities/Infracritical%20-%20Project%20SHINE%20Findings%20Report%20-%20Oct%202014.pdf
[241] https://www.dhs.gov/presidential-policy-directive-8-national-preparedness
[242] https://fas.org/irp/offdocs/ppd/ppd-41.html
[243] https://www.us-cert.gov/sites/default/files/ncirp/National_Cyber_Incident_Response_Plan.pdf
[244] http://www.fdle.state.fl.us/cms/FCCC/About-Us.aspx)
[245] http://www.ast.myflorida.com/publications.asp

to continually enhance cybersecurity and operational effectiveness. The key to the AST information security strategy is the protection of the confidentiality, integrity, and availability of the state's IT resources. The plan lists three strategies:

1) Establish a strong cybersecurity framework, improve situational awareness to empower information security personnel, and cultivate partnerships for response efforts;

2) Establish objectives for assessing and enhancing the state's data center infrastructure; and

3) Establish objectives for project assurance and oversight and promote strategic business alignment by collaborating with state agencies to understand and support their mission-specific strategies.

AST has accomplished several goals since they were created in 2014, including creating the Florida Cybersecurity Standards Security Rule in the Florida Administrative Code (74-2, FAC).[246]

Finally, the Florida Division of Emergency Management has a Cyber Incident Plan that details policies and procedures in the event of a cyber-incident within the Division.

The National Institute of Standards and Technology (NIST) has developed the Cybersecurity Framework, which promotes the protection of critical infrastructure through standards, guidelines, and practices for organizations to adopt. The framework is designed to work with existing business processes and to improve existing cybersecurity efforts.

The core functions of the framework follow along with the phases of emergency management. For example, the first two core functions are Identify and Protect, which are similar to Mitigation and Preparedness. In the framework, Identify means naming the risk and then removing the behavior creating the risk. This is completed by implementing policies and procedures to reduce, remove, or transfer risk. Protect refers to protecting data from unauthorized disclosure by authenticating access, promoting information security, implementing business continuity plans, and insuring confidentiality of data.[247] More information about the NIST Cybersecurity Framework can be found at: link.com.

There are many resources for agencies and organizations to develop a cybersecurity program. Some are outlined below.

US Computer Emergency Response Team (US-CERT) was created in the early 2000's in response to cyber breaches in federal government. The team responds to incidents and analyzes data about emerging cyber threats. Additionally, the team provides cybersecurity protection to Federal civilian executive branch agencies through intrusion detection and prevention capabilities. They also collaborate with foreign governments and international entities to enhance the nation's cybersecurity posture. US-CERT also has a scoring system to determine risk and priority in a national context, which can be viewed online[248].

The FBI has a Cyber Crime division and is the lead federal agency for investigating cyber-attacks by criminals, overseas adversaries, and terrorists. According to the FBI, cyber intrusions are becoming more common and dangerous, especially considering that our nation's critical infrastructure is targeted. The FBI

[246] https://www.flrules.org/gateway/ChapterHome.asp?Chapter=74-2
[247] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 1.38 – 1.43
[248] https://www.us-cert.gov/sites/default/files/publications/NCCIC_Cyber_Incident_Scoring_System.pdf

also has the Internet Crime Complaint Center to report cyber crimes and the Cyber Action Team which provides rapid incident response for major computer intrusions and other cyber related emergencies.

Infraguard is a partnership between the FBI and the private sector to share information and intelligence to prevent hostile acts against the US. Florida has several chapters including Jacksonville, Orlando, South Florida, Tallahassee, and Tampa Bay.[249]

Individuals can report identify theft to the Federal Trade Commission here: https://www.ftc.gov/.

The National Cyber Security Alliance has created the StaySafeOnline.org website with resources for individuals and businesses.[250]

NetSmartz is a resource for children to learn about different types of cyber crime and cybersecurity.[251]

Frequency

This hazard was determined to occur annually, giving it a Frequency ranking of Very Likely.

Magnitude

This hazards Injuries and Deaths Magnitude was determined to be High, meaning any deaths are recorded.

This hazards Infrastructure Magnitude was determined to be Medium, meaning significant damage to property occurs.

This hazards Environment Magnitude was determined to be Low, meaning little to no damage to the environment occurs.

2. Geographic Areas Affected by Cyber Incidents

Because cyber incidents occur in "cyber space," there are not always geographic areas affected by cyber incidents. However, cyber incidents may cause physical disruptions in critical infrastructure, which could affect a jurisdiction or a power grid. It is important to note that power grids are vast, sometimes crossing state lines, meaning that a cyber incident at one facility at one location could cause disruptions at other locations hundreds of miles away.

3. Historical Occurrences of Cyber Incidents

Table 56: Florida Historical Occurrences, Cyber Incidents, 2007-2017

Date	Location	Description
2007	Estonia	Dispute regarding the movement of a Russian statute led to a cyber-attack that crippled websites for government services, banks, media outlets, etc. (FEMA AWR 136-22)
2010	Iran	US agents introduced Stuxnet, a worm, to Iranian industrial sites including a uranium enrichment facility. The worm caused subtle increases in pressure

[249] infraguard.org
[250] staysafeonline.org
[251] netsmartz.org

		on spinning centrifuges while displaying normal readings in the control room. This led to the destruction of one of the five Iranian nuclear centrifuges. (FEMA AWR 136, 2-25; FEMA MGT 384, 2-32-33)
2011	Cyberspace	Twitter accounts of several news stations were hacked. The hackers tweeted false news reports. (FEMA AWR 136, 2-8)
2011	United States and Russia	A water treatment facility worker was on vacation in Russia when he remotely accessed the facility system to check on operations. The IT staff at the facility thought they were under attack from Russian hackers. (FEMA AWR 136, 1-12)
2011	Orlando, Florida	City of Orlando was targeted by the hacktivist group Anonymous because non-profit workers were arrested for distributing food without permits. (FEMA MGT 384, 1-30)
2013	United States	Hackers obtained 40 million credit and debit card numbers, including expiration dates and CCV codes when the retail company Target was attacked. Additionally, 70 million personal records including names, addresses, emails, and phone numbers were stolen. The attack cost credit unions and banks $200 million to re-issue nearly 22 million cards. Target experienced earnings losses and drops in the stock market for several months. (FEMA MGT 384, 1-25, 1-31)
2014	United States	Two Chinese agents were charged with hacking Yahoo and stealing information from at least 500,000 user accounts.
2014	Phoenix, Arizona	The City of Phoenix Internet systems were attacked with a DDoS, disrupting the police department computers. During this time, dispatchers were unable to send information to police officers regarding names, license plates, and criminal records. (FEMA MGT 384, 2-36-37)
2015	Panama City, Florida; global	An anonymous source leaked 11.5 million documents from a law firm in Panama City. The documents detailed financial and attorney-client information for more than 200,000 offshore entities. When reporters searched through the information, it was discovered that the law firm had been involved in illegal actions, including fraud and tax evasion. [252]
2016	Sarasota, Florida	A ransomware virus on the Sarasota City Hall computer systems encrypted 160,000 files and demanded $33 million in Bitcoins to unlock them. The IT staff quickly shut down the system, which saved the city from catastrophic data loss and financial costs, and the attack was contained within a few hours.[253]
2017	Florida	A cyber-attack on a server used to administer Florida Standard Assessments prevented students from testing. It also made clear that the student and employee information may not be safe. [254]

[252] Bloomberg, J. (2016, April 21). Cybersecurity Lessons Learned From 'Panama Papers' Breach. Retrieved from Forbes website: https://www.forbes.com/sites/jasonbloomberg/2016/04/21/cybersecurity-lessons-learned-from-panama-papers-breach/#3a353ae2003f

[253] Murdock, Z. (2017, July 28). The City of Sarasota, A Ransomware Attack, ISIS and the FBI. Herald-Tribune. Retrieved from http://www.heraldtribune.com/news/20170728/city-of-sarasota-ransomware-attack-isis-and-fbi

[254] http://www.fldoe.org/newsroom/latest-news/2010319-fdle-investigating-cyber-attacks-against-fsa-testing-system-.stml

2017	Global	Several ransomware attacks, called WannaCry and Petya, affected companies and organizations globally. The malware spread very quickly and encrypted files and demanded the user pay $300 in Bitcoins to unlock the files.

Undated and Widespread:

- A virus called "Sobig" infected the computer system at CSX Corp's Jacksonville, Florida headquarters. It shut down signaling, dispatching, and other systems and affected 23 states east of the Mississippi River.[255]
- Facebook was used in a phishing hack where victims would respond to an email asking for them to click on a link to their Facebook account. When they clicked the link, they were taken to a fake webpage and prompted to enter their account information. Hackers then took over their accounts and sent messages to friends asking for money via Western Union stating they had been robbed.[256]
- A disgruntled employee of a contractor that supplied IT and control system technology for the sewage system in Maroochy Shire Queensland, Australia used his insider knowledge of the sewage system to issue commands. This led to 800,000 liters of raw sewage spilling into local parks, rivers, and the grounds of a hotel. The effects included marine life dying, water turning black, and a stench that was unbearable for the residents.[257]
- Melbourne, Australia's Metropolitan ambulance service conducted an upgrade that disabled the service's computer-aided dispatch system for 24 hours. This caused delayed response and duplicate responses.[258]
- The WannaCry ransomware infected computers in 99 countries. This malware encrypted files and demanded $300 in Bitcoins to unlock the files. Computers affected included banks, healthcare facilities, shipping companies, utility companies, etc.[259]

4. Cyber Incident Impact Analysis

- Public
  - Release of sensitive information including bank accounts and social security numbers.
  - Financial loss
    - Possible loss of wages if organization is forced to close.
- Responders
  - Long hours outside of regular work hours to stop and/or remediate attack.

[255] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 2.32 – 2.33
[256] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 2.38 – 2.40
[257] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 2.41 – 2.42
[258] FEMA. (2016). *Community Preparedness for Cyber Incidents MGT 384* (Version 1.1). Page 2.42 – 2.43
[259] http://www.bbc.com/news/technology-39901382

- First responders may not be able to respond properly if a cyber-attack targets emergency or public safety systems.

- Property, Infrastructure, Facilities
  - Incident could lead to damage of equipment for infrastructure.
  - Organization may lose revenue and may have significant costs for remediation, legal fees, and public relations.
  - Organization may lose customer confidence, or may sustain damage to their reputation or to their market share.
- Continuity of Operations (including continued delivery of services)
  - Incident could take operations offline for any amount of time and/or make information inaccessible or distribute false information.
  - Interrupt public safety, etc. services.
  - Loss of productivity.
  - Loss of critical systems or data.
  - May disable emergency or public safety systems.
- Environment
  - An incident could cause a release of some material, which could damage the environment.
- Economic Condition
  - Incidents cost millions of dollars to consumers and organizations, in the form of lost wages, lost revenue, and recovery and remediation costs.
- Public Confidence in Jurisdiction's Governance
  - Lost confidence in ability to keep services operational and safe.
  - Private organization: Loss of public or consumer confidence in an organization leading to loss of market share and possibly loss of future sales.

5. Probability of Future Cyber Incidents

The probability of cyber incidents occurring is increasing every day. Hospitals are highly likely, but so are local jurisdictions and federal and state agencies.

It is estimated that every 40 seconds, a business falls victim to a ransomware attack and it is predicted that attacks will rise to every 14 seconds by 2019.[260]

In 2015, government was among the top five most cyber-attacked industries and that is expected to remain accurate in the future.[261]

According to an Accenture Cyber Crime Cost Study in 2017, the average number of security breaches each year is 130, which is a 27.4% increase in average annual number of security breaches.[262]

[260] https://cybersecurityventures.com/hackerpocalypse-cybercrime-report-2016/
[261] *X-Force Cyber Security Intelligence Index*. (2016). IBM
[262] https://www.accenture.com/t20170926T072837Z__w__/us-en/_acnmedia/PDF-61/Accenture-2017-CostCyberCrimeStudy.pdf

This hazard was determined to occur annually, giving it a Probability of Very Likely.

6. 2018 LMS Cyber Incident Integration

The following counties profile Cyber Incidents in their most recent LMS plan:

- Calhoun
- Duval
- Hillsborough
- Lee
- Miami-Dade
- Osceola
- Seminole
- Volusia

7. Vulnerability Analysis and Loss Estimation by Jurisdiction

Without having access to each county Cyber Incident Plan and the ability to analyze that plan, it is impossible to determine the vulnerability of a jurisdiction. However, it is reasonable to assume that counties and municipalities will continue to be vulnerable to cyber incidents. Any county that utilizes computers and the internet for major utilities, transportation routes, or data storage is vulnerable to a cyber-incident.

Cyber-attacks are very costly and it is expected that from 2017 until 2021, $6 trillion will be spent on cyber crime damages.[263]

Financial impacts on enterprises such as the electronic leakage of data cost an average of $1.9 million in 2017.[264]

The top five cyber attacked industries in 2015 were healthcare, manufacturing, financial services, government, and transportation, and it is believe this trend will continue.[265]

8. Vulnerability Analysis and Loss Estimation of State Facilities

Without having access to each state agency Cyber Incident Plan and the ability to analyze that plan, it is impossible to determine the vulnerability of each state facility. However, it is reasonable to assume that state agencies will continue to be vulnerable to cyber incidents. Any agency that utilizes computers and the internet is vulnerable to a cyber-incident. The State of Florida has a robust Cyber Incident Response plan and team and conducts regular trainings to maintain preparedness for cyber incidents.

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[263] Morgan, S. (2017, December 13). Cyber Attack Surface Facts, Figures and Statistics from 2017 to 2022. Retrieved from CSO website: https://www.csoonline.com/article/3241816/security/cyber-attack-surface-facts-figures-and-statistics-for-2017-to-2022.html

[264] Smith, M. (2017, September 20). Cyber Attacks Cost U.S. #1.3 Million On Average in 2017. Retrieved from CSO website: https://www.csoonline.com/article/3227065/security/cyber-attacks-cost-us-enterprises-13-million-on-average-in-2017.html

[265] *X-Force Cyber Security Intelligence Index*. (2016). IBM

9. Overall Vulnerability

Each category was given a number and when all 5 categories are added together, the overall vulnerability is a number between 5 and 15.

Based on the Frequency, Probability, and Magnitude summary, the Overall Vulnerability of this hazard was determined to be High, with a score of 12.

<table>
<tr><th colspan="5">CYBER INCIDENT</th><th rowspan="2">Overall Vulnerability</th></tr>
<tr><th colspan="5">Overview</th></tr>
<tr><td colspan="5">Cyber incidents are described as involving computers, networks, information, or services that affect daily operations of critical infrastructure. These hazards lack a physical presence as well as physical evidence, making them unlike traditional hazards, and therefore, difficult to plan for, respond to and recover from.</td><td rowspan="3">HIGH</td></tr>
<tr><th rowspan="2">Frequency</th><th rowspan="2">Probability</th><th colspan="3">Magnitude</th></tr>
<tr><th>Injuries/Deaths</th><th>Infrastructure</th><th>Environment</th></tr>
<tr><td>Very Likely</td><td>Very Likely</td><td>High</td><td>Medium</td><td>Low</td></tr>
</table>

Hazardous Materials Incident Hazard Profile

1. Hazardous Materials Description

A hazardous material is any substance that poses a threat to humans, animals, or the environment. Hazardous Materials, commonly referred to as HazMat, refers generally to hazardous substances, petroleum, natural gas, synthetic gas, and acutely toxic chemicals. Hazardous materials are defined and regulated in the United States primarily by laws and regulations administered by the EPA, OSHA, DOT, and the Nuclear Regulatory Commission (NRC).

The Occupational Safety and Health Administration (OSHA) further explains that HazMat is any substance or chemical which is a health hazard or physical hazard, including:

- chemicals which are carcinogens, toxic agents, irritants, corrosives, sensitizers;
- agents which act on the hematopoietic system;
- agents which damage the lungs, skin, eyes, or mucus membranes;
- chemicals which are combustible, explosive, flammable, oxidizers, pyrophorics, unstable-reactive or water-reactive; and
- chemicals which in the course of normal handling, use, or storage may produce or release dusts, gases, fumes, vapors, mists, or smoke which may have any of the previously mentioned characteristics.

Hazardous materials typically fall into one of three categories: Biological Hazards, Chemical Hazards, or Radiological Hazards. All of these HazMats have both short-term and long-term effects based on the timing of detection and the response time to mitigate the effects of the hazard.[266]

Biological Hazards

Biological Hazards are materials or incidents that involve exposure to a biological or living agent that cause harm. These agents include microorganisms, viruses, and any toxins originating from biological sources. Examples of biological hazards include Anthrax, Bloodborne Pathogens, Molds, Ebola, Small Pox, and any medical waste that comes into contact with such microorganisms or viruses. Biological hazards are extremely contagious and pose a threat to any populations that are exposed. For more information on Biological Hazards, please refer to the *Biological Incident Profile* on page 399.

Chemical Hazards

Chemical Hazards are hazards or incidents that involve exposure to chemicals that cause harm. Chemical HazMats include neurotoxins, immune agents, dermatologic agents, carcinogens, and other toxins. Chemical hazards can be introduced to populations through ingestion, inhalation, or physical contact. Chemicals enter the body through the eyes, skin, lungs, and digestive tract. Once in the body, the effect depends on the dosage and toxicity. The type of chemical, how it entered the body and the susceptibility of the individual all effect the outcome of exposure. Once exposed to chemical substances there can be

[266] https://www.ihmm.org/about-ihmm/what-are-hazardous-materials

acute (immediate) or chronic (long-term) health issues for the community. The effects of chemical hazards on an exposed population are not limited to the development of lesions and burns on skin and respiratory issues.

Radiological Hazards

Radiological Hazards are hazards or incidents that involve exposure to materials that have encountered radioactive substances, thus making them contaminated. Exposure to radiological materials have both short-term and long-term effects; some short-term effects include radiation burns and radiation sickness, while long-term effects include radiation poisoning and radiation damage.[267] For more information on Radiological Hazards, please look at the *Radiological Incident Profile* on page 354.

With the passage of the Federal Emergency Planning and Community Right-To-Know Act (EPCRA) in 1986, FDEM began implementation of a statewide Hazardous Materials Emergency Planning Program. For the first time, passage of the EPCRA allowed emergency planners, responders, and the public access to facility-specific information regarding the identification, location, and quantity of particular hazardous materials at fixed sites.

The law requires facilities with certain threshold quantities of federally mandated substances to report annually to state and local emergency officials. In addition, facilities must immediately notify officials of any releases of harmful chemicals that have the potential to result in offsite consequences. This information is utilized to prepare emergency plans for HazMat incidents, to allow responders to receive training based on specific known threats, and to inform and educate the public regarding the chemicals present in their communities. The term Extremely Hazardous Substance (EHS) is used in Title III of the Superfund Amendments and Reauthorization Act of 1986 to refer to those chemicals that could cause serious health effects following short-term exposure from accidental releases. Florida has more than 4,500 fixed facility locations that report the presence of an EHS in federally mandated threshold amounts.

The State Emergency Response Commission (SERC) is responsible for implementing the federal Emergency Planning and Community Right-To-Know Act (EPCRA) provisions in Florida. The SERC, along with the Local Emergency Planning Committees (LEPCs), work to mitigate the effects of a release or spill of hazardous materials by collecting data on the storage of hazardous chemicals above planning quantities. The Technological Hazards Unit at the Florida Division of Emergency Management provides programmatic support for the SERC.[268]

Hazardous Waste

Hazardous waste is unwanted or discarded hazardous materials that may harm the health or wellbeing of people or the environment. As hazardous materials are produced, stored, and used, hazardous waste is created and must be disposed of. A hazardous waste site can be any place, whether a landfill or former industrial facility, where chemicals have made contact with the water, soil, or air. Ensuring that hazardous wastes (HW) are handled in accordance with federal and state rules and laws is the responsibility of the Compliance and Enforcement staff at DEP. This group interacts with the public and with the Resource Conservation and Recovery Act (RCRA) branch of the Federal EPA to develop policies and guidance, to

[267] http://www.floridahealth.gov/environmental-health/chemicals
[268] https://www.floridadisaster.org/hazmat/serc/

provide compliance assistance to the public and the regulated community, and to enforce the laws regulating the handling of hazardous waste.

Due to the unregulated process of dumping hazardous materials and waste, Congress signed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) in 1980. This became known as the "Superfund" Act and gave the Environmental Protection Agency (EPA) authority to clean up hazardous waste sites and spills. The Superfund Program, through the EPA, is responsible for cleaning some of the most contaminated areas in the United States and responds to emergencies involving the environment such as oil spills, hazardous material spills, and hazardous waste sites. To assist with this task the National Priorities List (NPL) was created which tracks the known releases or threatened releases of hazardous substances, pollutants, or contaminants. The NPL has four distinct categories:

- *Proposed* – The site has been contaminated by hazardous waste and is a candidate for cleanup. The site isn't on the list yet.
- *Withdrawn* – The site poses no real or potential threat to the environment or community and was removed from the NPL.
- *Final* – These sites are currently on the list and pose a real or potential threat to the environment or community. The EPA will be part of the cleanup process.
- *Deleted* – These sites have been removed from the NPL because the cleanup goals were accomplished and the area requires no further response.

As of July 2017 Florida has 53 final sites on the NPL and 2 proposed sites.[269]

Hazardous Waste Generators

A generator is any person, organization, or agency who produces a hazardous waste as listed or characterized in Part 261 of Title 40 of the Code of Federal Regulations (CFR). Recognizing that generators produce waste in different quantities, the EPA established 3 categories of generators in the regulations. The volume of hazardous waste each generator produces in a calendar month determines which regulations apply to that generator.[270]

Conditionally Exempt Small Quantity Generators (CESQG's) generate less than 220 pounds per month of hazardous waste or less than 2.2 pounds per month of acutely hazardous waste, such as some pesticides, toxins, or arsenic and cyanide compounds.

Small Quantity Generators (SQG) generate 220 to 2,200 pounds per month and have additional regulations including emergency planning and storage time limits.

Large Quantity Generators (LQG) generate 2,200 pounds or more of hazardous waste per month or 2.2 pounds or more per month of acutely hazardous waste.[271]

[269] http://www.epa.gov/superfund
[270] https://www.epa.gov/hwgenerators/categories-hazardous-waste-generators
[271] https://floridadep.gov/waste/permitting-compliance-assistance/content/hazardous-waste-compliance-and-enforcement

Within the State of Florida there are 17,123 CESQG's, 3,547 SQG's, and 501 LQG's as well as 111 Hazardous Waste Transporters that are regulated and overseen by the Florida Department of Environmental Protection.[272]

Pipelines

There are a total of 34,019 miles of pipeline within Florida. The breakdown of pipeline types are as follows:

- 552 miles Intrastate Natural Gas Transmission
- 4,510 miles Interstate Natural Gas Transmission
- 203 miles Propane
- 80 miles Liquid Hazardous Materials
- 43 miles Oil
- 36 miles Refined Petroleum Products
- 28,567 miles Natural Gas Distribution Systems

Energy pipelines are a fundamentally safe and efficient means of transporting materials key to the U.S. energy supply but, given that they often carry toxic, volatile, or flammable material, energy pipelines have the potential to cause injury and environmental damage.

The Pipeline and Hazardous Materials Safety Administration (PHMSA) identifies "serious" and "significant" pipeline incidents. Serious incidents are those involving a fatality or injury requiring hospitalization. Significant incidents have the following conditions:

a) Fatality or injury requiring hospitalization,
b) $50,000 or more in total costs,
c) Highly volatile liquid releases of five or more barrels or other liquid releases of fifty barrels or more, and
d) Liquid release that results in fire or explosion. PHMSA, as of 2004, does not include gas distribution incidents that are caused by nearby fire or explosion and impacts the pipelines.

According to PHMSA there was 1 natural gas interstate transmission pipeline incident in 2014 with no injuries and 6 significant intrastate distribution pipeline incidents resulting in 2 injuries from 2014 through 2016 in the State of Florida. These incidents resulted in a total of $5,059,988 in property damages involving natural gas distribution systems incidents and $1,494,000 involving an interstate natural gas transmission pipeline.[273]

Historically nationwide, the most common threats to energy pipelines have been accidents and seismic activity; however, more recently, DHS has warned that U.S. natural gas pipelines are targets of cyber-attacks. DHS has been working with critical infrastructure owners and operators in the oil and natural gas sector to address a series of cyber intrusions targeting natural gas pipeline companies. Publically available information does not indicate the extent to which systems have been infiltrated but cyber security officials warn that, with sufficient access, a hacker could potentially "manipulate pressure and other control

[272] https://fldeploc.dep.state.fl.us/www_rcra/reports/handler_sel.asp
[273] http://www.ncsl.org/research/energy/state-gas-pipelines-pipeline-accidents.aspx#Significant_Incidents

system settings, potentially reaping explosions or other dangerous conditions." Additionally, sufficient access could shut down energy transit, significantly disrupting U.S. energy supply.

Within the State of Florida, the Department of Environmental Protection is the lead agency for the Emergency Support Function (ESF) that deals with HazMat and environmental affecting incidents. Florida Fish and Wildlife Conservation Committee (FWC) is an additional supporting agency that assists with HazMat incidents in the event that the material or incident in question is an environmental crime. The Department of Health (DOH) is a supporting agency for radiological incidents as well. The PHMSA is responsible for safety of interstate natural gas transmission lines, propane, and liquid transporting pipelines in Florida. The Florida Public Service Commission is responsible for natural gas safety of intrastate and distribution systems.

811 Call Before You Dig

Pipelines exist almost everywhere throughout the country and Florida has an extensive pipeline and utility grid. One nationwide program that works to mitigate the risks associated with utility or pipeline damage is 811. According to data collected by the Common Ground Alliance (CGA), an underground utility line or pipeline is damaged once every six minutes nationwide. Before digging or excavating, residents or businesses can call 811 to ensure there are no buried utilities or pipelines on the property. Officials will be sent to locate these utilities and pipelines and mark the approximate location. This is a free service and used to ensure residents proceed without damaging any critical utilities or pipelines. [274]

Oil Spill

An oil spill is the release of crude oil, or liquid petroleum, into the environment. This is usually associated with marine spills but can also happen on land. Oil spills are caused by the release of oil from offshore platforms, drilling rigs, tankers, ships that have sunk, and any vehicle used to transport crude oil, over the water or land. These spills have far reaching effects including continued damage to the environment and a financial loss to communities affected.

As of 2017, there are 23 operating rigs in the Gulf of Mexico, 19 drilling for crude oil and 4 drilling for natural gas.[275] While there are currently no drilling rigs on the east coast of Florida, the US Chamber of Commerce predicts that rigs could be seen in the future as exploration estimates roughly 4.72 billion barrels of recoverable oil and 37.51 trillion cubic feet of recoverable natural gas from Maine to Florida.[276] As of 2015, Florida produced 2.2 million barrels of crude oil.[277]

Given Florida's dependence on tourism and the related sales tax revenue, an oil spill, which is classified as a type of HazMat event, could affect any of Florida's many natural resources, which could be catastrophic. In 2015, Florida had over 105 million tourists visit the state, with 14.5% coming from international communities. Tourism generates roughly 23% of the state's sales tax revenue and as of 2014 employs over 1.5 million people.[278] The Florida impacts of the 2010 Deepwater Horizon incident were

[274] http://call811.com/
[275] http://www.wtrg.com/rotaryrigs
[276] Hackbarth, S. (2014, August 13). Will We See Oil Rigs In The Atlantic? Retrieved from U.S. Chamber of Commerce website: https://www.uschamber.com/above-the-fold/will-we-see-oil-rigs-the-atlantic
[277] https://s3images.americangeosciences.org/agi/statefactsheets/FL_GeoscienceInYourState_AGI.pdf
[278] http://www.visitflorida.org

mostly limited and contained, but the predictions at the time of potential impacts were severe. Moody's Analytics released a report which stated, should a significant amount of oil wash onto Florida's shores, the economic impact from tourism-related tax revenue and job losses could rival that of the ongoing recession and simulate a double dip recession. Following the lawsuits, Florida received over 200 million dollars in a settlement for lost tourism income.

In addition to economic impacts, an oil spill in Florida or off its shores could have severe consequences for wildlife, ecosystems, and the ecology. The Deepwater Horizon spill affected the wildlife populations of numerous species of turtles, birds, bottlenose dolphins, whales, and fish. Gulf states saw a decrease in bottlenose reproduction and a rise in deaths, the Kemp's Ridley sea turtle, already endangered, saw a massive drop in numbers, and scientists estimate the habitats on the bottom of the Gulf could take anywhere from multiple decades to hundreds of years to fully recover.[279]

Frequency

This hazard was determined to occur annually, giving it a Frequency ranking of Very Likely.

Magnitude

This hazards Injuries and Deaths Magnitude was determined to be Medium, meaning any injuries, but no deaths are recorded.

This hazards Infrastructure Magnitude was determined to be Medium, meaning significant damage to property occurs.

This hazards Environment Magnitude was determined to be Medium, meaning some damage to the environment occurs.

2. Geographic Areas Affected by Hazardous Materials

Hazardous material incidents can occur during the production, transportation, use, and storage of those hazardous materials and can happen anywhere within the State of Florida. As these materials are processed and stored, those in the immediate vicinity are at risk of toxic fumes, soil contamination, and water contamination. Even those communities removed from production or storage facilities are at risk given that hazardous materials are routinely and frequently transported via roadways, railways, pipelines, and waterways, concluding that all areas of the state are potentially at risk.

[279] http://www.nwf.org

3. Historical Occurrences of Hazardous Materials Incidents

Table 57: Florida Historical Occurrences, Hazardous Material Incidents, 2009-2017

Date	Description
December 15, 2009	Approximately 1,000 gallons of sodium hydroxide was released from a faulty gasket on a pipeline connected to an above ground storage tank at the liquid transfer facility in St. Marks, Florida. The product flowed to an adjacent tidal creek before ultimately releasing some of the product into the St. Marks River. A Unified Command was established between EPA, USCG, DEP, County EMA, DOI and the RP. Response efforts included stabilizing the leaking gasket, sampling the impacted water bodies, conducting water patrols to ensure endangered/threatened species did not enter the area (e.g., manatees, birds, and alligators), damming up the tidal creek and pumping out the majority of the contaminated water (ph12+) from the tidal creek. The contaminated water was transferred to a containment area and was properly treated and disposed of.
May 9, 2009	An east coast railway train consisting of 22 rail cars and 2 locomotives derailed in Palm Coast, Florida. One rail car containing hydrochloric acid (HCL) was breached, resulting in HCL being released into the environment. Response operations concentrated on providing air-monitoring support for worker safety, as well as ensuring the off-loading procedures were conducted in a safe manner.
May 31, 2011	The DEP's Bureau of Emergency Response reported a mercury spill in a residential house in Tampa, Florida. DEP personnel observed at least two ounces of visible mercury within the residence. Mercury vapor readings with windows open in two rooms were 43,000 ng/m3 and 47,000 ng/m3 respectively (Lumex readings). Based on the readings, DEP advised the owners and their children to relocate until the hazards could be mitigated. The source of mercury is unknown and was discovered during home renovation activities.
January 11, 2012	Exposure to an unknown substance on a forest service road overcame two nearby community members. The Lake County HazMat Team conducted field screening of material and identified formaldehyde as a constituent.
July 22, 2012	Kinder Morgan (Central Florida Pipeline) had an ongoing release of refined petroleum product from a 10 inch pipeline. Kinder Morgan shut off the pipeline and responded with state and local response agencies to locate the source and evaluate extent of impact. It was determined that the pipeline failed in a drainage ditch full of water. The ditch flows into a nearby creek which discharges into Tampa Bypass Canal and then into McKay Bay. Kinder Morgan estimated 750 barrels of refined product were released. About two miles of the creek, which includes ditches, creek, ponds, and wetlands were impacted.

January 28, 2014	A train derailment in McDavid, Florida resulted in railcars containing phosphoric acid submerging in Fletcher Creek. There were no reported injuries or fatalities. A total of four railcars with 96% concentration phosphoric acid were derailed, at least one was leaking into the creek. Each railcar contained 12,000 gallons.
September 23, 2016	A tanker truck containing 8,000 gallons of petroleum products overturned on Interstate 75 in North Port, Florida. Both shoulders of the interstate were affected as well as nearby wetlands. FDEP, Sarasota County HazMat, and Charlotte County Fire Rescue responded.
April 3, 2017	A collision between two trains resulted in the release of approximately 7,400 gallons of diesel fuel and 77 gallons of battery acid.

4. Probability of Future Hazardous Materials Incidents

Major disasters like that in Bhopal, India, in December 1984, which resulted in 2,000 deaths and over 200,000 injuries, are rare. Reports of hazardous material spills and releases, however, are increasingly commonplace. Thousands of new chemicals are developed each year and transported domestically and internationally creating the risk for accidents and spills.

Major chemicals spills can occur at any facility that produces, uses, or stores chemicals. These include chemical manifesting plants, laboratories, shipyards, railroad yards, warehouses, or chemical disposal areas. Illegal dumpsites can appear anywhere. Accidents involving the transportation of hazardous materials can occur at any time and severely impact the affected community. Recent evidence shows that hazardous materials incidents may be the most significant threat facing local jurisdictions.

This hazard was determined to occur annually, giving it a Probability of Very Likely.

5. Hazardous Materials Incident Impact Analysis

- Public
  - Loss of life or injury from contamination.
  - Diseases may be exacerbated.
- Responders
  - Loss of life or injury from contamination, explosions, cleanup and destruction.
  - Diseases.
  - Cleanup and destruction at waste sites and incident sites.
- Continuity of Operations (including continued delivery of services)
  - Lost material, such as gas, is unusable and could lead to shortages and price increases.
- Property, Facilities, Infrastructure
  - Damage due to excavation and removal of soil and water.
  - Inability to rebuild in affected areas.
  - Services could be closed or blocked due to the contaminant.
    - Roads
    - Trains

        - Airplanes
        - Bridges
        - Waterways
    - Long term contamination at hazardous waste sites.
- Environment
    - Death or illness to pets or wildlife near the spill.
    - Damage to plants and wildlife.
    - Airborne issues such as toxic fumes, gases or vapors caused by chemicals.
    - Water contamination.
    - Soil contamination.
    - Loss of critical or endangered species.
    - Pollution.
- Economic Condition
    - Business closures may lead to lost revenue and wages.
    - Loss of tourism and income.
    - Loss of product.
    - Cost of cleanup and restoration.
- Public Confidence in Jurisdiction's Governance
    - If the government doesn't communicate with the public, fear could ensue, leading to a fear of the government.
    - If cleanup is slow, the public could believe the government doesn't know how to properly clean it up or that the accident was malicious.

6. 2018 LMS Integration

The following counties profile hazardous materials:

- Brevard
- Broward
- Calhoun
- Charlotte
- Citrus
- Clay
- DeSoto
- Dixie
- Duval
- Escambia
- Flagler
- Glades
- Gulf

- Hamilton
- Hendry
- Hernando
- Highlands
- Hillsborough
- Indian River
- Jackson
- Lee
- Leon
- Levy
- Manatee
- Marion
- Martin
- Miami-Dade
- Nassau
- Orange
- Osceola
- Palm Beach
- Pasco
- Pinellas
- Polk
- Putnam
- Seminole
- St. Johns
- St. Lucie
- Sumter
- Taylor
- Volusia
- Wakulla
- Walton
- Washington

7. Vulnerability Analysis and Estimated Losses by Jurisdiction

Major HazMat incidents can occur at any facility that produces, uses, or stores hazardous materials. These include chemical manifesting plants, laboratories, shipyards, railroad yards, warehouses, or chemical disposal areas. Illegal dumpsites can appear anywhere. Accidents involving the transportation of hazardous materials can occur at any time and severely impact the affected community. The entire State of Florida is vulnerable to HazMat Incidents.

8. Vulnerability Analysis and Estimated Losses of State Facilities

Hazardous Materials Incidents can, and do, occur anywhere and at any time. In most cases, they do not result in serious impacts to state facilities. However, state facilities that store or handle hazardous chemicals listed in the SARA Title III Superfund Amendments and Reauthorization Act are most vulnerable.

9. Overall Vulnerability

Each category was given a number and when all 5 categories are added together, the overall vulnerability is a number between 5 and 15.

Based on the Frequency, Probability, and Magnitude summary, the Overall Vulnerability of this hazard was determined to be Medium, with a score of 12.

HAZARDOUS MATERIALS INCIDENT					Overall Vulnerability
Overview					
A hazardous material is any substance that poses a threat to humans, animals, or the environment. Hazardous Materials, commonly referred to as HazMat, refers generally to hazardous substances, petroleum, natural gas, synthetic gas, and acutely toxic chemicals. Hazardous materials are defined and regulated in the United States primarily by laws and regulations administered by the EPA, OSHA, DOT, and the Nuclear Regulatory Commission (NRC). Hazardous materials typically fall into one of three categories: Biological Hazards, Chemical Hazards, or Radiological Hazards.					MEDIUM
Frequency	Probability	Magnitude			
		Injuries/Deaths	Infrastructure	Environment	
Very Likely	Very Likely	Medium	Medium	Medium	

Space Weather Hazard Profile

1. Space Weather Description and Background Information

Space Weather is a broad term used to describe atmospheric events that have the potential to adversely affect conditions on Earth. Space Weather events are caused by the interaction of Earth with emissions from the Sun. There are two causes of space weather events, coronal mass ejections (CMEs) and solar flares, which are different incidents that occur on the Sun. CMEs and solar flares can cause three different types of space weather events on Earth, Geomagnetic Storms, Solar Radiation Storms, and Radio Blackouts.

When Space Weather does interact with the Earth and its magnetic field, the technology on Earth can be disrupted, including that which operates critical infrastructure. For example, communications networks, satellite and airline operations, navigation systems, and the electric power grid could be disrupted, causing severe problems and damage.

According to the National Space Weather Strategy, published in October 2015, space weather poses a significant risk to the security of our country, including infrastructure and the economy. This is because our nation is becoming more and more dependent on technology and the failure of one critical infrastructure facility or system could lead to failures in many other systems.[280]

The Space Weather Operations, Research and Mitigation (SWORM) Task Force was created in 2014 with the goal of uniting the national and homeland security field with the science and technology industry to formulate a cohesive vision to enhance national preparedness for space weather. The SWORM Task Force created two documents, the Space Weather Strategy and the Space Weather Action Plan,[281] to guide federal level actions to achieve the goal. Both documents build on recent efforts to reduce risks associated with natural hazards and improve resilience of essential facilities and systems. The Strategy contains goals and objectives and the Action Plan contains measurable actions to take to improve preparedness and resilience.

Causes

As stated before, Space Weather events are caused by two types of incidents on the surface of the Sun. These will be discussed below.

Coronal Mass Ejections

Coronal Mass Ejections (CMEs) are large eruptions of plasma and magnetic field structures in the Sun's atmosphere, which then travel through space at millions of miles per hour, eventually reaching Earth and affecting Earth's own magnetic field. When CMEs erupt from active regions on the Sun, they are often accompanied by large solar flares.

[280] National Space Weather Strategy, National Science and Technology Council, October 2015
[281] National Space Weather Action Plan, National Science and Technology Council, October 2015

Solar Flares

Solar Flares are sudden bursts of electromagnetic radiation, including x rays and ultraviolet light. The Sun continually streams out solar wind, which consists of charged particles, or plasma, travelling at high speeds. Solar wind carries the solar magnetic field into space where it interacts with magnetic fields of planets. When solar wind is very fast or turbulent, it can cause changes in the magnetic fields of planets; this is the basis of a Geomagnetic Storm. X-rays from Solar Flares affect Earth's ionosphere by causing a prompt loss of its ability to reflect long-range radio waves, which results in a radio blackout event. The plasma from Solar Flares can damage satellites and cause high frequency radio blackouts in polar-regions and the sun-facing side of the Earth.

Space Weather Events

CMEs and solar flares can cause three different types of Space Weather events on Earth. These will be discussed below.

1) **Geomagnetic Storms**

Geomagnetic Storms occur when CMEs affect Earth's magnetic field. The Earth's magnetic field attempts to adjust to the large amounts of energy from the Sun, carried in solar wind. CMEs from the Sun can disturb Earth's geomagnetic field for days and several CMEs at once may cause prolonged disturbed periods. Geomagnetic storms usually last from a few hours to a few days, but stronger storms can last up to a week.

These storms induce currents that can have significant impacts on technological systems and critical infrastructure, including electrical transmission equipment. Electric power companies have procedures in place to mitigate the impact of Geomagnetic Storms. Strong Geomagnetic Storms are visible from Earth, in the form of aurora, which during a storm becomes brighter and moves closer to the equator.

Geomagnetic Storms are measured on a scale from G1: Minor to G5: Extreme. The chart below from the National Oceanic and Atmosphere Administration (NOAA) describes the effects and frequency in detail.

Table 58: Geomagnetic Storm Scale

Scale	Description	Effect	Physical measure	Average Frequency (1 cycle = 11 years)
G5	Extreme	**Power systems:** Widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage. **Spacecraft operations:** May experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites. **Other systems:** Pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.).	Kp = 9	4 per cycle (4 days per cycle)
G4	Severe	**Power systems:** Possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid. **Spacecraft operations:** May experience surface charging and tracking problems, corrections may be needed for orientation problems. **Other systems:** Induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-	Kp = 8	100 per cycle (60 days per cycle)

		frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.).		
G3	Strong	**Power systems:** Voltage corrections may be required, false alarms triggered on some protection devices. **Spacecraft operations:** Surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems. **Other systems:** Intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.).	Kp = 7	200 per cycle (130 days per cycle)
G2	Moderate	**Power systems:** High-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage. **Spacecraft operations:** Corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions. **Other systems:** HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.).	Kp = 6	600 per cycle (900 days per cycle)
G1	Minor	**Power systems:** Weak power grid fluctuations can occur. **Spacecraft operations:** Minor impact on satellite operations possible. **Other systems:** Migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine).	Kp = 5	1700 per cycle (900 days per cycle)

2) Solar Radiation Storms

Solar Radiation Storms occur when there is a giant eruption from a sunspot region, causing large quantities of charged particles, or plasma, to accelerate through space and cover the near-Earth satellite environment with high-energy particles. These storms occur about 30 minutes to several hours after a solar flare and they can last from a few hours to a few days. Sometimes these storms can penetrate down to the Earth's surface.

Solar Radiation storms cause the loss of High Frequency (HF) radio communications in the polar region. Because of the increase in radiation, astronauts, as well as passengers and crew in aircraft at high altitudes and latitudes, are at risk of increased radiation exposure. Additionally, these storms can cause navigation position errors and damage to satellite systems.

Solar Radiation Storms are measured on a scale from S1: Minor to S5: Extreme. The chart below from NOAA describes the effects and frequency in detail.

Table 59: Solar Radiation Storm Scale

Scale	Description	Effect	Physical measure	Average Frequency
S5	Extreme	**Biological:** Unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** Satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. **Other systems:** Complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	10^5	Fewer than 1 per cycle

S4	Severe	**Biological:** Unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** May experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. **Other systems:** Blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.	10^4	3 per cycle
S3	Strong	**Biological:** Radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. **Satellite operations:** Single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. **Other systems:** Degraded HF radio propagation through the polar regions and navigation position errors likely.	10^3	10 per cycle
S 2	Moderate	**Biological:** Passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk. **Satellite operations:** Infrequent single-event upsets possible. **Other systems:** Small effects on HF propagation through the polar regions and navigation at polar cap locations possibly affected.	10^2	25 per cycle
S1	Minor	**Biological:** None. **Satellite operations:** None. **Other systems:** Minor impacts on HF radio in the polar regions.	10	50 per cycle

3) Radio Blackouts

Radio Blackouts are caused by the bursts of x-rays and ultra-violet radiation from solar flares. These x-ray and ultra-violet ray emissions that come along with solar flares ionize (by increasing electron densities) the sunlit side of the Earth, which increases the amount of energy lost as radio waves pass through the region. These blackouts are the fastest and among the most common of Space Weather events to affect Earth. Earth is impacted after about 8 minutes because the x-rays travel at the speed of light and it takes about 8 minutes for the light from the Sun to reach the Earth. This makes advance warning for these events difficult. These blackouts usually last for several minutes, but can last up to a few hours.

High Frequency (HF) communications ranging from 3 to 30 MHz can be disrupted by solar flares. Very High Frequency (VHF) communications range from 30 to 300 MHz can be faded or have diminished reception because of solar flares. Similar to Solar Radiation Storms, Radio Blackouts affect HF and VHF communications, polar-regions, and the sunlit side of the Earth, with impacts ~~are~~ being primarily felt by aviation and marine industries.

Radio Blackouts are measured from R1: Minor to R5: Extreme. The chart below from NOAA describes the effects and frequency in detail.

Table 60: Radio Blackout Scale

Scale	Description	Effect	Physical measure	Average Frequency
R5	Extreme	**HF Radio:** Complete HF (high frequency) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector. **Navigation:** Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth for many hours, causing loss in positioning. Increased satellite	X20	Less than 1 per cycle

		navigation errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side.		
R4	Severe	**HF Radio:** HF radio communication blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time. **Navigation:** Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of satellite navigation possible on the sunlit side of Earth.	X10	8 per cycle (8 days per cycle)
R3	Strong	**HF Radio:** Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth. **Navigation:** Low-frequency navigation signals degraded for about an hour.	X1	175 per cycle (140 days per cycle)
R2	Moderate	**HF Radio:** Limited blackout of HF radio communication on sunlit side, loss of radio contact for tens of minutes. **Navigation:** Degradation of low-frequency navigation signals for tens of minutes.	M5	350 per cycle (300 days per cycle)
R1	Minor	**HF Radio:** Weak or minor degradation of HF radio communication on sunlit side, occasional loss of radio contact. **Navigation:** Low-frequency navigation signals degraded for brief intervals.	M1	2000 per cycle (950 days per cycle)

Protection

Earth's magnetosphere, ionosphere, and atmosphere protect us from the most hazardous effects of Space Weather. However, the amount of protection from Space Weather events depends on the location of impact. The polar-regions are most affected because the magnetic field lines at the poles extend vertically downwards, allowing particles to spiral down the field lines and penetrate the atmosphere, increasing ionization. Extreme storms can produce disruptive and potentially damaging effects to medium and low Earth orbit satellites and lower mid-latitude terrestrial electric grids. Both satellite communications and ground-based utilities have mitigation measures that can be activated, such as temporarily ceasing non-essential maintenance operations, reducing the load on vulnerable equipment, increasing reactive reserve power and taking steps to maximize system reliability.

Forecasting

Space Weather can be predicted and forecasted. There are three levels of alerts that can be sent out for Space Weather: a Watch, a Warning, and an Alert.

A Watch is when the risk of a potentially hazardous Space Weather event has increased significantly, but its occurrence or timing is still uncertain. A Space Weather Watch is intended to provide enough advance notice, usually a few hours or days, for protection plans to be implemented.

Warnings are sent out when a significant space weather event is occurring, imminent, or likely. These alerts are short term and there is a high confidence of occurrence. The Warning is intended to give a lead time of a few minutes to a few hours.

An Alert is sent out to indicate observed conditions, usually after a Warning has been sent out, to inform that a Space Weather event has already started.

Solar Cycle

The solar cycle is a 9 to 14 year period, or an 11 year average, that the Sun goes through to release magnetic energy. The peak is the solar maximum, when there may be hundreds of sunspots visible at any time. The low is the solar minimum, when there can be many days in a row with no sunspots visible.

The first recorded solar cycle began in 1755. We are currently in cycle 24, which began in 2008, therefore 2018 will be year 10 of the current cycle.[282]

Frequency

This hazard was determined to occur about every 5-10 years, giving it a Frequency ranking of Likely.

Magnitude

This hazards Injuries and Deaths Magnitude was determined to be Medium, meaning any injuries, but no deaths are recorded.

This hazards Infrastructure Magnitude was determined to be Medium, meaning significant damage to property occurs.

This hazards Environment Magnitude was determined to be Low, meaning little to no damage to the environment occurs.

2. Geographic Areas Affected by Space Weather

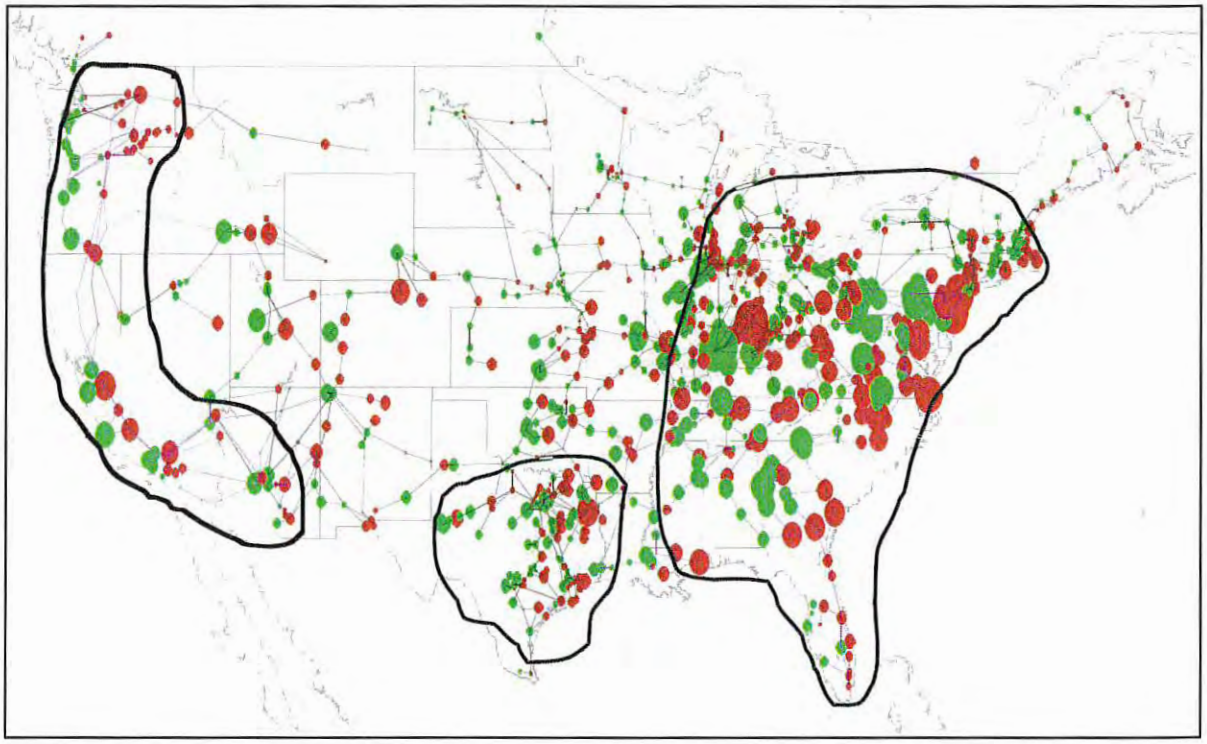
As mentioned in the section above, any region of the Earth is susceptible to the effects of Space Weather. The sunlit side of the Earth – whichever that happens to be at the time of impact – will have more effects than the unlit side of Earth. Additionally, there are stronger effects to communication systems and radiation exposure at higher altitudes and higher latitudes, such as at the polar-regions.

The effects of Space Weather can affect more than the physical location of the impact. In fact, space weather could affect the whole of North America at the same time, and potentially become a global incident. For example, there may be cascading impacts. Because our power grids and communication systems are interconnected, an outage in one location could have far-reaching effects.

Florida has not been significantly affected by space weather since modern infrastructure began to be built in the 1950's. However, due to the high uncertainty of geomagnetically induced current impact locations, extreme geomagnetic storms could produce electrical system disturbances and possibly widespread disruptions or blackouts. The follow figures demonstrate that Florida is potentially vulnerable due to both ground connectivity and proximity to the ocean coastline.

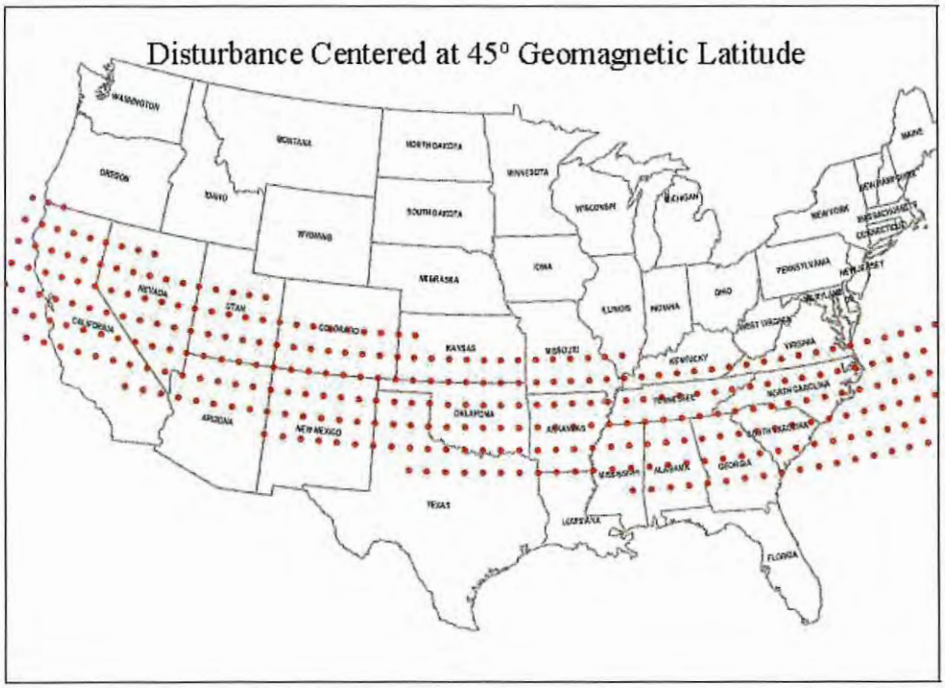
[282] http://www.nws.noaa.gov/om/space/index.shtml

Figure 100: United States Regions Susceptible to Electric System Collapse, 100-year Geomagnetic Storm 45 degree Latitude Scenario, [283]



[283] https://www.ferc.gov/industries/electric/indus-act/reliability/cybersecurity/ferc_meta-r-319.pdf

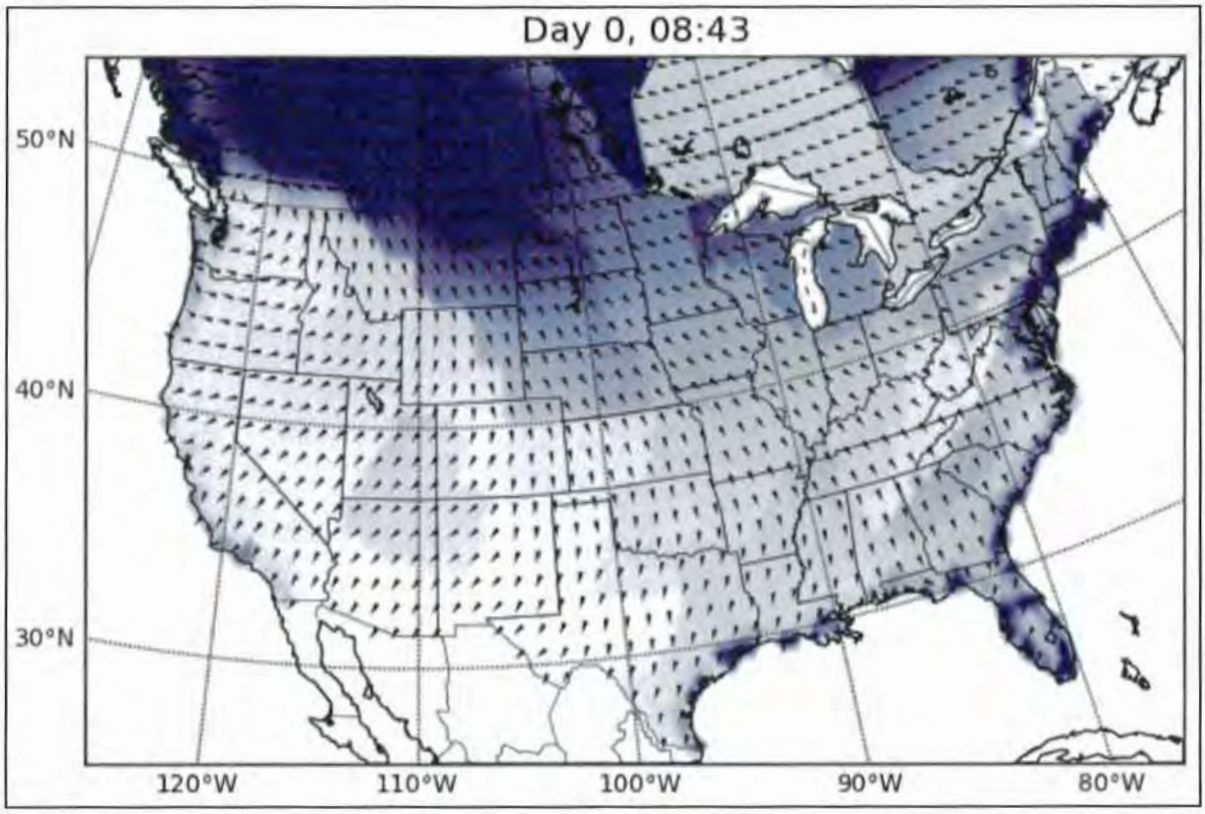
Figure 101: Disturbance Regions, Geomagnetic Storm, 45 degree Latitude[284]



Below is a figure depicting the electric field amplitudes (color-scale) and direction (barbs) during a simulated Carrington-level storm. Regions shaded in dark purple are experiencing the strongest surface electric fields at that time.

[284] https://www.ferc.gov/industries/electric/indus-act/reliability/cybersecurity/ferc_meta-r-319.pdf

Figure 102: Carrington Level Storm Electric Field Amplitudes Model[285]



3. Historical Occurrences of Space Weather

There has not been a Space Weather event to significantly affect Florida since our country began recording such incidents. However, Space Weather can affect any region at any time.

Table 61: Florida Historical Occurrences, Space Weather

Date	Description
September 1859	The strongest Geomagnetic Storm in recorded history, called the Carrington Event, occurred. Excess currents caused telegraph lines to fail. Technicians were shocked and some telegraph equipment even caught fire. The Aurorae from this event were seen as far south as Cuba and Hawaii.
May 1921	A powerful geomagnetic storm called the New York Railroad Storm caused similar effects as the Carrington Event. There was interference in telegraph equipment, trans-Atlantic cable communications (telephone and telegraph), and railroad switching systems. Fires were also ignited in telegraph switchgear.
August 1972	A large solar flare disrupted long distance telephone communications across Illinois.

[285] Lloyd's/Atmospheric and Environmental Research, Solar Storm Risk to the North American Electric Grid, 2013, Figure 5, p 11

March 1989	A very powerful Geomagnetic Storm led to a major blackout in Canada, which left 6 million people without electricity for 9 hours. The storm disrupted electric power transmission from a generating station in Quebec and damaged power transformers in New Jersey.
October and November 2003	The Halloween geomagnetic storms were the strongest since March 1989. Both terrestrial electric utilities, aviation and spacecraft operations were affected by storms, but most were recoverable without incident. Temporary blackouts were reported in northern Europe. The November 20th storm also caused blackouts in northern Europe and South Africa. Several high-voltage transformers were damaged or destroyed in South Africa.
December 2005	X-rays from a solar storm disrupted satellite to ground communications and global positioning systems (GPS) navigation systems for 10 minutes.

4. Probability of Future Space Weather

Power outages due to Space Weather are rare; however, significant effects could occur.

The entire State of Florida and its population and infrastructure is susceptible to solar storms; however, the effect that minor solar events could have on the public, property, environment, and operations would be minimal. If a rare, major solar storm were to occur, there could be a much larger impact on the population, property, and operations. However, the environment would still not be affected.

This hazard was determined to occur about every 5-10 years, giving it a Frequency ranking of Likely.

Geomagnetic Storms

The frequency of Geomagnetic Storms depends on where Earth is in the average 11-year solar cycle, with most storms occurring around the solar maximum. The current solar cycle (cycle 24) maximum occurred from early 2012 to late 2014. These storms are also common in the declining phase, due to an increase in solar wind speeds. However, severe space weather can be observed at any time during the solar cycle.

Additionally, a CME may intensify a geomagnetic storm as it approaches the Earth. With sufficient time, a CME with a southward oriented magnetic field will cause geomagnetic storming by compressing and agitating the Earth's magnetic field. Weak sub-storm to strong storming is common with hundreds of occurrences per solar cycle, less than 10-year long-term occurrence rates.

Storm intensity can also be measured in Disturbance storm time (*Dst*) with greater intensity represented by a more negative *Dst* value. Geomagnetic storms that cause the most significant disruptions and damage have Dst values of more than -300 nT[286], which may occur on Earth about 4 days per solar cycle. This means the probability of a storm with a Dst intensity value of about -450 nT occurs about once per solar cycle. A storm with an intensity similar to the March 1989 Great Storm may occur about one every 60 years, or about once per five solar cycles. Larger geomagnetic storms with intensities similar to the Carrington Event are rare and may occur about once every 250 years or more.

[286] nanotesla, unit of measurement

Furthermore, periods with very active sunspot groups, features such as corotating interaction regions can create an interstellar environment where unexpectedly intense and prolonged geomagnetic storming can occur.

The table below describes long-term geomagnetic storm occurrence and intensity.

Table 62: Space Weather Geomagnetic Storm Occurrence and Intensity Indicators

Space Weather Geomagnetic Storm Occurrence and Intensity					
Long-term Occurrence, years	Storm Intensity Physical Measure Indicators				
	Kyoto Equatorial *Dst* Index, nT	Number of Storm Days per Cycle, days	Planetary K	NOAA Geomagnetic Storm Scale	Storm Intensity Description
< 10	> -100	900	< 7	< 3	weak - moderate
	-100	130	7	3	strong
	-200	60	8/9-	4	severe
	-350	4	9	5	extreme
10 [287]	-451	1			
20 [5]	-501	< 1			Great Storms
30 [5]	-534				
50 [5]	-578				
60 [288]	-589				
100 [5]	-645				
200 [5]	-721				
250 [289]	-800				Carrington Class
500 [6]	-850				
1000 [6]	-925				
nT – nanotesla; Dst – Disturbance Storm Time					

The long-term geomagnetic occurrence rates illustrated above do not necessarily reflect the sun's potential to produce extreme storms at any time when active sunspot groups are present, even during lower than normal sunspot cycles. As an example, the STEREO A spacecraft orbits the sun at a location that is 1 AU distant from the sun, but with a view of the farside. At least twice during solar cycle 24, the sun produced major farside CME that would have likely impacted Earth if it had been in the path. The STEREO A spacecraft was able to directly observe the extreme interstellar conditions of a major CME in

[287] Table 2. Probable Storm Intensity S_T, *Long-term occurrence probabilities of intense geomagnetic storm events*, K. Tsubouchi and Y. Omura, Space Weather, Vol 5, 2007

[288] March 13/14, 1989 Great Geomagnetic Storm (Quebec Blackout)

[289] Estimates based on Figure 6. Probable storm intensity S_T as a function of year, *Long-term occurrence probabilities of intense geomagnetic storm events*, K. Tsubouchi and Y. Omura, Space Weather, Vol 5, 2007