2 Hazard Identification & Risk Assessment

Contents

Requirement §201.6(c)(2): [The plan shall include] A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.
Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

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

44 CFR Subsection D §201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community. Plans approved after October 1, 2008 must also address NFIP insured structures that have been repetitively damaged by floods. The plan should describe vulnerability in terms of:
A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;

(B): An estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate; and

(C): Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

2.1 OVERVIEW

This section describes the Hazard Identification and Risk Assessment process for the development of the Collier County Local Mitigation Strategy. It describes how the County met the following requirements from the 10-step planning process:

- Planning Step 4: Assess the Hazard
- Planning Step 5: Assess the Problem

As defined by FEMA, risk is a combination of hazard, vulnerability, and exposure. "It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage."

This hazard risk assessment covers all of Collier County, including the unincorporated County and all incorporated jurisdictions participating in this plan.

The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The process allows for a better understanding of the potential risk to natural hazards in the county and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events. This risk assessment followed the methodology described in the FEMA publication Understanding Your Risks—Identifying Hazards and Estimating Losses (FEMA 386-2, 2002), which breaks the assessment down to a four-step process:

Data collected through this process has been incorporated into the following sections of this plan:

- **Section 2.2**: **Hazard Identification** identifies the natural and human-caused hazards that threaten the planning area.
- **Section 2.3: Risk Assessment Methodology and Assumptions**
- **Section 2.4: Asset Inventory** details the population, buildings, and critical facilities at risk within the planning area.
- **Section 2.5**: **Hazard Profiles, Analysis, and Vulnerability** discusses the threat to the planning area, describes previous occurrences of hazard events and the likelihood of future occurrences, and assesses the planning area's exposure to each hazard profiled; considering assets at risk, critical facilities, and future development trends.
- **Section 2.6: Conclusions on Hazard Risk** summarizes the results of the Priority Risk Index and defines each hazard as a Low, Medium, or High-Risk hazard.

2.2 HAZARD IDENTIFICATION

To identify hazards relevant to the planning area, the LMS working group began with a review of the list of hazards identified in the 2018 State Hazard Mitigation Plan and the 2015 Collier County Local Mitigation Strategy (LMS) as summarized in Table 2.1. The LMS working group used these lists to identify a full range of hazards for potential inclusion in this plan update and to ensure consistency across these planning efforts. All hazards listed below were evaluated for inclusion in this plan update.

Table 2.1 – Full Range of Hazards Evaluated

Hazard	Included in 2018 State HMP?	Included in 2015 Collier County LMS?
Flood	Yes	Yes
Tropical Cyclones	Yes	Yes (Storm Surge)
Severe Storms and Tornadoes	Yes	Yes
Wildfire	Yes	Yes
Coastal Erosion	Yes	Yes
Drought	Yes	No
Extreme Heat	Yes	No
Sea Level Rise and other Climate Change Characteristics	Yes	Yes
Sink holes	Yes	No
Winter Storms and Freeze	Yes	No
Earthquake	Yes	No
Tsunami	Yes	No
Major Transportation Incidents	Yes	No
Pandemic Outbreak	Yes	No
Hazardous Materials	Yes	No
Coastal Oil Spills	Yes	No
Nuclear Power Plant	Yes	No
Terrorism	Yes	No
Mass Migration Incident	Yes	No
Civil Disturbance	Yes	No
Critical Infrastructure Disruption (Cyber)	Yes	No

Hazard	Included in 2018 State HMP?	Included in 2015 Collier County LMS?
Special Events (Dignitary visits or events of national significance)	No	No
Red Tide/Algae Bloom	No	No

The LMS working group evaluated the above list of hazards using existing hazard data, past disaster declarations, local knowledge, and information from the 2018 State Plan and the 2015 Collier County Plan to determine the significance of these hazards to the planning area. Significance was measured in general terms and focused on key criteria such as frequency and resulting damage, which includes deaths and injuries, as well as property and economic damage.

One key resource in this effort was the National Oceanic and Atmospheric Administration's National Center for Environmental Information (NCEI), which has been tracking various types of severe weather since 1950. Their Storm Events Database contains an archive by county of destructive storm or weather data and information which includes local, intense and damaging events. NCEI receives storm data from the National Weather Service (NWS), which compiles their information from a variety of sources, including but not limited to: county, state and federal emergency management officials; local law enforcement officials; SkyWarn spotters; NWS damage surveys; newspaper clipping services; the insurance industry and the general public, among others. The NCEI database contains 366 records of severe weather events that occurred in Collier County in the 20-year period from 2000 through 2019. Table 2.2 summarizes these events.

Table 2.2 – NCEI Severe Weather Reports for Collier County, 2000 – 2019

Type	# of Events	Property Damage	Crop Damage	Deaths	Injuries
Coastal Flood	9	$71,000	0	0	0
Dense Fog	4	0	0	0	0
Drought	64	0	0	0	0
Extreme Cold/Wind Chill	7	0	$34,030,000	0	0
Flash Flood	6	$300,000	0	0	0
Flood	11	$43,500	0	0	0
Frost/Freeze	22	0	$301,030,000	0	0
Funnel Cloud	25	0	0	0	0
Hail	39	0	0	0	0
Heavy Rain	5	$60,000	0	0	0
High Wind	2	$5,000	0	0	0
Hurricane (Typhoon)	4	$2,500,000	0	1	0
Lightning	27	$4,773,000	0	3	11
Rip Current	1	0	0	0	6
Storm Surge/Tide	5	$6,060,000	0	0	0
Thunderstorm Wind	54	$200,500	0	0	0
Tornado	24	$786,590	0	0	1
Tropical Storm	7	$70,000	0	0	0
Waterspout	6	0	0	0	0
Wildfire	17	$5,428,000	0	0	1
Total:	**366**	**$20,297,590**	**$335,060,000**	**4**	**19**

Source: National Center for Environmental Information Storm Events Database, September 2019
Note: Losses reflect totals for all impacted areas for each event.

The LMS working group also researched past events that resulted in a federal and/or state emergency or disaster declaration for Collier County in order to identify significant hazards. Federal and/or state disaster declarations may be granted when the Governor certifies that the combined local, county and state resources are insufficient, and that the situation is beyond their recovery capabilities. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. If the disaster is so severe that both the local and state government capacities are exceeded, a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

Records of designated counties for FEMA major disaster declarations start in 1964. Since then, Florida has been designated in 69 major disaster declarations, and Collier County, including the Immokalee Indian Reservation, has been designated in 25 major disaster declarations, as detailed in Table 2.3, and 9 emergency declarations, as detailed in Table 2.4. Two such designations are for Hurricane Dorian – one for Collier County and one for the Immokalee Reservation.

Table 2.3 – FEMA Major Disaster Declarations, Collier County

Disaster #	Dec. Date	Incident Type	Event Title	Individual Assistance Applications Approved	Total Individual and Households Program Dollars Approved	Total Public Assistance Grant Dollars Obligated
4341	9/27/2017	Hurricane	Hurricane Irma Seminole Tribe	3	$9,674.92	$3,794,477.53
4337	9/10/2017	Hurricane	Hurricane Irma	774,691	$1,020,968,233.16	$1,825,881,275.84
4084	10/18/2012	Hurricane	Hurricane Isaac	--	--	$22,292,837.45
4068	7/3/2012	Tropical Storm	Tropical Storm Debby	6,757	$27,791,929.44	$47,913,435.25
1785	8/24/2008	Tropical Storm	Tropical Storm Fay	5,383	$19,216,129.55	$98,200,979.98
1609	10/24/2005	Hurricane	Hurricane Wilma	227,320	$342,239,388.43	$1,491,325,871.49
1602	8/28/2005	Hurricane	Hurricane Katrina	--	--	$188,865,729.15
1561	9/26/2004	Hurricane	Hurricane Jeanne	180,826	$398,620,293.65	$520,360,976.27
1551	9/16/2004	Hurricane	Hurricane Ivan	79,390	$164,517,307.53	$695,021,414.57
1545	9/4/2004	Hurricane	Hurricane Frances	229,577	$411,815,685.98	$682,789,667.24
1539	8/13/2004	Severe Storm(s)	Hurricane Charley and Tropical Storm Bonnie	116,769	$208,970,753.97	$611,396,718.48
1393	9/28/2001	Tropical Storm	Tropical Storm Gabrielle	--	--	$22,990,447.07
1359	2/5/2001	Freeze	Severe freeze	--	--	--
1345	10/4/2000	Severe Storm(s)	Heavy rains and flooding	--	--	$288,481,152.48
1306	10/20/1999	Hurricane	Hurricane Irene	--	--	$106,261,560.28
1223	6/18/1998	Fire	Extreme Fire Hazard	--	--	--
1195	1/6/1998	Tornado	Tornadoes	--	--	--
1069	10/4/1995	Hurricane	Hurricane Opal	--	--	--
982	3/13/1993	Severe Storm(s)	Tornadoes, flooding, high winds, tides, freezing	--	--	--
955	8/24/1992	Hurricane	Hurricane Andrew	--	--	--
851	1/15/1990	Freeze	Severe freeze	--	--	--
732	3/18/1985	Freeze	Severe freeze	--	--	--
526	1/31/1977	Severe Storm(s)	Severe winter weather	--	--	--

Disaster #	Dec. Date	Incident Type	Event Title	Individual Assistance Applications Approved	Total Individual and Households Program Dollars Approved	Total Public Assistance Grant Dollars Obligated
304	3/15/1971	Freeze	Freeze	--	--	--
209	9/14/1965	Hurricane	Hurricane Betsy	--	--	--

Source: FEMA Disaster Declarations Summary, January 2020

Note: Number of applications approved, and all dollar values represent totals for all counties included in disaster declaration.

Table 2.4 – FEMA Emergency Declarations, Collier County

Disaster #	Dec. Date	Incident Type	Event Title/Description
3419/3420	8/31/2019	Hurricane	Hurricane Dorian
3385	9/5/2017	Hurricane	Hurricane Irma
3288	8/21/2008	Tropical Storm	Tropical Storm Fay
3131	9/25/1998	Hurricane	Hurricane Georges
3259	9/20/2005	Tropical Storm	Tropical Storm Rita
3220	9/5/2005	Hurricane	Hurricane Katrina Evacuation
3150	10/15/1999	Hurricane	Hurricane Irene
3139	4/27/1999	Fire	Fire Hazard

Source: FEMA Disaster Declarations Summary, January 2020

Using the above information and additional discussion, the LMS working group evaluated each hazard's significance to the planning area in order to decide which hazards to include in this plan update. Some hazard titles have been updated either to better encompass the full scope of a hazard or to assess closely related hazards together. Table 2.5 summaries the determination made for each hazard.

Table 2.5 – Hazard Evaluation Results

Hazard	Included in this plan update?	Explanation for Decision
Natural Hazards		
Flood	Yes	The 2015 Collier County plan and 2018 State plan addressed this hazard. As a coastal county, over 95 percent of the county is within the 100-year-floodplain, and the county is also vulnerable to localized and stormwater flooding.
Tropical Cyclones	Yes	Both the 2015 Collier County plan and the 2018 State plan addressed Tropical Cyclones. Since 1965, the county has received 14 Major Disaster declarations from FEMA for Hurricanes/Tropical storms.
Severe Storms and Tornadoes	Yes	The 2015 Collier County plan profiled these hazards together. The County experienced 78 thunderstorm and tornado events causing close to $1m in damages.
Wildfire	Yes	The 2015 Collier County plan as well as the 2018 State plan addressed this hazard. According to NCEI, in the past 20 years Collier County has had 17 wildfire events.
Coastal Erosion	Yes	The 2015 Collier County Floodplain Management Plan classified erosion as a priority hazard with a high likelihood of future occurrence.
Drought	Yes	Although drought was excluded from the 2015 LMS, NCEI records 64 drought events between 2000-2019. The LMS working group decided this hazard was worth assessment.
Extreme Heat	Yes	The 2015 Collier County plan did not address this hazard, however the LMS working group decided to include it in this plan update.

Hazard	Included in this plan update?	Explanation for Decision
Sea Level Rise and other Climate Change Characteristics	Yes	Sea Level Rise and Climate Change were addressed in the 2015 Collier County floodplain management plan as well as the 2018 State plan. NOAA's Sea Level Rise Viewer shows the County will experience impacts from even just one foot of sea level rise.
Sink Holes	Yes	The 2015 Collier County plan did not address Sink Holes, but the 2018 State plan did. The LMS working group chose to include it in this update.
Winter Storms and Freeze	No	The 2015 Collier County plan did not address Winter Storms and Freeze, but the 2018 State plan did. The LMS working group chose to include it in this update.
Earthquake	Yes	The 2015 Collier County plan did not address Earthquake, but the 2018 State plan did. The LMS working group chose to include it in this update.
Tsunami	Yes	The 2015 Collier County plan did not address Tsunami, but the 2018 State plan did. The LMS working group chose to include it in this update.
Technological and Human-Caused Hazards & Threats		
Major Transportation Incidents	Yes	The 2015 Collier County plan did not address this hazard, but the LMS working group chose to include it in this plan update. The plan area has many bridges and major transportation routes.
Pandemic Outbreak	Yes	The 2015 Collier County plan did not address Pandemic Outbreak, but the 2018 State plan did. The LMS working group chose to include it in this update.
Hazardous Materials	Yes	The 2015 Collier County plan did not address Hazardous Materials, but the 2018 State plan did. The LMS working group chose to include it in this update. The County has 13 sites listed on the Toxic Release Inventory.
Coastal Oil Spills	Yes	The 2015 Collier County plan did not address Coastal Oil Spills, but the 2018 State plan did. The LMS working group chose to include it in this update.
Nuclear Power Plant	Yes	The 2015 Collier County plan did not address Nuclear Power Plant incidents, but the 2018 State plan did. The LMS working group chose to include it in this update. The southeastern corner of the County is in the Turkey Point Nuclear Power Facility Ingestion Exposure Pathway.
Terrorism	Yes	The 2015 Collier County plan did not address Terrorism, but the 2018 State plan did. The LMS working group chose to include it in this update.
Mass Migration Incident	Yes	The 2015 Collier County plan did not address Mass Migration Incident, but the 2018 State plan did. The LMS working group chose to include it in this update.
Civil Disturbance	Yes	The 2015 Collier County plan did not address Civil Disturbance, but the 2018 State plan did. The LMS working group chose to include it in this update.
Critical Infrastructure Disruption (Cyber)	Yes	The 2015 Collier County plan did not address Critical Infrastructure Disruption, but the 2018 State plan did. The LMS working group chose to include it in this update.

Hazard	Included in this plan update?	Explanation for Decision
Special Events (Dignitary visits or events of national significance)	Yes	The 2015 Collier County plan did not address Special Events, but the 2018 State plan did. The LMS working group chose to include it in this update.
Red Tide/Algae Bloom	Yes	The 2015 Collier County plan did not address Red Tide/Algae Bloom, but the 2018 State plan did. The LMS working group chose to include it in this update.

2.3 RISK ASSESSMENT METHODOLOGY AND ASSUMPTIONS

The Disaster Mitigation Act of 2000 requires that the LMS working group evaluate the risks associated with each of the hazards identified in the planning process. Each hazard was evaluated to determine its probability of future occurrence and potential impact. A vulnerability assessment was conducted for each hazard using either quantitative or qualitative methods depending on the available data, to determine its potential to cause significant human and/or monetary losses. A consequence analysis was also completed for each hazard.

Each hazard is profiled in the following format:

Hazard Description

This section provides a description of the hazard, including discussion of its speed of onset and duration, as well as any secondary effects followed by details specific to the Collier County planning area.

Location

This section includes information on the hazard's physical extent, with mapped boundaries where applicable.

Extent

This section includes information on the hazard extent in terms of magnitude, describe how the severity of the hazard can be measured. Where available, the most severe event on record used as a frame of reference.

Historical Occurrences

This section contains information on historical events, including the location and consequences of all past events on record within or near the Collier County planning area.

Probability of Future Occurrence

This section gauges the likelihood of future occurrences based on past events and existing data. The frequency is determined by dividing the number of events observed by the number of years on record and multiplying by 100. This provides the percent chance of the event happening in any given year according to historical occurrence (e.g. 10 winter storm events over a 30-year period equates to a 33 percent chance of experiencing a severe winter storm in any given year). The likelihood of future occurrences is categorized into one of the classifications as follows:

- ***Highly Likely*** – Near or more than 100 percent chance of occurrence within the next year
- ***Likely*** – Between 10 and 100 percent chance of occurrence within the next year (recurrence interval of 10 years or less)

- ***Possible*** – Between 1 and 10 percent chance of occurrence within the next year (recurrence interval of 11 to 100 years)
- ***Unlikely*** – Less than 1 percent chance or occurrence within the next 100 years (recurrence interval of greater than every 100 years)

Climate Change

Where applicable, this section discusses how climate change may or may not influence the risk posed by the hazard on the planning area in the future.

Vulnerability Assessment

This section quantifies, to the extent feasible using best available data, assets at risk to natural hazards and potential loss estimates. People, properties and critical facilities, and environmental assets that are vulnerable to the hazard are identified. Future development is also discussed in this section, including how exposure to the hazard may change in the future or how development may affect hazard risk.

The vulnerability assessments followed the methodology described in the FEMA publication Understanding Your Risks—Identifying Hazards and Estimating Losses (August 2001). The vulnerability assessment first describes the total vulnerability and values at risk and then discusses vulnerability by hazard. Data used to support this assessment included the following:

- Geographic Information System (GIS) datasets, including building footprints, topography, aerial photography, and transportation layers;
- Hazard layer GIS datasets from state and federal agencies;
- Written descriptions of inventory and risks provided by the 2018 Florida Enhanced State Hazard Mitigation Plan;
- Written descriptions of inventory and risks provided by the 2015 Collier County Local Mitigation Strategy and the 2015 Collier County Floodplain Management Plan;
- Exposure and vulnerability estimates derived using local parcel and building data; and
- Crop insurance claims by cause from USDA's Risk Management Agency.

Two distinct risk assessment methodologies were used in the formation of the vulnerability assessment. The first consists of a quantitative analysis that relies upon best available data and technology, while the second approach consists of a qualitative analysis that relies on local knowledge and rational decision making. The quantitative analysis involved the use of FEMA's Hazus-MH, a nationally applicable standardized set of models for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses a statistical approach and mathematical modeling of risk to predict a hazard's frequency of occurrence and estimated impacts based on recorded or historic damage information. The Hazus risk assessment methodology is parametric, in that distinct hazard and inventory parameters—such as wind speed and building type—were modeled using the Hazus software to determine the impact on the built environment. Collier County's GIS-based risk assessment was completed using data collected from local, regional and national sources that included Collier County, Florida DEM, and FEMA.

Vulnerability can be quantified in those instances where there is a known, identified hazard area, such as a mapped floodplain. In these instances, the numbers and types of buildings subject to the identified hazard can be counted and their values tabulated. Other information can be collected regarding the hazard area, such as the location of critical facilities, historic structures, and valued natural resources (e.g., an identified wetland or endangered species habitat). Together, this information conveys the vulnerability of that area to that hazard.

Priority Risk Index

The conclusions drawn from the hazard profiling and vulnerability assessment process can be used to prioritize all potential hazards to the Collier County planning area. The Priority Risk Index (PRI) was applied for this purpose because it provides a standardized numerical value so that hazards can be compared against one another (the higher the PRI value, the greater the hazard risk). PRI values are obtained by assigning varying degrees of risk to five categories for each hazard (probability, impact, spatial extent, warning time, and duration). Each degree of risk was assigned a value (1 to 4) and a weighting factor as summarized in Table 2.6.

PRI ratings by category for the planning area as a whole are provided throughout each hazard profile. Ratings specific to each jurisdiction are provided at the end of each hazard profile. The results of the risk assessment and overall PRI scoring are provided in Section 2.6 Conclusions on Hazard Risk.

Table 2.6 – Priority Risk Index

RISK ASSESSMENT CATEGORY	LEVEL	DEGREE OF RISK CRITERIA	INDEX	WEIGHT
PROBABILITY What is the likelihood of a hazard event occurring in a given year?	UNLIKELY	LESS THAN 1% ANNUAL PROBABILITY	1	30%
	POSSIBLE	BETWEEN 1 & 10% ANNUAL PROBABILITY	2	
	LIKELY	BETWEEN 10 &100% ANNUAL PROBABILITY	3	
	HIGHLY LIKELY	100% ANNUAL PROBABILTY	4	
IMPACT In terms of injuries, damage, or death, would you anticipate impacts to be minor, limited, critical, or catastrophic when a significant hazard event occurs?	MINOR	VERY FEW INJURIES, IF ANY. ONLY MINOR PROPERTY DAMAGE & MINIMAL DISRUPTION ON QUALITY OF LIFE. TEMPORARY SHUTDOWN OF CRITICAL FACILITIES.	1	30%
	LIMITED	MINOR INJURIES ONLY. MORE THAN 10% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR > 1 DAY	2	
	CRITICAL	MULTIPLE DEATHS/INJURIES POSSIBLE. MORE THAN 25% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR > 1 WEEK.	3	
	CATASTROPHIC	HIGH NUMBER OF DEATHS/INJURIES POSSIBLE. MORE THAN 50% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES > 30 DAYS.	4	
SPATIAL EXTENT How large of an area could be impacted by a hazard event? Are impacts localized or regional?	NEGLIGIBLE	LESS THAN 1% OF AREA AFFECTED	1	20%
	SMALL	BETWEEN 1 & 10% OF AREA AFFECTED	2	
	MODERATE	BETWEEN 10 & 50% OF AREA AFFECTED	3	
	LARGE	BETWEEN 50 & 100% OF AREA AFFECTED	4	
WARNING TIME Is there usually some lead time associated with the hazard event? Have warning measures been implemented?	MORE THAN 24 HRS	SELF DEFINED	1	10%
	12 TO 24 HRS	SELF DEFINED	2	
	6 TO 12 HRS	SELF DEFINED	3	
	LESS THAN 6 HRS	SELF DEFINED	4	
DURATION How long does the hazard event usually last?	LESS THAN 6 HRS	SELF DEFINED	1	10%
	LESS THAN 24 HRS	SELF DEFINED	2	
	LESS THAN 1 WEEK	SELF DEFINED	3	
	MORE THAN 1 WEEK	SELF DEFINED	4	

The sum of all five risk assessment categories equals the final PRI value, demonstrated in the equation below (the highest possible PRI value is 4.0).

PRI = [(PROBABILITY x .30) + (IMPACT x .30) + (SPATIAL EXTENT x .20) + (WARNING TIME x .10) + (DURATION x .10)]

The purpose of the PRI is to categorize and prioritize all potential hazards for the Collier County planning area as high, moderate, or low risk. The summary hazard classifications generated using the PRI allows for the prioritization of those high and moderate hazard risks for mitigation planning purposes. Mitigation actions are not necessarily developed for hazards identified as low risk through this process.

2.4 ASSET INVENTORY

An inventory of assets within Collier County was compiled to identify those structures potentially at risk to the identified hazards and assess the level of vulnerability. Assets include elements such as buildings, property, business/industry goods, and civil infrastructure. Building footprint, foundation type, and building value data were provided by Collier County. By identifying the type and number of assets that exist and where they are in relation to known hazard areas, the relative risk and vulnerability for such assets can be assessed.

2.4.1 Building Exposure

The properties identified to be at risk include all improved properties in Collier County and its incorporated jurisdictions according to parcel and building footprint data provided by Collier County. The information is provided in Table 2.7.

Table 2.7 – Collier County Building Exposure by Jurisdiction and Occupancy

Occupancy	Estimated Parcel Count	Structure Value	Estimated Content Value	Total Value
Everglades City	**559**	**$63,766,737**	**$41,405,956**	**$105,172,693**
Commercial	40	$6,532,698	$6,532,698	$13,065,396
Education	2	$5,970,494	$5,970,494	$11,940,988
Government	12	$4,201,718	$4,201,718	$8,403,436
Industrial	10	$677,235	$1,015,853	$1,693,088
Religious	4	$985,794	$985,794	$1,971,588
Residential	491	$45,398,798	$22,699,399	$68,098,197
Immokalee Reservation	**1**	**$32,843,815**	**$16,421,908**	**$49,265,723**
Residential	1	$32,843,815	$16,421,908	$49,265,723
Marco Island	**18,938**	**$8,456,653,079**	**$4,321,417,171**	**$12,778,070,250**
Commercial	271	$110,002,047	$110,002,047	$220,004,094
Education	2	$21,217,449	$21,217,449	$42,434,898
Government	22	$18,316,045	$18,316,045	$36,632,090
Industrial	15	$3,884,325	$5,826,488	$9,710,813
Religious	9	$28,877,072	$28,877,072	$57,754,144
Residential	18,619	$8,274,356,141	$4,137,178,071	$12,411,534,212
Naples	**19,648**	**$15,061,447,248**	**$8,031,303,248**	**$23,092,750,496**
Commercial	406	$684,149,867	$684,149,867	$1,368,299,734
Education	7	$71,175,419	$71,175,419	$142,350,838
Government	79	$154,495,988	$154,495,988	$308,991,976
Industrial	22	$26,951,820	$40,427,730	$67,379,550
Religious	23	$37,434,333	$37,434,333	$74,868,666
Residential	19,111	$14,087,239,821	$7,043,619,911	$21,130,859,732
Unincorporated Collier County	**166,272**	**$52,057,903,949**	**$28,524,521,680**	**$80,582,425,629**
Agriculture	535	$89,139,393	$89,139,393	$178,278,786
Commercial	2,109	$2,126,531,891	$2,126,531,891	$4,253,063,782
Education	77	$875,549,728	$875,549,728	$1,751,099,456
Government	344	$539,499,844	$539,499,844	$1,078,999,688
Industrial	894	$546,290,183	$819,435,275	$1,365,725,458
Religious	132	$267,838,189	$267,838,189	$535,676,378
Residential	162,181	$47,613,054,721	$23,806,527,361	$71,419,582,082

Occupancy	Estimated Parcel Count	Structure Value	Estimated Content Value	Total Value
Countywide Total	**205,418**	**$75,672,614,828**	**$40,935,069,962**	**$116,607,684,790**
Agriculture	535	$89,139,393	$89,139,393	$178,278,786
Commercial	2,826	$2,927,216,503	$2,927,216,503	$5,854,433,006
Education	88	$973,913,090	$973,913,090	$1,947,826,180
Government	457	$716,513,595	$716,513,595	$1,433,027,190
Industrial	941	$577,803,563	$866,705,345	$1,444,508,908
Religious	168	$335,135,388	$335,135,388	$670,270,776
Residential	200,403	$70,052,893,296	$35,026,446,648	$105,079,339,944

Source: Collier County parcel data, 2019

Note: Content value estimations are generally based on the FEMA Hazus methodology of estimating value as a percent of improved structure values by property type. The residential property type assumes a content replacement value equal to 50% of the building value. Agricultural and commercial property types assume a content replacement value equal to 100% of the building value. The industrial property type assumes a content replacement value equal to 150% of the building value.

2.4.2 Critical Facilities and Infrastructure Exposure

Of significant concern with respect to any disaster event is the location of critical facilities and infrastructure in the planning area. Critical facilities are often defined as those essential services and lifelines that, if damaged during an emergency event, would result in severe consequences to public health, safety, and welfare. Critical facility information is regularly updated by the County. Critical facilities and infrastructure in Collier County are listed by type in Table 2.8. A detailed list of critical facilities is provided in each jurisdictional annex. These facilities were identified and verified by the LMS working group.

Table 2.8 – Critical Facilities and Infrastructure in Collier County

Jurisdiction	Schools	Fire & EMS	Government	Hazardous Materials	Health	Police Dept.	Public Works	Utilities	Transportation	Water	Total
Unincorporated Collier County	47	56	1	101	54	2	20	21	12	15	**329**
Everglades City	1	2	1	3	-	-	1	-	1	-	**9**
Immokalee Reservation	-	-	-	-	-	-	-	1	-	-	**1**
Marco Island	2	3	1	4	2	1	1	2	2	2	**20**
Naples	5	11	1	8	12	4	1	2	2	-	**46**
Countywide Total	**55**	**72**	**4**	**116**	**68**	**7**	**23**	**26**	**17**	**17**	**405**

Source: Collier County

2.5 HAZARD PROFILES, ANALYSIS, AND VULNERABILITY

2.5.1 Flood

Hazard Description

Flooding is defined by the rising and overflowing of water onto normally dry land. As defined by FEMA, a flood is a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties. Flooding can result from an overflow of inland waters or an unusual accumulation or runoff of surface waters from any source.

Flooding is the most frequent and costly of all natural hazards in the United States and has caused more than 10,000 deaths since 1900. Approximately 90 percent of presidentially declared disasters result from flood-related natural hazard events. Taken as a whole, more frequent, localized flooding problems that do not meet federal disaster declaration thresholds ultimately cause most damages across the United States.

Sources and Types of Flooding

Per the 2012 Flood Insurance Study (FIS), flooding results from two major sources in Collier county. Coastal areas are subject to inundation from ocean surges, whereas inland areas can become flooded when rainfall accumulates in low, flat areas. Rainfall primarily occurs during thunderstorms in the summer months, with additional rainfall resulting from the passage of hurricanes. A transition region near the coast is vulnerable to both rainfall and ocean surge flooding. Coastal lands typically lie below an elevation of 9 feet, North America Vertical Datum of 1988 (NAVD88), and are subject to flooding from hurricanes and tropical storms.

The general topography of Collier County is extremely flat, with land slopes on the order of 1 foot per mile to 0.5 foot per mile in the interior regions. There are no major natural streams, such as those found in areas of steeper topography. Rather, flow occurs over wide, flat areas, in sloughs, and through manmade canal systems. Natural, well-drained channels are apparent only close to the coast. The lack of steep slopes precludes rapid runoff; therefor, water accumulates in ponded areas and slowly infiltrates the groundwater system or sluggishly drains over the land.

Coastal Tidal Flooding: All lands bordering the Gulf Coast are susceptible to tidal effects and flooding. Coastal land such as sand bars, barrier islands and deltas provide a buffer zone to help protect human life and real property relative to the sea much as flood plains provide a buffer zone along rivers and other bodies of water. Coastal floods usually occur because of abnormally high tides or tidal waves, storm surge and heavy rains in combination with high tides, tropical storms and hurricanes.

Overland Sheet Flow: Due to the relative flatness of Collier County's topography, historical water flow has always been shallow overland sheet flow during the wet season, when this flow enters sloughs and the man-made canal system.

Shallow Ponding: Because much of the County is flat, whatever rainfall doesn't she flow from an area tends to pond and percolate into the ground, causing water tables to rise during the wet season to within a foot or less of the ground in most of Collier County, so there is little soil storage.

Other forms of flooding in the county might include:

Flash or Rapid Flooding: A flash flood occurs when water levels rise at an extremely fast rate as a result of intense rainfall over a brief period, possibly from slow-moving intense thunderstorms and sometimes combined with saturated soil, or impermeable surfaces. Flash flooding can happen in Special Flood Hazard Areas (SFHAs) as delineated by the National Flood Insurance Program (NFIP) and can also happen in areas not associated with floodplains. Flash flood hazards caused by surface water runoff are most common in urbanized areas, where greater population density generally equates to more impervious surface (e.g., pavement and buildings) which increases the amount of surface water generated.

Flash flooding is a dangerous form of flooding which can reach full peak in only a few minutes. Rapid onset allows little or no time for protective measures. Flash flood waters move at very fast speeds and can move boulders, tear out trees, scour channels, destroy buildings, and obliterate bridges. Flash flooding can result in higher loss of life, both human and animal, than slower developing river and stream flooding.

Localized/Stormwater Flooding: Localized stormwater flooding can occur throughout Collier County. Localized stormwater flooding occurs when heavy rainfall and an accumulation of runoff overburden the stormwater drainage system. The cause of localized stormwater flooding in Collier County can be attributed to its generally flat topography, among other factors.

Localized flooding may be caused by the following issues:

- **Inadequate Capacity –** An undersized/under capacity pipe system can cause water to back-up behind a structure which can lead to areas of ponded water and/or overtopping of banks.
- **Clogged Inlets** – Debris covering the asphalt apron and the top of grate at catch basin inlets may contribute to an inadequate flow of stormwater into the system. Debris within the basin itself may also reduce the efficiency of the system by reducing the carrying capacity.
- **Blocked Drainage Outfalls** – Debris blockage or structural damage at drainage outfalls may prevent the system from discharging runoff, which may lead to a back-up of stormwater within the system.
- **Improper Grade** – Poorly graded asphalt around catch basin inlets may prevent stormwater from entering the catch basin as designed. Areas of settled asphalt may create low spots within the roadway that allow for areas of ponded water.

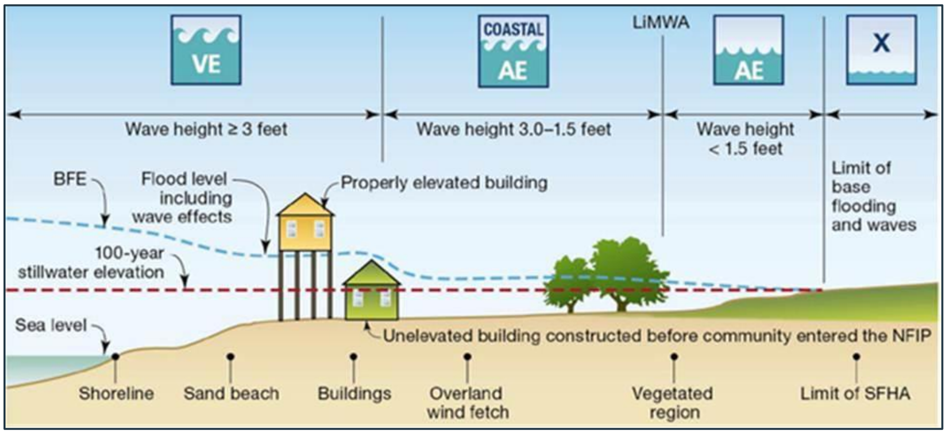
While localized flooding may not be as destructive as coastal flooding, it is a chronic problem. The repetitive damage caused by such flooding can add up. Sewers may back up, yards can be inundated, and homes, businesses and vehicles can be flooded. Drainage and sewer systems not design to carry the capacity currently needed to handle increased storm runoff can cause water to back into basements and damage mechanical systems. These impacts, and other localized flooding impacts, can create public health and safety concerns.

In addition to these different types of flooding, flooding in Collier County is a factor of the amount and timing of rainfall and the tide cycle elevation. The amount of rainfall occurring in March would not have the same flooding effect if the same amount occurred in September. During the dry season, the water table elevation typically drops to several feet below natural ground elevations. This allows for larger storage volume in the soil, lakes, canals, ditches, and swales. During the wet season, however, the water table elevation is often near the natural ground surface, lakes are filled, and ditches are flowing. The rainfall added to such conditions creates more stormwater runoff.

Flooding and Floodplains

In coastal areas, flooding occurs due to high tides, tidal waves, storm surge, or heavy rains. In these areas, flood hazards typically include the added risk of wave action delineated by the VE Zone and Coastal AE Zone. Wave height and intensity decreases as floodwaters move inland. Figure 2.1 shows the typical coastal floodplain and the breakdown of flood zones in these settings. These flood zones are discussed further in Table 2.9

Figure 2.1 – Characteristics of a Coastal Floodplain



Source: FEMA

In its common usage, the floodplain most often refers to that area that is inundated by the "100-year flood," which is the flood that has a 1% chance in any given year of being equaled or exceeded. The 500-year flood is the flood that has a 0.2 percent chance of being equaled or exceeded in any given year. The potential for flooding can change and increase through various land use changes and changes to land surface, which result in a change to the floodplain. A change in environment can create localized flooding problems inside and outside of natural floodplains by altering or confining natural drainage channels. These changes are most often created by human activity.

The 100-year flood, which is the minimum standard used by most federal and state agencies, is used by the National Flood Insurance Program (NFIP) as the standard for floodplain management and to determine the need for flood insurance. Participation in the NFIP requires adoption and enforcement of a local floodplain management ordinance which is intended to prevent unsafe development in the floodplain, thereby reducing future flood damages. Participation in the NFIP allows for the federal government to make flood insurance available within the community as a financial protection against flood losses. Since floods have an annual probability of occurrence, have a known magnitude, depth and velocity for each event, and in most cases, have a map indicating where they will likely occur, they are in many ways often the most predictable and manageable hazard.

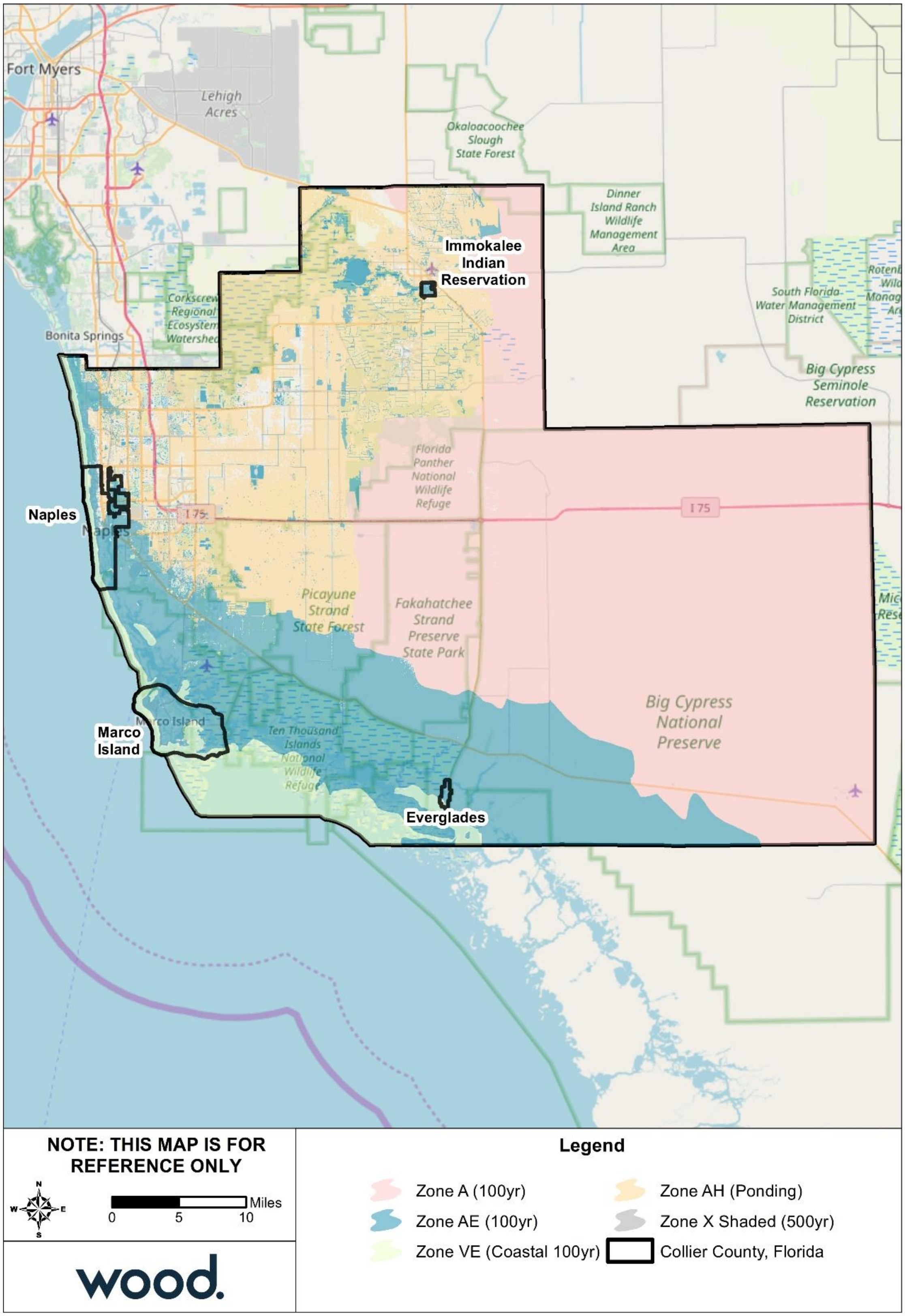
Warning Time: 3 – 6 to 12 hours

Duration: 3 – Less than 1 week

Location

Figure 2.2 reflects the effective mapped flood insurance zones for Collier County. Maps for each participating jurisdiction are provided in the jurisdictional annexes.

Figure 2.2 – FEMA Flood Hazard Areas in Collier County



Source: FEMA Effective DFIRM

Extent

Flood extent can be defined by the amount of land in the floodplain and the potential magnitude of flooding as measured by flood height and velocity.

Regulated floodplains are illustrated on inundation maps called Flood Insurance Rate Maps (FIRMs). It is the official map for a community on which FEMA has delineated both the Special Flood Hazard Areas (SFHAs) and the risk premium zones applicable to the community. SFHAs represent the areas subject to inundation by the 100-year flood event. Structures located within the SFHA have a 26-percent chance of flooding during the life of a standard 30-year mortgage. Flood prone areas were identified within Collier County using the Effective FIRMs, dated May 16, 2012. Table 2.9 summarizes the flood insurance zones identified by the Digital FIRM (DFIRM).

Table 2.9 – Mapped Flood Insurance Zones within Collier County

Zone	Description
VE	Also known as the coastal high hazard areas. They are areas subject to high velocity water including waves; they are defined by the 1% annual chance (base) flood limits (also known as the 100-year flood) and wave effects 3 feet or greater. The hazard zone is mapped with base flood elevations (BFEs) that reflect the combined influence of stillwater flood elevations, primary frontal dunes, and wave effects 3 feet or greater.
AE	AE Zones, also within the 100-year flood limits, are defined with BFEs that reflect the combined influence of stillwater flood elevations and wave effects less than 3 feet. The AE Zone generally extends from the landward VE zone limit to the limits of the 100-year flood from coastal sources, or until it reaches the confluence with riverine flood sources. The AE Zones also depict the SFHA due to riverine flood sources, but instead of being subdivided into separate zones of differing BFEs with possible wave effects added, they represent the flood profile determined by hydrologic and hydraulic investigations and have no wave effects. The Coastal AE Zone is differentiated from the AE Zone by the Limit of Moderate Wave Action (LiMWA) and includes areas susceptible to wave action between 1.5 to 3 feet.
AH	Areas subject to inundation by 1% -annual-chance shallow flooding (usually areas of ponding) where average depths are between one and three feet. Base Flood Elevations (BFEs) derived from detailed hydraulic analyses are shown in this zone.
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths or base flood elevations are shown within these zones.
0.2% Annual Chance (shaded Zone X)	Moderate risk areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by a levee. No BFEs or base flood depths are shown within these zones. (Zone X (shaded) is used on new and revised maps in place of Zone B.)
Zone X (unshaded)	Minimal risk areas outside the 1-percent and .2-percent-annual-chance floodplains. No BFEs or base flood depths are shown within these zones. Zone X (unshaded) is used on new and revised maps in place of Zone C.

Over 95 percent of Collier County falls within the SFHA. Table 2.10 provides a summary of the County's total area (excluding open water) by flood zone on the 2012 effective DFIRM. Figure 2.3 shows the depth of flooding predicted from a 1% annual chance flood.

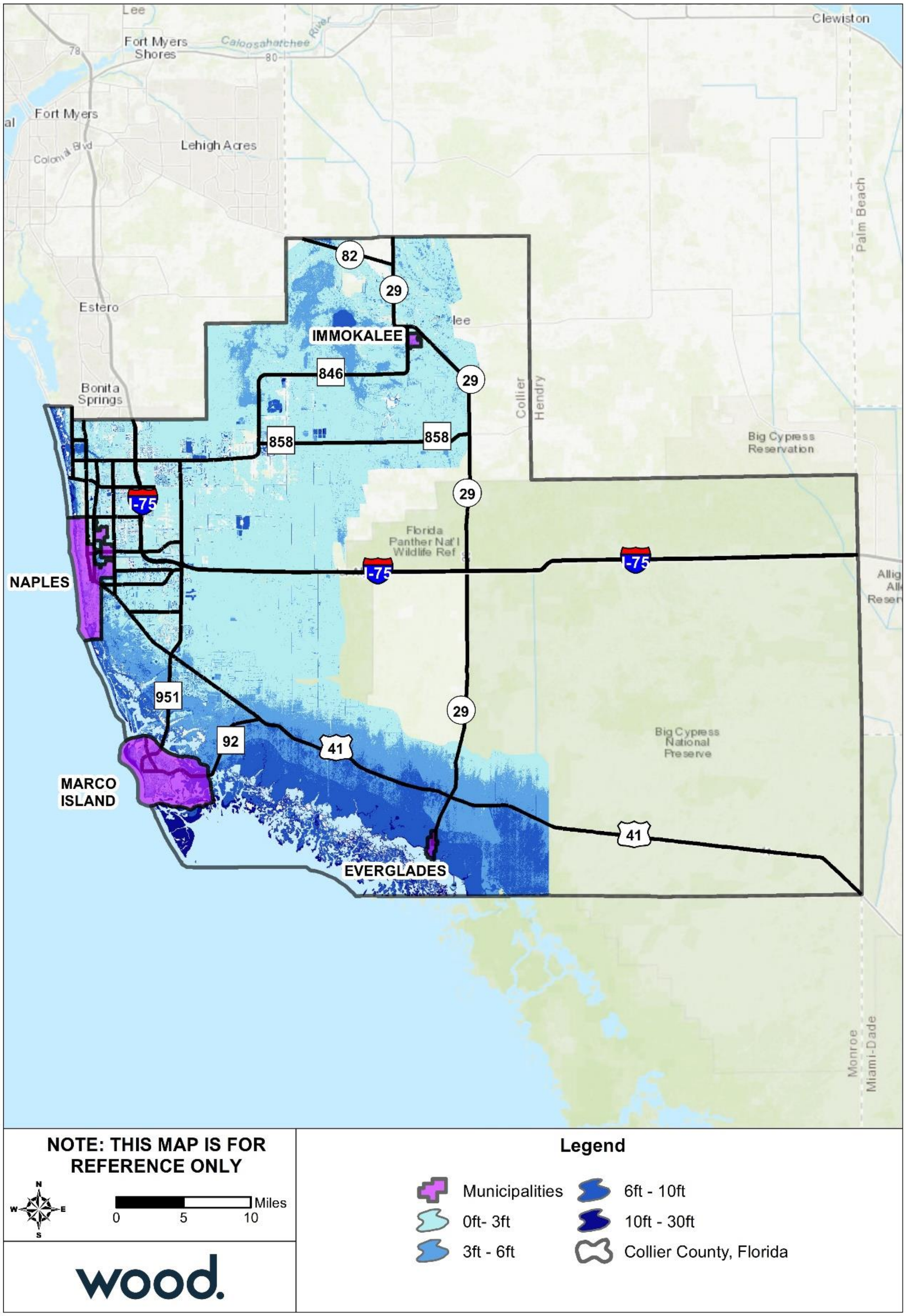
Table 2.10 – Flood Zone Acreage in Collier County

Flood Zone	Acreage	Percent of Total (%)
Everglades City		
A	0.0	0.0%
AE	608.4	80.3%
AH	0.0	0.0%
VE	147.6	19.5%
Unshaded X	0.0	0.0%
0.2% Annual Chance Flood Hazard	1.2	0.2%
Total	757.3	--
SFHA Total	**756.0**	**99.8%**
Immokalee Reservation		
A	0.0	0.0%
AE	519.3	86.6%
AH	2.1	0.4%
VE	0.0	0.0%
Unshaded X	61.1	10.2%
0.2% Annual Chance Flood Hazard	17.2	2.9%
Total	599.6	--
SFHA Total	**521.4**	**86.9%**
Marco Island		
A	0.0	0.0%
AE	9,858.1	62.5%
AH	0.0	0.0%
VE	5,623.2	35.7%
Unshaded X	235.5	1.5%
0.2% Annual Chance Flood Hazard	51.2	0.3%
Total	15,768.0	--
SFHA Total	**15,481.3**	**98.2%**
Naples		
A	0.0	0.0%
AE	7,198.0	59.9%
AH	449.7	3.7%
VE	2,998.3	25.0%
Unshaded X	772.5	6.4%
0.2% Annual Chance Flood Hazard	597.0	5.0%
Total	12,015.5	--
SFHA Total	**10,646.0**	**88.6%**
Unincorporated Collier County		
A	660,494.5	49%
AE	294,133.9	21.8%
AH	280,605.8	20.8%
VE	55,582.8	4.1%
Unshaded X	19,963.0	1.5%
0.2% Annual Chance Flood Hazard	37,174.7	2.8%
Total	1,347,954.7	--
SFHA Total	**1,290,817.0**	**95.8%**

Flood Zone	Acreage	Percent of Total (%)
Collier County Total		
A	660,494.5	48.0%
AE	312,317.7	22.7%
AH	281,057.6	20.4%
VE	64,351.9	4.7%
Unshaded X	38,243.8	2.8%
0.2% Annual Chance Flood Hazard	20,629.6	1.5%
Total	1,377,095.0	--
SFHA Total	**1,318,221.7**	**95.7%**

Source: FEMA Effective DFIRM

Figure 2.3 – Flood Depth, 100-Year Floodplain, Collier County



Source: FEMA Effective DFIRM

The NFIP utilizes the 100-year flood as a basis for floodplain management. The Flood Insurance Study (FIS) defines the probability of flooding as flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 100-year period (recurrence intervals). Considered another way, properties in a 100-year flood zone have a one percent probability of flooding during any given year. Mortgage lenders require that owners of properties with federally-backed mortgages located within SFHAs purchase and maintain flood insurance policies on their properties. Consequently, newer and recently purchased properties in the community are typically insured against flooding.

Impact: 3 – Critical

Spatial Extent: 3 – Moderate

Historical Occurrences

Table 2.11 details the historical occurrences of flooding identified from 2000 through 2019 by NCEI Storm Events database. It should be noted that only those historical occurrences listed in the NCEI database are shown here and that other, unrecorded or unreported events may have occurred within the planning area during this timeframe.

Table 2.11 – NCEI Records of Flooding, 2000-2019

Type	Event Count	Deaths/ Injuries	Reported Property Damage
Coastal Flood	9	0/0	$71,000
Flash Flood	6	0/0	$300,000
Flood	11	0/0	$43,500
Heavy Rain	4	0/0	$60,000
Storm Surge	5	0/0	$6,060,000
Total	**35**	**0/0**	**$6,534,500**

Source: NCEI

According to NCEI, 35 recorded flood events affected the planning area from 2000 to 2019 causing an estimated $6,534,500 in property damage, with no fatalities, injuries, or crop damage.

Table 2.12 provides a summary of this historical information by location. It is important to note that many of the events attributed to the county are countywide or include incorporated areas. Similarly, though some events have a starting location identified, the event may have covered a larger area including multiple jurisdictions. Still, this list provides an indication of areas that may be particularly flood prone.

Table 2.12 – Summary of Historical Flood Occurrences by Location, 2000-2019

Location	Event Count	Deaths/Injuries	Property Damage
Immokalee Reservation	2	0/0	$0
Marco Island	5	0/0	$193,000
Naples	10	0/0	$50,500
Unincorporated/Countywide	18	0/0	$6,291,000
Total	**35**	**0/0**	**$6,534,500**

Source: NCEI

The following event narratives are provided in the NCEI Storm Events Database and illustrate the impacts of flood events on the county:

July 23, 2001 – At least four residences and 20 vehicles were damaged by flood waters on Marco Island and in East Naples. 48-hour rainfall amounts of 4 to 10 inches of rain were measured over southwest Florida as a trough of low pressure stalled in the eastern Gulf of Mexico. Radar estimated 8-12 inches of rain fell over a 96-hour period in Marco Island. Strong onshore winds caused some minor tidal flooding of streets.

September 29, 2003 – Very heavy rainfall fell across southwest Florida with radar estimated amount of 8 to 10 inches. Naples measured a record 6.99 inches. The resulting flood closed numerous roads in Collier County. Numerous cars were stalled. Houses and businesses, including a shopping mall, suffered minor flood damage.

October 24, 2005 – Hurricane Wilma produced a maximum measured storm tide of 8 feet at the USGS tide gauge at the Turner River near Chokoloskee in southern Collier County, with a storm surge of 7 feet after subtracting a 1-foot astronomical tide. Significant damage to structures close to the water was observed in Chokoloskee, along with some washing out of part of the road leading to the town. A storm tide of 7 feet was estimated in Marco Island by Collier County Emergency Management, along with significant beach erosion. An NWS survey team estimated a storm tide of 4 feet in Everglades City based on debris line heights, with little structural damage. The NOS tide gauge in Naples recorded a maximum storm tide of 4.8 feet, with a storm surge of 3.8 feet after considering astronomical tide levels.

July 16, 2008 – A low pressure area over the eastern Gulf of Mexico provided a moist southwest flow across South Florida, leading to heavy rain bands which set up along portions of the Southwest Florida gulf coast. A combination of 6 to 8 inches of rain over a short period of time and high tide caused flooding on Marco Island. Coconuts, palm fronds, and plastic bags also clogged storm drains at some locations, exacerbating the flooding. One towing company in Marco Island pulled out 35 to 40 cars alone. Water reached around 2 feet deep in some roadways and a few inches deep in some residences. Several roads were closed, including the main bridge connecting Marco Island to the Mainland.

August 27, 2012 – Tropical Storm Isaac moved west-northwest across the Florida Straits south of the Florida Keys on August 26th. The northern edge of the wind and rain area associated with Isaac affected the South Florida peninsula throughout the day on the 26th. Severe beach erosion and coastal flooding occurred in Collier County on Monday, August 27th as the center of the storm moved into the Gulf of Mexico. A storm surge of 2.05 feet was measured at the Naples pier. Farther east along the coast, inundation depths as high as 3 feet were reported in Goodland and Everglades city. Inundation in the Naples area was about 1 foot. Most damage from coastal flooding was to infrastructure in Goodland and Everglades City areas and was estimated at $400,000. Severe beach erosion in the Naples and Marco Island areas led to damaged estimated at $5.6 million.

August 4, 2014 – Intense rainfall associated with several bands of thunderstorms developed across much of the Naples area during the early afternoon. The band moved little between 1230 and 1500 EDT with the training of cells leading to copious rain amounts and severe street flooding in parts of Naples and Golden Gate. The first report stated that at least two feet of water was on roads near Airport Road and Mercantile Avenue with cars stalled out. The Collier County Sheriff's Office reported at around 1510 EDT that there was severe flooding and stalled vehicles from Collier Blvd. to Tamiami Trail with some roads closed. Rainfall totals included 7 inches at Naples Beach Hotel and Club with 6.73 inches at the Naples Municipal Airport. A trained spotter measured 4.21 inches in just under an hour in the area of Airport and Pine Ridge Roads. A few businesses had water enter their structures, with one business estimating $12,000 in damage. Over 300 cars were towed from area streets due to stalling in deep water. Damage total indicated in this report is estimated and based on number of cars stalled as well as the damage to businesses from water intrusion.

June 6, 2017 – A disturbance meandering across the Gulf of Mexico in combination with an upper level system across the western Gulf of Mexico lead to nearly a week of heavy rainfall across South Florida. The heaviest rainfall fell in the corridor from Marco Island and southern Collier county northeast into Broward and southern Palm Beach counties. Many locations in this swath saw rainfall amounts in excess of 9 to 10 inches in a single day, and as high as almost 15 inches on the heaviest day, resulting in event totals of 15 to 20 inches in this area. This rainfall forced the closure of numerous roads across South Florida, especially in Collier and Broward counties where cars were trapped at times in the flood waters.

Multiple streets in Marco Island were closed due to flooding, including Bald Eagle Road from Bayport to San Marco Roads and South Collier Boulevard near Winterberry Drive. Multiple cars were stalled in the middle of the road at the time of call. Marco Island had received 6 to 8 inches of rainfall in 6 to 12 hours, with a storm total of up to 15 inches over a 3-day period. Flooding across central and eastern Collier County resulted in the closure of Gulf Coast Visitor Center of Everglades National Park, in Everglades City, the Everglades City Airport, as well as Big Cypress National Preserve from June 6th through June 7th. Pictures received from the National Park Service show flooding of numerous access roads, trails, campgrounds, and bridges around the park, along with widespread areas of higher than normal water across the park, including flooding of normally dry forest. The Ochopee Post Office was flooding during the event, with water encroaching on Tamiami Trail (US 41) in places where it bisects the park. County Road 29 south of Tamiami Trail (US 41), which is used to access many of these areas, was also closed.

August 25-27, 2017 – A slow moving tropical disturbance first moved west across South Florida, then northeast across Central and North Florida as a frontal boundary dropped into the state. This system would develop into Potential Tropical Cyclone 10 as it moved up the east coast, leaving a trailing trough that would bring additional heavy rainfall through Aug 29th. Significant flooding was reported over three days across Collier County, especially across the Naples area, with multiple roadways and intersections closed and standing water across the city. Flood waters entered a guest home along Trail Terrace, along with stranding vehicles along 10th Street south of 5th Avenue. As rain continued to fall, there was additional flooding along Logan Boulevard as well as Vanderbilt beach, with several sections impassable due to flooding.

September 10, 2017 – Major Hurricane Irma made landfall in Southwest Florida on Marco Island as a Category 3 hurricane around 3:30 PM EDT on September 10th. The storm traveled north through southwest Florida through the evening. Effects from Irma were felt across South Florida from September 9th through September 11th. Irma brought a significant storm surge on both coasts of South Florida and widespread rainfall and some flooding across the region. From the period between 8 AM September 9th and 8 AM September 11th, 8 to 15 inches of rain were measured over interior portions of Southwest Florida. This rainfall near the end of a wet summer led to significant flooding.

Storm surge across Collier County ranged from 4 to 8 feet, highest in the Chokoloskee and Everglades City area and lowest at the northern Collier County coast. Impacts were most severe in Chokoloskee, Everglades City, Plantation Island and Goodland where numerous homes were flooded and suffered major to catastrophic damage. Storm survey and data from USGS rapid deployment gauges indicated highest inundation from storm surge in Chokoloskee with up to 8 feet at waterfront, approximately 8 feet above Mean Higher High Water (MHHW), as well as 3-5 feet of inundation across the island. In Everglades City, there was a maximum 6 ft of inundation at the Everglades National Park Gulf Visitor Center, with 2-4 feet across the town and as high as 5 feet in a few areas. USGS high water mark data showed 1-2 feet of inundation as far inland as Tamiami Trail between State Road 29 and Collier-Seminole State Park. In Goodland, maximum storm tide was about 5.5 ft above MHHW, translating to between 5-6 ft of inundation at the waterfront and 3-4 ft across most of town. In Marco Island, storm tide was as high as 4.5 feet above MHHW, translating to between 2-4 ft inundation mainly over south and east parts of the island. Inland penetration was generally less than a half-mile. In Naples, NOS tide gauge at Naples Pier measured maximum storm tide of 5.14 feet above MHHW. Between 3-4 feet of inundation was noted along the Gulf beachfront within 1 block of beach, with less than a half-mile of inland penetration. Along

Naples Bay, a maximum storm tide of about 2-3 ft above MHHW resulted in inundation of 1 to 2 feet on west side of bay just south of Tamiami Trail. This led to flooding of restaurants and shops.

October 9, 2018 – The high October astronomical tides, King tides, in combination with the strong winds and minor surge from Hurricane Michael in the Gulf of Mexico brought a couple days of minor saltwater flooding along both the Atlantic and Gulf coasts of South Florida. NBC2 in Fort Myers reported water covering County Road 92A between Marco Island and Goodland. Videos and photos shared via social media shows abnormally high tide moving into and above sand dunes at Naples Beach as well as water over topping the seawall and approaching the backs of residences in the Isles of Capri neighborhood.

Probability of Future Occurrence

By definition of the 100-year flood event, SFHAs are defined as those areas that will be inundated by the flood event having a 1-percent chance of being equaled or exceeded in any given year. Properties located in these areas have a 26 percent chance of flooding over the life of a 30-year mortgage.

The 500-year flood area is defined as those areas that will be inundated by the flood event having a 0.2-percent chance of being equaled or exceeded in any given year; it is not the flood that will occur once every 500 years.

While exposure to flood hazards vary across jurisdictions, all jurisdictions have at least some area of land in FEMA flood hazard areas. Additionally, there is risk of localized and stormwater flooding as well as severe wind-driven surge in areas outside the SFHA and at different intervals than the 1% annual chance flood. Based on these considerations as well as the 35 flood-related events recorded by NCEI over the last 20 years, the probability of flooding is considered highly likely (100% annual probability) for all jurisdictions.

Probability: 4 – Highly Likely

Climate Change

Per the Fourth National Climate Assessment, frequency and intensity of heavy precipitation events is expected to increase across the country. More specifically, it is “very likely” (90-100% probability) that most areas of the United States will exhibit an increase of at least 5% in the maximum 5-day precipitation by late 21st century. Additionally, increases in precipitation totals are expected in the Southeast. The mean change in the annual number of days with rainfall over 1 inch for the Southeastern United States is 0.5 to 1.5 days. Therefore, with more rainfall falling in more intense incidents, the region may experience more frequent flash flooding. Increased flooding may also result from more intense tropical cyclone; researchers have noted the occurrence of more intense storms bringing greater rainfall totals, a trend that is expected to continue as ocean and air temperatures rise.

Vulnerability Assessment

Methodologies and Assumptions

Wood conducted a Level 2 Hazus Flood Simulation by leveraging the 100-year (Zone AE, VE & AH) flood boundaries from the effective FEMA Flood Insurance Study dated 5/26/2012. Base Flood Elevations were converted to a depth raster using LiDAR topography obtained from USGS. Wood also leveraged the 2019 parcel data provided by Collier County for the loss determination. Parcels that were potentially at risk of flooding from the three 100-year flood zones listed above were selected for analysis. From there, Wood excluded all parcels for which a LOMC determination was made following the effective FIS date of 5/26/2012; this removed approx. 7,400 parcels from the loss estimation.

Losses were derived in Hazus using USACE depth damage functions, shown in Table 2.13. Flood damage is directly related to the depth of flooding by the application of a depth damage curve. In applying the curve, a specific depth of water translates to a specific percentage of damage to the structure, which translates to the same percentage of the structure's replacement value. Figure 2.3 depicts the depth of flooding that can be expected within the Collier County planning area during the 100-year flood event.

Table 2.13 – Depth Damage Percentages

	Percent Damaged (%)						
Depth (ft)	Agricultural	Commercial	Education	Government	Industrial	Religious	Residential
0	0	1	0	0	1	0	18
1	6	9	5	5	10	10	22
2	11	14	7	8	12	11	25
3	15	16	9	13	15	11	28
4	19	18	9	14	19	12	30
5	25	20	10	14	22	12	31
6	30	23	11	15	26	13	40
7	35	26	13	17	30	14	43
8	41	30	15	19	35	14	43
9	46	34	17	22	29	15	45
10	51	38	20	26	42	17	46
11	57	42	24	31	48	19	47
12	63	47	28	37	50	24	47
13	70	51	33	44	51	30	49
14	75	55	39	51	53	38	50
15	79	58	45	59	54	45	50
16	82	61	52	65	55	52	50
17	84	64	59	70	55	58	51
18	87	67	64	74	56	64	51
19	89	69	69	79	56	69	52
20	90	71	74	83	57	74	52
21	92	74	79	87	57	78	53
22	93	76	84	91	57	82	53
23	95	78	89	95	58	85	54
24	96	80	94	98	58	88	54

Source: Hazus

Building foundation types were not available in the parcel or building data provided by Collier County but are required for Hazus. Therefore, based on local knowledge and experience, Wood made the assumption that 90% of the foundations in Collier County are slab on grade, 5% are crawl space and 5% are elevated. Number of stories was also not provided so by default Hazus assumes all buildings are one story. Finally, 49 parcels had to be removed from the Hazus analysis because they fell outside the Hazus census tract extent.

Loss numbers are based on improved parcel values listed in the 2019 parcel data from Collier County. Content value estimations are based on Hazus methodologies of estimating value as a percent of improved structure values by property type. Table 2.14 shows the breakdown of the different property types and their estimated content replacement value percentages.

Table 2.14 – Content Replacement Factors

Property Type	Content Replacement Values
Residential	50%
Commercial	100%
Educational	100%
Government	100%
Religious	100%
Industrial/Agriculture	150%

Source: Hazus

People

Certain health hazards are common to flood events. While such problems are often not reported, three general types of health hazards accompany floods. The first comes from the water itself. Floodwaters carry anything that was on the ground that the upstream runoff picked up, including dirt, oil, animal waste, and lawn, farm and industrial chemicals. Pastures and areas where farm animals are kept or where their wastes are stored can contribute polluted waters to the receiving streams.

Debris also poses a risk both during and after a flood. During a flood, debris carried by floodwaters can cause physical injury from impact. During the recovery process, people may often need to clear debris out of their properties but may encounter dangers such as sharp materials or rusty nails that pose a risk of tetanus. People must be aware of these dangers prior to a flood so that they understand the risks and take necessary precautions before, during, and after a flood.

Floodwaters also saturate the ground, which leads to infiltration into sanitary sewer lines. When wastewater treatment plants are flooded, there is nowhere for the sewage to flow. Infiltration and lack of treatment can lead to overloaded sewer lines that can back up into low-lying areas and homes. Even when it is diluted by flood waters, raw sewage can be a breeding ground for bacteria such as E. coli and other disease-causing agents.

The second type of health problem arises after most of the water has gone. Stagnant pools can become breeding grounds for mosquitoes, and wet areas of a building that have not been properly cleaned breed mold and mildew. A building that is not thoroughly cleaned becomes a health hazard, especially for small children and the elderly.

Another health hazard occurs when heating ducts in a forced air system are not properly cleaned after inundation. When the furnace or air conditioner is turned on, the sediments left in the ducts are circulated throughout the building and breathed in by the occupants. If a City water system loses pressure, a boil order may be issued to protect people and animals from contaminated water.

The third problem is the long-term psychological impact of having been through a flood and seeing one's home damaged and personal belongings destroyed. The cost and labor needed to repair a flood-damaged home puts a severe strain on people, especially the unprepared and uninsured. There is also a long-term problem for those who know that their homes can be flooded again. The resulting stress on floodplain residents takes its toll in the form of aggravated physical and mental health problems.

Floods can also result in fatalities. Individuals face high risk when driving through flooded streets. According to NCEI records, however, there have been no deaths in Collier County caused by flood events.

An estimate of population at risk to flooding was developed based on the assessment of residential property at risk. Counts of residential buildings at risk were multiplied by a household factor for each jurisdiction, derived from a weighted average of the 2014-2018 American Community Survey's average household size for owner- and renter-occupied housing. The resulting estimates of population at risk are shown in Table 2.15. Overall, approximately 75,289 people live in high-risk flood zones.

Table 2.15 – Collier County Population at Risk to Flood

Jurisdiction	Residential Parcels at Risk	Household Factor	Population at Risk
Everglades City	367	1.96	719
Immokalee Reservation	-	4.43	-
Marco Island	7,667	2.08	15947
Naples	6,770	1.96	13269
Unincorporated Collier County	77,395	2.55	197357
Total	**92,199**	**--**	**227,293**

Source: FEMA; U.S. Census Bureau 2014-2018 ACS 5-Year Estimates; Collier County 2019 parcel data

Property

Residential, commercial, and public buildings, as well as critical infrastructure such as transportation, water, energy, and communication systems may be damaged or destroyed by flood waters.

Table 2.16 details the estimated losses for the 100-year flood event, calculated using the methodology and assumptions described above. The total damage estimate value is based on damages to the total of improved building value and contents value. Land value is not included in any of the loss estimates as generally land is not subject to loss from floods.

Table 2.16 – Estimated Building Damage and Content Loss for 1% Annual Chance Flood

Occupancy Type	Total Parcels with Loss	Total Value (Building & Contents)	Estimated Building Damage	Estimated Content Loss	Estimated Total Damage	Loss Ratio
Everglades City						
Agriculture	0	$0	$0	$0	$0	0%
Commercial	23	$7,556,456	$90,345	$421,163	$511,508	7%
Educational	1	$438,142	$167	$900	$1,066	0%
Government	7	$4,408,010	$75,771	$524,045	$599,816	14%
Industrial	5	$950,048	$6,077	$45,458	$51,535	5%
Religious	0	$0	$0	$0	$0	0%
Residential	391	$50,958,570	$3,552,298	$1,915,671	$5,467,969	11%
Total	**427**	**$64,311,226**	**$3,724,658**	**$2,907,237**	**$6,631,895**	**10%**
Immokalee Reservation						
Agriculture	0	$0	$0	$0	$0	0%
Commercial	0	$0	$0	$0	$0	0%
Educational	0	$0	$0	$0	$0	0%
Government	1	$65,687,630	$4,401,540	$25,491,022	$29,892,562	46%
Industrial	0	$0	$0	$0	$0	0%
Religious	0	$0	$0	$0	$0	0%
Residential	0	$0	$0	$0	$0	0%
Total	**1**	**$65,687,630**	**$4,401,540**	**$25,491,022**	**$29,892,562**	**46%**

Occupancy Type	Total Parcels with Loss	Total Value (Building & Contents)	Estimated Building Damage	Estimated Content Loss	Estimated Total Damage	Loss Ratio
Marco Island						
Agriculture	0	$0	$0	$0	$0	0%
Commercial	177	$125,701,074	$2,941,386	$10,551,105	$13,492,491	11%
Educational	0	$0	$0	$0	$0	0%
Government	9	$6,694,338	$434,624	$2,670,976	$3,105,600	46%
Industrial	13	$5,791,493	$133,714	$557,344	$691,057	12%
Religious	1	$16,400,542	$860,168	$5,066,961	$5,927,129	36%
Residential	9,589	$5,826,797,939	$641,340,871	$398,199,393	$1,039,540,264	18%
Total	**9,789**	**$5,981,385,385**	**$645,710,763**	**$417,045,777**	**$1,062,756,540**	**18%**
Naples						
Agriculture	0	$0	$0	$0	$0	0%
Commercial	284	$591,654,328	$18,961,978	$55,415,850	$74,377,827	13%
Educational	0	$0	$0	$0	$0	0%
Government	41	$103,954,242	$2,299,546	$14,887,922	$17,187,468	17%
Industrial	11	$16,584,525	$113,808	$329,072	$442,879	3%
Religious	8	$12,358,250	$428,326	$2,915,657	$3,343,983	27%
Residential	16,105	$18,582,524,955	$3,021,725,462	$1,845,367,142	$4,867,092,604	26%
Total	**16,449**	**$19,307,076,300**	**$3,043,529,120**	**$1,918,915,642**	**$4,962,444,762**	**26%**
Unincorporated Collier County						
Agriculture	169	$49,803,960	$1,484,657	$5,626,798	$7,111,455	14%
Commercial	1,012	$1,277,354,130	$16,099,459	$62,896,829	$78,996,288	6%
Educational	6	$142,789,728	$6,279,973	$42,796,184	$49,076,157	34%
Government	106	$158,837,654	$4,842,582	$29,444,865	$34,287,447	22%
Industrial	167	$308,890,810	$1,266,269	$4,192,617	$5,458,886	2%
Religious	33	$40,506,780	$1,432,249	$8,882,215	$10,314,464	25%
Residential	84,719	$37,233,992,061	$3,368,889,584	$2,042,320,159	$5,411,209,743	15%
Total	**86,212**	**$39,212,175,123**	**$3,400,294,774**	**$2,196,159,667**	**$5,596,454,441**	**14%**
Countywide Totals						
Agriculture	169	$49,803,960	$1,484,657	$5,626,798	$7,111,455	14%
Commercial	1,496	$2,002,265,988	$38,093,168	$129,284,946	$167,378,115	8%
Educational	7	$143,227,870	$6,280,140	$42,797,084	$49,077,224	34%
Government	164	$339,581,874	$12,054,064	$73,018,829	$85,072,893	25%
Industrial	196	$332,216,875	$1,519,867	$5,124,490	$6,644,357	2%
Religious	42	$69,265,572	$2,720,744	$16,864,832	$19,585,576	28%
Residential	110,804	$61,694,273,525	$7,035,508,214	$4,287,802,365	$11,323,310,580	18%
Total	**112,878**	**$64,630,635,664**	**$7,097,660,855**	**$4,560,519,345**	**$11,658,180,200**	**18%**

Source: Hazus

The loss ratio is the loss estimate divided by the total potential exposure (i.e., total of improved and contents value for all buildings located within the 100-year floodplain) and displayed as a percentage of loss. FEMA considers loss ratios greater than 10% to be significant and an indicator a community may have more difficulties recovering from a flood. Loss ratios for all participating jurisdictions are at or above 10%.. Therefore, in the event of a flood with a magnitude of the 1%-annual-chance event or greater, the planning area would face extreme difficulty in recovery. Even smaller, more probabilistic floods may also result in the county having difficulty recovering. Estimated loss ratios are greatest in Immokalee

Reservation and the City of Naples, therefore these jurisdictions may face the greatest potential impacts from a flood event.

Across the planning area there are 244 critical facilities located in the AE, A, and AH zones and 2 facilities located in the VE zone which may be at risk to damages. Table 2.17 details these critical facilities at risk to flooding by type. Table 2.18 lists each critical facility at risk to flood and the flood zone and estimated 100-year flood depth at that location.

Table 2.17 – Summary of Critical Facilities at Risk to Flood, 1% Annual Chance Event

	Critical Facility Count by SFHA Zone				
Facility Type	**Zone A**	**Zone AE**	**Zone AH**	**Zone VE**	**Total Facilities at Risk**
Schools	-	11	4	-	15
Fire & EMS	2	26	17	-	45
Government	-	3	-	-	3
Hazmat	6	37	38	1	82
Health	-	19	19	-	38
Law Enforcement	-	5	1	-	6
Public Works	2	8	5	-	15
Transportation	3	7	2	1	13
Utilities	-	8	9	-	17
Water	2	7	3	-	12
Total	**15**	**131**	**98**	**2**	**246**

Table 2.18 – Critical Facilities at Risk to Flood, 1% Annual Chance Event

Facility Type	Facility Name	Jurisdiction	Flood Zone	100-Yr Flood Depth (NAVD Ft)
Fire & EMS	Medic Rescue 60	Everglades	AE	5.7
Fire & EMS	Greater Naples Fire Station 60	Everglades	AE	5.7
Fire & EMS	Medic 50	Marco Island	AE	2.1
Fire & EMS	Marco Island Station 50 & Fire HQ	Marco Island	AE	3.4
Fire & EMS	Marco Island Station 51	Marco Island	AE	2.8
Fire & EMS	Medic 1	Naples	AE	2.3
Fire & EMS	HOC Medflight 1/BC 83	Naples	AE	1.0
Fire & EMS	Medic 24	Naples	AE	0.1
Fire & EMS	Naples Fire Station 1	Naples	AE	2.3
Fire & EMS	Naples Fire Department HQ	Naples	AE	0.8
Fire & EMS	Naples Fire Station 3	Naples	AE	0.1
Fire & EMS	Greater Naples Fire & Safety Office	Naples	AE	0.1
Fire & EMS	Naples Fire Station 2	Naples	AH	1.3
Fire & EMS	Greater Naples Fire Station 24	Naples	AE	0.1
Fire & EMS	North Collier Fire Station 47	Naples	AE	0.1
Fire & EMS	Medic 90	Unincorp. Collier County	AE	1.5
Fire & EMS	Medic 23/Als Eng 23	Unincorp. Collier County	AE	1.9
Fire & EMS	Medic 21	Unincorp. Collier County	AE	0.1
Fire & EMS	Medic 81	Unincorp. Collier County	AE	0.1
Fire & EMS	EOC & EMS Logistics & HQ	Unincorp. Collier County	AH	0.1
Fire & EMS	Medic 25	Unincorp. Collier County	AH	0.1

Facility Type	Facility Name	Jurisdiction	Flood Zone	100-Yr Flood Depth (NAVD Ft)
Fire & EMS	Medic 22	Unincorp. Collier County	AE	0.1
Fire & EMS	Medic 20	Unincorp. Collier County	AH	0.1
Fire & EMS	Medic 75/BC 80	Unincorp. Collier County	AH	0.1
Fire & EMS	Medic 76	Unincorp. Collier County	AH	0.1
Fire & EMS	Medic 44/BC 81	Unincorp. Collier County	AE	0.1
Fire & EMS	Medic 42	Unincorp. Collier County	AH	0.4
Fire & EMS	Medic 48	Unincorp. Collier County	AH	0.1
Fire & EMS	Greater Naples Fire Station 66 (Logistics)	Unincorp. Collier County	AE	3.8
Fire & EMS	Greater Naples Fire Station 90	Unincorp. Collier County	AE	2.0
Fire & EMS	Greater Naples Fire Station 23	Unincorp. Collier County	AE	1.9
Fire & EMS	Greater Naples Fire Station 21	Unincorp. Collier County	AE	0.1
Fire & EMS	Greater Naples Fire Maintenance	Unincorp. Collier County	AE	0.1
Fire & EMS	Greater Naples Fire Station 22	Unincorp. Collier County	AE	0.1
Fire & EMS	Greater Naples Fire Station 20	Unincorp. Collier County	AH	0.1
Fire & EMS	Greater Naples Fire Station 75	Unincorp. Collier County	AH	0.1
Fire & EMS	Greater Naples Fire Station 72	Unincorp. Collier County	AH	1.3
Fire & EMS	Als Res 63	Unincorp. Collier County	A	0.1
Fire & EMS	Greater Naples Fire Station 63	Unincorp. Collier County	A	0.1
Fire & EMS	Greater Naples Fire Station 71	Unincorp. Collier County	AH	2.0
Fire & EMS	North Collier Fire Station 45 & HQ	Unincorp. Collier County	AH	0.1
Fire & EMS	North Collier Fire Station 42	Unincorp. Collier County	AH	0.4
Fire & EMS	North Collier Fire Station 48	Unincorp. Collier County	AH	0.1
Fire & EMS	FPL	Unincorp. Collier County	AH	0.1
Fire & EMS	North Collier Fire Station 12	Unincorp. Collier County	AH	1.9
Government	Everglades City Hall	Everglades	AE	6.5
Government	Marco Island City Hall	Marco Island	AE	0.1
Government	Naples Town Hall	Naples	AE	0.6
Hazardous Materials	City of Everglades City - WWTP	Everglades	AE	5.3
Hazardous Materials	Embarq-Everglades Central	Everglades	AE	7.0
Hazardous Materials	City of Everglades City - Booster WTP	Everglades	AE	4.9
Hazardous Materials	Marco Island - Reverse Osmosis Facility	Marco Island	AE	0.8
Hazardous Materials	Embarq - Marco Island Central Office	Marco Island	AE	3.4
Hazardous Materials	Comcast of the South - 28624	Marco Island	AE	2.0
Hazardous Materials	Marco Island Wastewater Treatment Facility	Marco Island	AE	2.8
Hazardous Materials	Embarq - Midway South Naples	Naples	AE	3.1
Hazardous Materials	Embarq - Naples---28863	Naples	AH	0.1
Hazardous Materials	Naples Beach Hotel and Golf Club	Naples	AE	6.5
Hazardous Materials	Sears Roebuck Auto Center - 6065	Naples	AH	1.8
Hazardous Materials	Embarq - Naples Mooring Central Office	Naples	AH	1.2
Hazardous Materials	Comcast of the South - 28623	Naples	AE	1.0
Hazardous Materials	Embarq - North Naples---28862	Naples	VE	6.8
Hazardous Materials	City of Everglades City - Lee Cypress Pump Station	Unincorp. Collier County	AE	2.1
Hazardous Materials	City of Everglades City - Water Plant	Unincorp. Collier County	AE	2.6

Facility Type	Facility Name	Jurisdiction	Flood Zone	100-Yr Flood Depth (NAVD Ft)
Hazardous Materials	Port of The Islands WWTP/WTP	Unincorp. Collier County	AE	0.2
Hazardous Materials	Farm Op - Farm 7 Pump Station 01	Unincorp. Collier County	AE	2.4
Hazardous Materials	Farm Op - Farm 7 Pump Station 03	Unincorp. Collier County	AE	3.3
Hazardous Materials	Farm Op - Farm 7 Pump Station 02	Unincorp. Collier County	AE	3.2
Hazardous Materials	Embarq-Corporation - Naples - Lake Park Boulevard	Unincorp. Collier County	AE	1.4
Hazardous Materials	Gargiulo - Farm 7	Unincorp. Collier County	AE	2.8
Hazardous Materials	Farm Op - Farm 7 Greenhouse / Pump Station 9	Unincorp. Collier County	AE	1.0
Hazardous Materials	Farm Op - Farm 7 Pump Station 04	Unincorp. Collier County	AE	1.8
Hazardous Materials	Farm Op - Farm 7 Pump Station 05	Unincorp. Collier County	AE	1.2
Hazardous Materials	Farm Op - Farm 7 Pump Station 15	Unincorp. Collier County	AE	1.3
Hazardous Materials	Deseret Farms	Unincorp. Collier County	AE	0.1
Hazardous Materials	Farm Op - Farm 7 Pump Station 10	Unincorp. Collier County	AE	1.1
Hazardous Materials	Farm Op - Farm 7 Pump Station 7	Unincorp. Collier County	AE	1.9
Hazardous Materials	Farm Op - Farm 7 Pump Station 14	Unincorp. Collier County	AE	1.0
Hazardous Materials	Farm Op - Farm 7 Pump Station 8	Unincorp. Collier County	AE	1.1
Hazardous Materials	Farm Op - Farm 7 Pump Station 06	Unincorp. Collier County	AE	0.1
Hazardous Materials	Comcast of the South - 28622	Unincorp. Collier County	AE	3.0
Hazardous Materials	Farm Op - Farm 7 Pump Station 11	Unincorp. Collier County	AH	1.4
Hazardous Materials	Farm Op - Farm 7 Pump Station 17	Unincorp. Collier County	AH	1.5
Hazardous Materials	Farm Op - Farm 7 Pump Station 13	Unincorp. Collier County	AE	0.5
Hazardous Materials	Embarq - Eagle Creek Rls	Unincorp. Collier County	AE	0.1
Hazardous Materials	Farm Op - Farm 7 Pump Station 12	Unincorp. Collier County	AE	0.6
Hazardous Materials	F G U A - Golden Gate WWTP - 2188	Unincorp. Collier County	A	0.1
Hazardous Materials	Collier County Utilities - South Regional WTP	Unincorp. Collier County	A	0.1
Hazardous Materials	Emarq - Naples Southeast Central Office	Unincorp. Collier County	AE	3.8
Hazardous Materials	F G U A - Golden Gate WTP - 2184	Unincorp. Collier County	A	0.1
Hazardous Materials	Collier County Utilities - Pelican Bay Water Rec Facility	Unincorp. Collier County	AH	0.1
Hazardous Materials	Golf Turf Applications - Royal Palm Country Club	Unincorp. Collier County	AH	0.1
Hazardous Materials	Golf Turf Applications	Unincorp. Collier County	AH	0.8
Hazardous Materials	Embarq - Naples---28864	Unincorp. Collier County	AH	0.1
Hazardous Materials	Qwest - Naples Pop	Unincorp. Collier County	AH	0.3
Hazardous Materials	Embarq - Golden Gate Central Office	Unincorp. Collier County	AH	0.9
Hazardous Materials	Garguilo, Inc. Superior Plant Co.	Unincorp. Collier County	AH	1.5
Hazardous Materials	Embarq - Naples---28870	Unincorp. Collier County	AH	1.3
Hazardous Materials	Golf Turf Applications - Kathleen Court	Unincorp. Collier County	AH	0.2
Hazardous Materials	Haleakala Construction	Unincorp. Collier County	AH	0.8
Hazardous Materials	Collier County Utilities - Carica Repump Station	Unincorp. Collier County	AH	0.6
Hazardous Materials	City of Naples - WWTP	Unincorp. Collier County	AE	2.9
Hazardous Materials	Embarq - Naples Central Office	Unincorp. Collier County	AH	0.1

Facility Type	Facility Name	Jurisdiction	Flood Zone	100-Yr Flood Depth (NAVD Ft)
Hazardous Materials	North Regional Water Reclamation Facility	Unincorp. Collier County	AE	0.1
Hazardous Materials	Collier County Utilities - North Regional Water Reclamation Facility	Unincorp. Collier County	AH	0.1
Hazardous Materials	Pacific Tomato Growers---2373	Unincorp. Collier County	AH	1.6
Hazardous Materials	Comcast of the South - 28627	Unincorp. Collier County	AE	0.1
Hazardous Materials	Pacific Tomato Growers---2373	Unincorp. Collier County	AH	1.2
Hazardous Materials	Ag Mart Produce - Farm 12	Unincorp. Collier County	AH	0.1
Hazardous Materials	Farm Op - Farm 8	Unincorp. Collier County	A	0.1
Hazardous Materials	Everglades Farms	Unincorp. Collier County	A	0.1
Hazardous Materials	Resource Conservation Systems - Mediterra Corso Circle	Unincorp. Collier County	AE	0.1
Hazardous Materials	Resource Conservation Systems - Messina Lane	Unincorp. Collier County	AH	0.1
Hazardous Materials	Barnett Farms	Unincorp. Collier County	A	0.1
Hazardous Materials	Immokalee Groves	Unincorp. Collier County	AH	0.4
Hazardous Materials	Immokalee Groves	Unincorp. Collier County	AH	0.3
Hazardous Materials	Ag Mart Produce - Immokalee Farm	Unincorp. Collier County	AH	1.8
Hazardous Materials	Manatee Fruit - Naples Farm	Unincorp. Collier County	AH	1.0
Hazardous Materials	Gargiulo - Bhn Research	Unincorp. Collier County	AH	0.1
Hazardous Materials	Troyer Brothers Agri	Unincorp. Collier County	AH	0.1
Hazardous Materials	B W J Farms - Lake Trafford Division	Unincorp. Collier County	AH	0.1
Hazardous Materials	Immokalee Water and Sewer District - Jerry V Warden WTP	Unincorp. Collier County	AH	1.7
Hazardous Materials	Immokalee Water and Sewer District - Jerry V Warden WTP	Unincorp. Collier County	AH	0.1
Hazardous Materials	Immokalee Water and Sewer District – WWTP	Unincorp. Collier County	AH	0.0
Hazardous Materials	U A P Distribution - Immokalee	Unincorp. Collier County	AH	0.8
Hazardous Materials	Howard Fertilizer - Immokalee	Unincorp. Collier County	AH	2.7
Hazardous Materials	Farmers Supply	Unincorp. Collier County	AH	2.0
Hazardous Materials	Helena Chemical - Immokalee	Unincorp. Collier County	AH	0.6
Hazardous Materials	Immokalee Water and Sewer District - Carson Road WTP	Unincorp. Collier County	AH	0.2
Hazardous Materials	Immokalee Water and Sewer District - Airport Road WTP	Unincorp. Collier County	AH	0.1
Health	Marco Urgent Care (239-394-8234)	Marco Island	AE	0.1
Health	Nch Downtown Naples Hospital	Naples	AE	1.2
Health	Naples Medical Center / Millennium Physician Group (239-261-5511)	Naples	AH	0.1
Health	Advanced Medical of Naples (239-330-9809)	Naples	AE	0.9
Health	Lakeside Pavilion Rehabilitation and Nursing Home	Naples	AH	0.1
Health	Moorings Park Oakstone At Grey Oaks	Naples	AE	0.1
Health	Naples Care Alf	Unincorp. Collier County	AE	1.0
Health	Simelant Adult Family Care Home	Unincorp. Collier County	AE	0.4

Facility Type	Facility Name	Jurisdiction	Flood Zone	100-Yr Flood Depth (NAVD Ft)
Health	Willough At Naples (Priv.)	Unincorp. Collier County	AE	0.1
Health	Tuscany Villa of Naples	Unincorp. Collier County	AE	0.1
Health	Arlington of Naples, The	Unincorp. Collier County	AH	0.1
Health	Physicians Regional Hosp - Collier	Unincorp. Collier County	AH	0.1
Health	Barrington Terrace of Naples	Unincorp. Collier County	AE	0.1
Health	Manorcare at Lely Palms	Unincorp. Collier County	AH	0.1
Health	Discovery Village at Naples Llc	Unincorp. Collier County	AH	0.1
Health	Manorcare at Lely Palms	Unincorp. Collier County	AH	0.1
Health	Manorcare Nursing & Rehab Ctr	Unincorp. Collier County	AE	0.1
Health	Hogar Dulce Hogar	Unincorp. Collier County	AH	0.1
Health	Villa at Terracina Grand	Unincorp. Collier County	AH	0.1
Health	Gardens at Terracina Grand	Unincorp. Collier County	AH	0.1
Health	Beach House Naples Alf	Unincorp. Collier County	AE	0.1
Health	David Lawrence Mental Health Ctr	Unincorp. Collier County	AH	0.1
Health	Glenview At Pelican Bay	Unincorp. Collier County	AE	2.4
Health	Angels for The Golden Years of Naples Inc	Unincorp. Collier County	AH	0.1
Health	Cove at Marbella, The	Unincorp. Collier County	AE	7.1
Health	Vanderbilt Beach Assisted Living	Unincorp. Collier County	AH	0.1
Health	Landmark Hospital	Unincorp. Collier County	AE	0.1
Health	Naples Urgent Care (239-597-8000)	Unincorp. Collier County	AE	0.1
Health	Pointe Medical Facility (239-598-1250)	Unincorp. Collier County	AE	0.1
Health	Gaviota Care Inc.	Unincorp. Collier County	AH	0.1
Health	Naples Green Village	Unincorp. Collier County	AH	0.1
Health	Nch North Naples Hospital	Unincorp. Collier County	AE	0.6
Health	Watercrest (To Be Built)	Unincorp. Collier County	AH	0.1
Health	Juniper Village of Naples	Unincorp. Collier County	AE	0.1
Health	Keystoneplace at Naples Preserve	Unincorp. Collier County	AH	0.1
Health	Bayshore Memory Care	Unincorp. Collier County	AE	0.1
Health	All Seasons in Naples	Unincorp. Collier County	AH	0.1
Health	Golden Retreat of Nap	Unincorp. Collier County	AH	0.1
Law Enforcement	Marco Island Police HQ	Marco Island	AE	0.4
Law Enforcement	Naples Police HQ	Naples	AE	1.5
Law Enforcement	Naples Police Dispatch	Naples	AE	0.1
Law Enforcement	Collier Sheriff'S Spec Opns	Naples	AE	1.2
Law Enforcement	Collier Sheriff'S 911 & Dispatch	Unincorp. Collier County	AH	0.1
Law Enforcement	Collier Sheriffs HQ & Jail	Unincorp. Collier County	AE	0.1
Public Works	Everglades City, City Of - WWTF	Everglades	AE	7.2
Public Works	Marco Island WWTF & Reclaimed Water Service Area	Marco Island	AE	2.1
Public Works	Naples, City Of - WWTP I	Naples	AE	0.7
Public Works	Goodland Isles Estates	Unincorp. Collier County	AE	5.8
Public Works	Port of The Islands WWTP	Unincorp. Collier County	AE	1.1
Public Works	Marco Island, City Of - Ro Plant	Unincorp. Collier County	AE	0.1
Public Works	Marco Shores Utilities	Unincorp. Collier County	AE	0.1
Public Works	I-75 Big Cypress Rest Stop	Unincorp. Collier County	A	0.1
Public Works	Pelican Bay Sewage Treat Plant	Unincorp. Collier County	AE	0.6

Facility Type	Facility Name	Jurisdiction	Flood Zone	100-Yr Flood Depth (NAVD Ft)
Public Works	Collier County North Regional WRF	Unincorp. Collier County	AH	0.7
Public Works	Sunniland Mine - Florida Rock	Unincorp. Collier County	A	0.1
Public Works	Orange Tree WWTP	Unincorp. Collier County	AH	0.1
Public Works	Immokalee WWTF	Unincorp. Collier County	AH	0.1
Public Works	Davis Oil Company - Davis Service Ctr	Unincorp. Collier County	AH	0.6
Public Works	Handy Food Store #91	Unincorp. Collier County	AH	0.1
School	Everglades City	Everglades	AE	0.7
School	Tommie Barfield	Marco Island	AE	1.1
School	Marco Island Charter	Marco Island	AE	0.3
School	Parkside	Unincorp. Collier County	AE	0.1
School	Avalon	Unincorp. Collier County	AE	0.5
School	Shadowlawn	Unincorp. Collier County	AE	1.3
School	Alternative Schools	Unincorp. Collier County	AE	0.3
School	Lorenzo Walker Institute	Unincorp. Collier County	AE	0.1
School	Walker Institute of Technology	Unincorp. Collier County	AE	0.1
School	East Naples	Unincorp. Collier County	AE	0.2
School	Mike Davis	Unincorp. Collier County	AH	0.1
School	Palmetto	Unincorp. Collier County	AH	0.1
School	Pine Ridge	Unincorp. Collier County	AH	0.1
School	Naples Park	Unincorp. Collier County	AE	0.1
School	North Naples	Unincorp. Collier County	AH	0.1
Transportation	Everglades Airpark	Everglades	VE	8.8
Transportation	Goodland Bridge (SR-92)	Marco Island	AE	13.1
Transportation	Jolley Bridge	Marco Island	AE	12.1
Transportation	Naples Hospital	Naples	AE	1.5
Transportation	Naples Muni	Naples	AE	1.0
Transportation	Oasis Ranger Station-U.S. Government	Unincorp. Collier County	A	0.1
Transportation	Dade-Collier Training and Transition	Unincorp. Collier County	A	0.1
Transportation	Us 41/State 90 And County 29	Unincorp. Collier County	AE	2.0
Transportation	Isles of Capri Fire Dept	Unincorp. Collier County	AE	3.2
Transportation	Marco Island	Unincorp. Collier County	AE	0.5
Transportation	I-75 & State 29	Unincorp. Collier County	A	0.1
Transportation	Naples Grand Golf Resort	Unincorp. Collier County	AH	0.1
Transportation	Immokalee	Unincorp. Collier County	AH	0.1
Utilities	LCEC-Immokalee	Immokalee	AH	0.1
Utilities	LCEC-Fred H. Smith	Marco Island	AE	0.6
Utilities	LCEC-Marco	Marco Island	AE	2.5
Utilities	Naples	Naples	AE	2.3
Utilities	LCEC-Carnestown	Unincorp. Collier County	AE	2.5
Utilities	LCEC-Belle Meade	Unincorp. Collier County	AE	1.3
Utilities	FPL-Capri	Unincorp. Collier County	AE	2.6
Utilities	Substation Dist 5 E Tamiami Trl	Unincorp. Collier County	AE	0.1
Utilities	FPL	Unincorp. Collier County	AE	0.1
Utilities	Substation Dist 3 E Naples	Unincorp. Collier County	AH	0.0
Utilities	FPL	Unincorp. Collier County	AH	0.1
Utilities	Alligator	Unincorp. Collier County	AH	0.1
Utilities	FPL	Unincorp. Collier County	AH	0.3

Facility Type	Facility Name	Jurisdiction	Flood Zone	100-Yr Flood Depth (NAVD Ft)
Utilities	Substation Dist 4 Estates	Unincorp. Collier County	AH	0.1
Utilities	LCEC-Ave Maria South	Unincorp. Collier County	AH	0.1
Utilities	FPL	Unincorp. Collier County	AH	0.8
Utilities	LCEC-North Immokalee	Unincorp. Collier County	AH	0.1
Water	City of Marco Island	Marco Island	AE	4.8
Water	City of Marco Island	Marco Island	AE	0.7
Water	Oasis Ranger Station	Unincorp. Collier County	A	0.1
Water	Everglades Shores/Big Cypress Pres.	Unincorp. Collier County	AE	3.7
Water	Lee Cypress Co-Op	Unincorp. Collier County	AE	2.9
Water	Port of The Islands Water Plant	Unincorp. Collier County	AE	0.7
Water	Trees Camp WTP	Unincorp. Collier County	AE	1.7
Water	Marco Shores Utilities	Unincorp. Collier County	AE	3.9
Water	I-75 Reststop & Recreat. Area	Unincorp. Collier County	A	0.1
Water	Collier County Regional WTP	Unincorp. Collier County	AH	0.9
Water	Immokalee Water	Unincorp. Collier County	AH	2.2
Water	S.W. Florida Research Ed. Ctr.	Unincorp. Collier County	AH	1.1

Repetitive Loss Analysis

A repetitive loss property is a property for which two or more flood insurance claims of more than $1,000 have been paid by the NFIP within any 10-year period since 1978. An analysis of repetitive loss was completed to examine repetitive losses within the planning area.

According to 2019 NFIP records, there are a total of 75 repetitive loss properties within the Collier County planning area including 11 mitigated properties and 64 unmitigated properties. Of the unmitigated properties, 34 (53%) are insured. Overall, approximately 77% of all repetitive loss properties in the County are residential, and 23% are non-residential. There are five properties on the list classified as severe repetitive loss properties. A severe repetitive loss property is classified as such if it has four or more separate claim payments of more than $5,000 each (including building and contents payments) or two or more separate claim payments (building only) where the total of the payments exceeds the current value of the property.

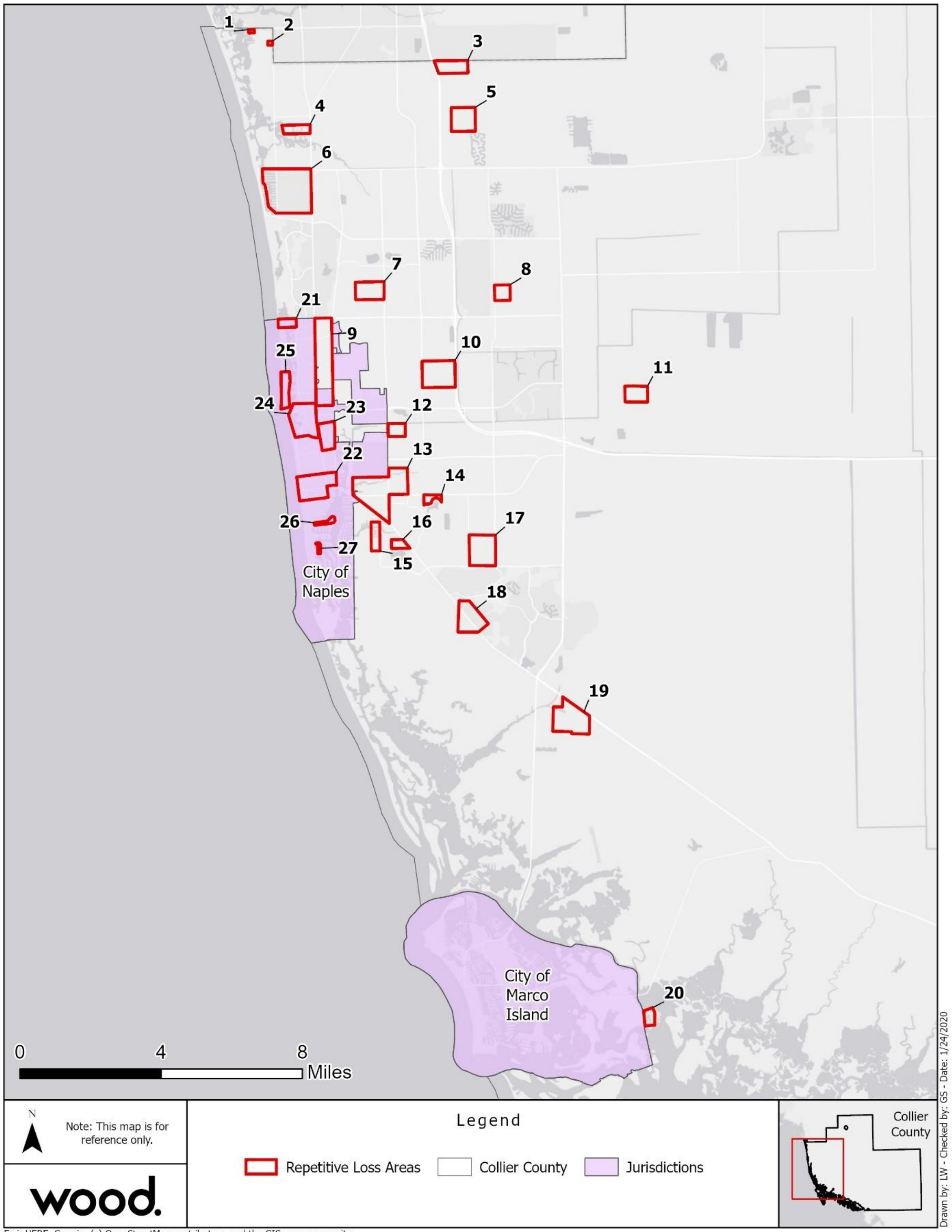
Table 2.19 summarizes repetitive loss properties by jurisdiction in Collier County as identified by FEMA through the NFIP. Figure 2.4 shows the general areas where repetitive losses have occurred throughout the planning area. Note that repetitive loss areas are not mapped for Marco Island because addresses were not made available for these properties.

Table 2.19 – Repetitive Loss Properties by Jurisdiction

Jurisdiction	Property Count	Total Number of Losses	Occupancy		% Insured	Total Amount of Claims Payments	Average Claim Payment	SRL Count
			Res	Non-Res				
Marco Island	3	9	2	1	67%	$266,310	$88,770	0
Naples	19	45	16	3	68%	$1,695,605	$41,353	0
Collier County	53	146	40	13	51%	$2,623,149	$19,065	5
Total	**75**	**200**	**58**	**17**	**56%**	**$4,585,064**	**$49,729**	**5**

Source: FEMA/ISO; Note: SRL = Severe Repetitive Loss; Res = Residential, Non-Res = Non-Residential

Figure 2.4 – Repetitive Loss Areas



Source: FEMA/ISO

Environment

During a flood event, chemicals and other hazardous substances may end up contaminating local water bodies. Flooding kills animals and in general disrupts the ecosystem. Snakes and insects may also make their way to the flooded areas.

Floods can also cause significant erosion, which can alter streambanks and deposit sediment, changing the flow of streams and rivers and potentially reducing the drainage capacity of those waterbodies.

Consequence Analysis

Table 2.20 summarizes the potential detrimental consequences of flood.

Table 2.20 – Consequence Analysis - Flood

Category	Consequences
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	First responders are at risk when attempting to rescue people from their homes. They are subject to the same health hazards as the public. Flood waters may prevent access to areas in need of response or the flood may prevent access to the critical facilities themselves which may prolong response time. Damage to personnel will generally be localized to those in the flood areas at the time of the incident and is expected to be limited.
Continuity of Operations (including Continued Delivery of Services)	Floods can severely disrupt normal operations, especially when there is a loss of power. Damage to facilities in the affected area may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities and Infrastructure	Buildings and infrastructure, including transportation and utility infrastructure, may be damaged or destroyed. Impacts are expected to be localized to the area of the incident. Severe damage is possible.
Environment	Chemicals and other hazardous substances may contaminate local water bodies. Wildlife and livestock deaths possible. The localized impact is expected to be severe for incident areas and moderate to light for other areas affected by the flood or HazMat spills.
Economic Condition of the Jurisdiction	Local economy and finances will be adversely affected, possibly for an extended period. During floods (especially flash floods), roads, bridges, farms, houses and automobiles are destroyed. Additionally, the local government must deploy firemen, police and other emergency response personnel and equipment to help the affected area. It may take years for the affected communities to be re-built and business to return to normal.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery are not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes flood hazard risk by jurisdiction. Flood risk due to storm surge, high tide flooding, flash flooding, and stormwater flooding exists across the entire county. All participating jurisdictions have over 85% of their area in the SFHA and thus have a high degree of exposure to flooding; given that other sources of flooding and other levels of flooding may occur beyond these areas, the spatial extent was considered large for all jurisdictions. Impact ratings were based upon Hazus loss estimates as well as the overall risk of death or injury; all jurisdictions were rated with an impact of critical. All communities also face a uniform probability of flooding.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	4	3	4	3	3	3.5	H
Immokalee Reservation	4	3	4	3	3	3.5	H
Marco Island	4	3	4	3	3	3.5	H
Naples	4	3	4	3	3	3.5	H
Unincorporated Collier County	4	3	4	3	3	3.5	H

2.5.2 Tropical Cyclones

Hazard Description

Hurricanes and tropical storms are classified as cyclones and defined as any closed circulation developing around a low-pressure center in which the winds rotate counter-clockwise in the Northern Hemisphere (or clockwise in the Southern Hemisphere) and whose diameter averages 10 to 30 miles across. A tropical cyclone refers to any such circulation that develops over tropical waters. Tropical cyclones act as a "safety-valve," limiting the continued build-up of heat and energy in tropical regions by maintaining the atmospheric heat and moisture balance between the tropics and the pole-ward latitudes. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation, and tornadoes.

The key energy source for a tropical cyclone is the release of latent heat from the condensation of warm water. Their formation requires a low-pressure disturbance, warm sea surface temperature, rotational force from the spinning of the earth, and the absence of wind shear in the lowest 50,000 feet of the atmosphere. Most hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico during the official Atlantic hurricane season, which encompasses the months of June through November. The peak of the Atlantic hurricane season is in early to mid-September and the average number of storms that reach hurricane intensity per year in the Atlantic basin is about six.

While hurricanes pose the greatest threat to life and property, tropical storms and depressions also can be devastating. A tropical disturbance can grow to a more intense stage through an increase in sustained wind speeds. The progression of a tropical disturbance is described below.

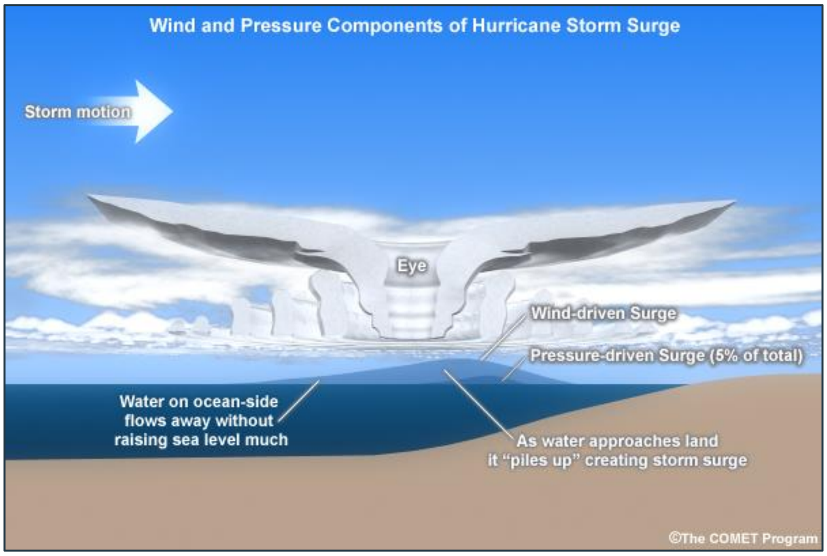
- **Tropical Depression:** A tropical cyclone with maximum sustained winds of 38 mph (33 knots) or less.
- **Tropical Storm:** A tropical cyclone with maximum sustained winds of 39 to 73 mph (34 to 63 knots).
- **Hurricane:** A tropical cyclone with maximum sustained winds of 74 mph (64 knots) or higher. In the western North Pacific, hurricanes are called typhoons; similar storms in the Indian Ocean and South Pacific Ocean are called cyclones.
- **Major Hurricane:** A tropical cyclone with maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4 or 5 on the Saffir-Simpson Hurricane Wind Scale.

As an incipient hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and is monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. Hurricanes are given a classification based on the Saffir-Simpson Scale; this scale is reproduced in Table 2.21.

The greatest potential for loss of life related to a hurricane is from the storm surge. Storm surge is water that is pushed toward the shore by the force of the winds swirling around the storm as shown in Figure 2.5. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level to heights impacting roads, homes and other critical infrastructure. In addition, wind driven waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm tide coincides with the normal high tides.

The maximum potential storm surge for a location depends on several different factors. Storm surge is a very complex phenomenon because it is sensitive to the slightest changes in storm intensity, forward speed, size (radius of maximum winds-RMW), angle of approach to the coast, central pressure (minimal contribution in comparison to the wind), and the shape and characteristics of coastal features such as bays and estuaries. Other factors which can impact storm surge are the width and slope of the continental shelf and the depth of the ocean bottom. A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water close to the shoreline, tends to produce a lower surge but higher and more powerful storm waves. A shallow slope, as is found off the coast of Collier County, will produce a greater storm surge than a steep shelf.

Figure 2.5 – Components of Hurricane Storm Surge



Source: NOAA/The COMET Program

Damage during hurricanes may also result from inland flooding from associated heavy rainfall.

Like hurricanes, nor'easters are ocean storms capable of causing substantial damage to coastal areas in the Eastern United States due to their strong winds and heavy surf. Nor'easters are named for the winds that blow in from the northeast and drive the storm up the East Coast along the Gulf Stream. They are caused by the interaction of the jet stream with horizontal temperature gradients and generally occur during the fall and winter months when moisture and cold air are plentiful.

Nor'easters are known for dumping heavy amounts of rain and snow, producing hurricane-force winds, and creating high surf that causes severe beach erosion and coastal flooding. There are two main components to a nor'easter: (1) a Gulf Stream low-pressure system (counter-clockwise winds) generated off the southeastern U.S. coast, gathering warm air and moisture from the Atlantic, and pulled up the East Coast by strong northeasterly winds at the leading edge of the storm; and (2) an Arctic high-pressure system (clockwise winds) which meets the low-pressure system with cold, arctic air blowing down from Canada. When the two systems collide, the moisture and cold air produce a mix of precipitation and can produce dangerously high winds and heavy seas. As the low-pressure system deepens, the intensity of the winds and waves increases and can cause serious damage to coastal areas as the storm moves northeast.

Warning Time: 1 – More than 24 hours

Duration: 3 – Less than 1 week

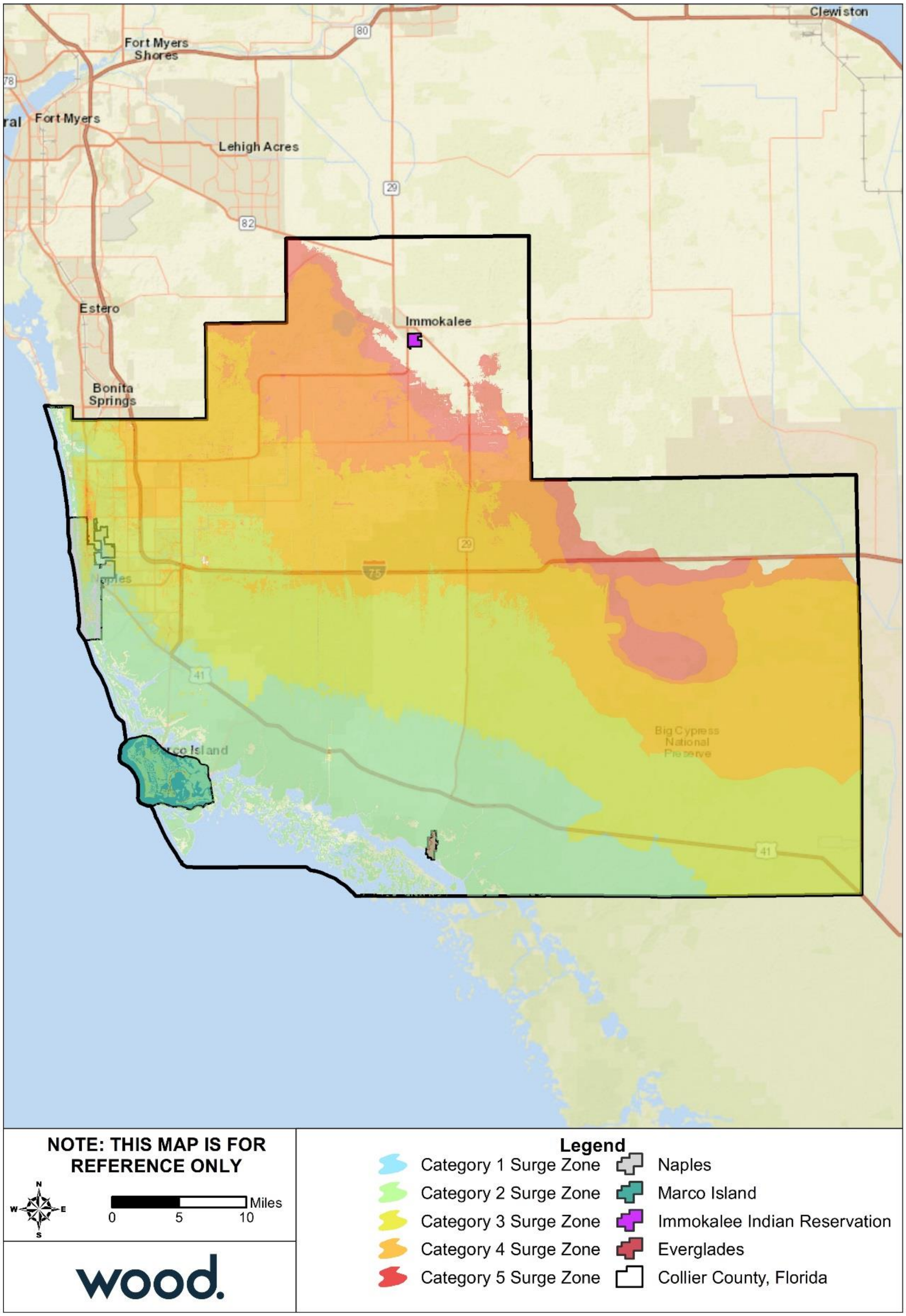
Location

Hurricanes and tropical storms can occur anywhere within the Collier County planning area. While coastal areas are most vulnerable to hurricanes, their wind and rain impacts can be felt hundreds of miles inland.

Storm surge impacts are more limited, affecting areas along coastal and estuarine shorelines and reaching further inland depending on the height of the surge. All of Collier County is vulnerable to hurricane and tropical storm surge, but to varying degrees, with areas closer to the coast and water bodies that drain into the coast facing greater risk.

Figure 2.6 shows the estimated extent of surge by storm category according to NOAA Sea, Lake, and Overland Surges from Hurricanes (SLOSH) data. the SLOSH model is a computerized numerical model developed by the NWS to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by considering the atmospheric pressure, size, forward speed, and track data. The model creates outputs for all different storm simulations from all points of the compass. Each direction has a MEOW (maximum envelope of water) for each category of storm (1-5), and all directions combined result in a MOMs (maximum of maximums) set of data. Note that the MOM does not illustrate the storm surge that will occur from any given storm but rather the full potential extent of surge from all possible storms. As shown in these maps, Collier County is vulnerable to storm surge impacts from all storm categories. Marco Island, Everglades City, and much of Naples are likely to be impacted from storms rated as Category 1 and greater.

Figure 2.6 – Storm Surge Inundation for All Categories



Source: NOAA SLOSH Data

Extent

As an incipient hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and is closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Scale (Table 2.21), which rates hurricane intensity on a scale of 1 to 5, with 5 being the most intense.

Table 2.21 – Saffir-Simpson Scale

Category	Maximum Sustained Wind Speed (MPH)	Types of Damage
1	74–95	Very dangerous winds will produce some damage; Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap, and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96–110	Extremely dangerous winds will cause extensive damage; Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	111–129	Devastating damage will occur; Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	130–156	Catastrophic damage will occur; Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted, and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	157 +	Catastrophic damage will occur; A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: National Hurricane Center

The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds and barometric pressure, which are combined to estimate potential damage. Categories 3, 4, and 5 are classified as “major” hurricanes and, while hurricanes within this range comprise only 20 percent of total tropical cyclone landfalls, they account for over 70 percent of the damage in the United States. Table 2.22 describes the damage that could be expected for each category of hurricane. Damage during hurricanes may also result from spawned tornadoes, storm surge, and inland flooding associated with heavy rainfall that usually accompanies these storms.

Table 2.22 – Hurricane Damage Classifications

Storm Category	Damage Level	Description of Damages	Photo Example
1	MINIMAL	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal flooding and minor pier damage.	
2	MODERATE	Some roofing material, door, and window damage. Considerable damage to vegetation, mobile homes, etc. Flooding damages piers and small craft in unprotected moorings may break their moorings.	
3	EXTENSIVE	Some structural damage to small residences and utility buildings, with a minor amount of curtainwall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures, with larger structures damaged by floating debris. Terrain may be flooded well inland.	
4	EXTREME	More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland.	
5	CATASTROPHIC	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required.	

Source: National Hurricane Center; Federal Emergency Management Agency

The Saffir-Simpson scale provides a measure of extent of a hurricane. The county is susceptible to the full force of every category of hurricane.

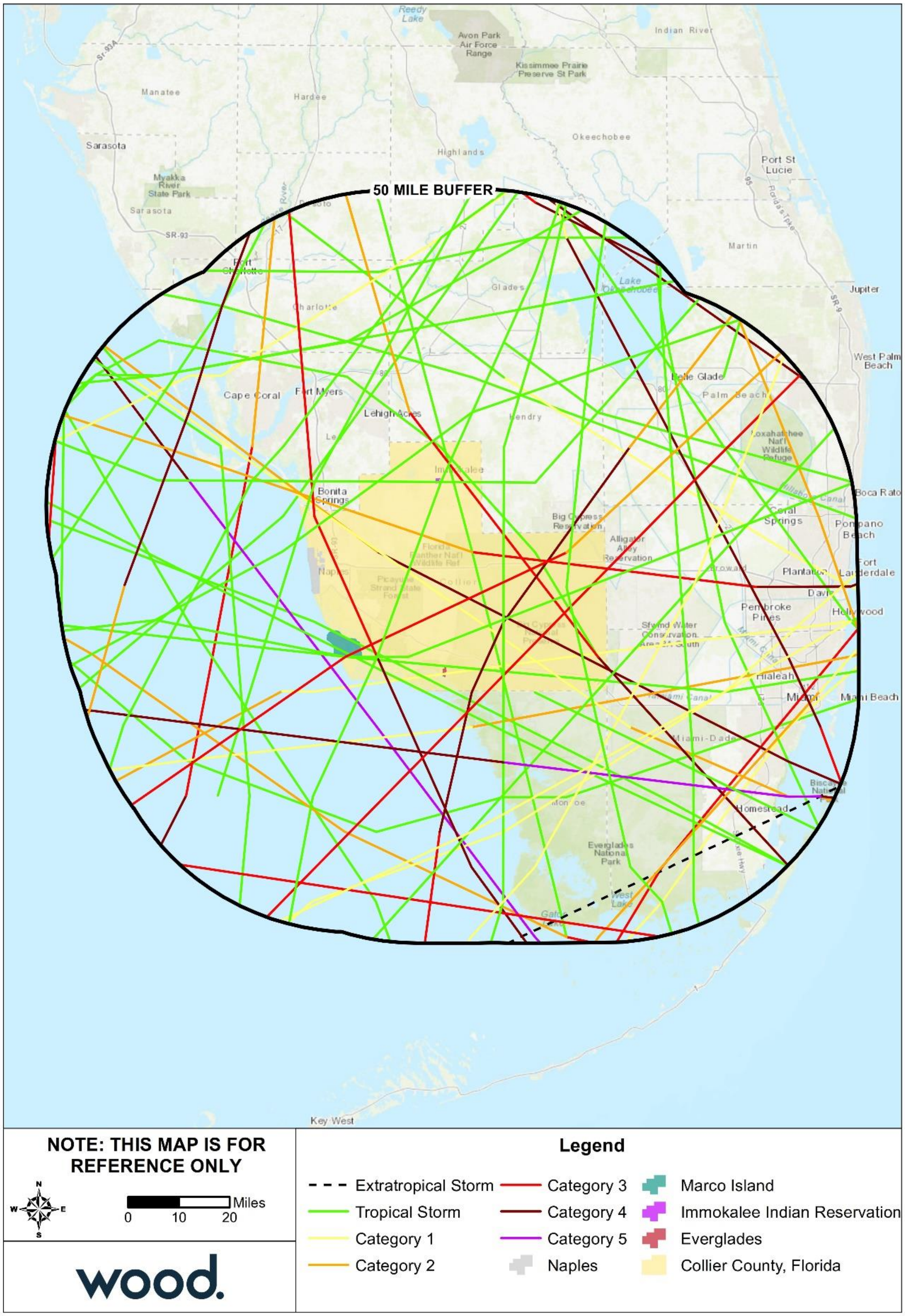
Impact: 4 – Catastrophic

Spatial Extent: 4 – Large

Historical Occurrences

According to the Office of Coastal Management's Tropical Cyclone Storm Segments data, which is a subset of the International Best Track Archive for Climate Stewardship (IBTrACS) dataset, 59 hurricanes and tropical storms passed within 50 miles of Collier County between 1900 and 2016. These storm tracks are shown in Figure 2.7. The date, storm name, storm category, and maximum wind speed of each event are detailed in Table 2.23. It should be noted that Hurricane Irma made landfall in Collier County on September 10, 2017, but Irma was not included in updated data sets at the time this report was made. Irma was a category 3 hurricane when it hit the County with max wind speeds of 115 miles per hour.

Figure 2.7 – Hurricane/Tropical Storm Tracks within 50 miles of Collier County, 1900-2016



Source: NOAA Office of Coastal Management

Table 2.23 – Tropical Cyclone Tracks Passing within 50 Miles of Collier County, 1900-2017

Date	Storm Name	Max Storm Category*	Max Wind Speed (mph)
8/10/1901	Unnamed	Tropical Storm	46
9/11/1903	Unnamed	Category 1	86
10/17/1904	Unnamed	Category 1	81
6/17/1906	Unnamed	Category 1	86
10/18/1906	Unnamed	Category 3	121
6/28/1909	Unnamed	Tropical Storm	52
8/29/1909	Unnamed	Tropical Storm	52
10/17/1910	Unnamed	Category 4	132
5/14/1916	Unnamed	Tropical Storm	46
8/25/1916	Unnamed	Tropical Storm	46
11/15/1916	Unnamed	Extratropical Storm	63
10/20/1924	Unnamed	Category 2	104
12/1/1925	Unnamed	Tropical Storm	63
9/18/1926	Unnamed	Category 4	144
8/13/1928	Unnamed	Tropical Storm	69
9/17/1928	Unnamed	Category 4	144
9/28/1929	Unnamed	Category 3	115
8/30/1932	Unnamed	Tropical Storm	63
7/31/1933	Unnamed	Tropical Storm	58
9/3/1935	Unnamed	Category 5	184
11/4/1935	Unnamed	Category 2	98
6/15/1936	Unnamed	Tropical Storm	46
7/29/1936	Unnamed	Tropical Storm	63
10/6/1941	Unnamed	Category 2	98
10/19/1944	Unnamed	Category 3	115
9/4/1945	Unnamed	Tropical Storm	40
9/15/1945	Unnamed	Category 4	132
9/17/1947	Unnamed	Category 4	132
10/12/1947	Unnamed	Category 1	92
9/22/1948	Unnamed	Category 4	132
10/5/1948	Unnamed	Category 2	104
8/27/1949	Unnamed	Category 4	132
10/18/1950	King	Category 4	132
10/2/1951	How	Tropical Storm	63
10/9/1953	Hazel	Category 1	86
10/16/1956	Unnamed	Tropical Storm	63
10/18/1959	Judith	Tropical Storm	63
9/10/1960	Donna	Category 4	144
9/24/1960	Florence	Tropical Storm	40
8/27/1964	Cleo	Category 2	104
10/14/1964	Isbell	Category 3	127
9/8/1965	Betsy	Category 3	127
6/4/1968	Abby	Tropical Storm	69
10/2/1969	Jenny	Tropical Storm	46
8/19/1976	Dottie	Tropical Storm	40
8/17/1981	Dennis	Tropical Storm	40
7/23/1985	Bob	Tropical Storm	46
10/11/1990	Marco	Tropical Storm	58

Date	Storm Name	Max Storm Category*	Max Wind Speed (mph)
8/24/1992	Andrew	Category 5	167
11/16/1994	Gordon	Tropical Storm	52
11/5/1998	Mitch	Tropical Storm	63
8/21/1999	Harvey	Tropical Storm	58
10/15/1999	Irene	Category 1	81
8/13/2004	Charley	Category 4	150
8/25/2005	Katrina	Category 1	81
10/24/2005	Wilma	Category 3	127
8/30/2006	Ernesto	Tropical Storm	46
8/19/2008	Fay	Tropical Storm	69
7/23/2010	Bonnie	Tropical Storm	40
9/10/2017	Irma**	Category 4	132

*Reports the most intense category that occurred within 50 miles of Collier County, not for the storm event overall.
**Hurricane Irma is listed on this table, but the Hurricane's track is not shown in Figure 2.7.
Source: Office of Coastal Management, 2020. https://marinecadastre.gov/data/

The above map of storms is not an exhaustive list of hurricanes that have affected Collier County. Several storms have passed further than 50 miles away from the Region yet had strong enough wind or rain impacts to cause impacts. NCEI records hurricane and tropical storm events across the region by county and zone; therefore, one event that impacts multiple jurisdictions may be recorded multiple times. During the 20-year period from 2000 through 2019, NCEI records 12 hurricane and tropical storm reports across 9 separate days. These events are summarized in Table 2.24. This table only represents those events reported to NCEI as a Hurricane or Tropical Storm. Where property damage estimates were broken out by type, NCEI reports only the value of wind-related damages. While there are no records for wind related damages from Hurricane Irma and no reported damages due to storm surge in the NCEI database, it had significant impact on the County. Following the storm, it was reported that $320 million in damages occurred in unincorporated areas of the County alone, a number which is likely much higher when considering Naples, Marco Island, and Everglades City all experienced damage as well. In total, 50 Florida counties were included in the disaster declaration and eligible for individual assistance. FEMA has approved over $1 billion individual and household program dollars across these counties.

Table 2.24 – Recorded Hurricanes and Typhoons in Collier County, 2000-2019

Date	Storm	Deaths/ Injuries	Property Damage	Crop Damage
9/16/2000	Tropical Storm Gordon	0/0	$0	$0
9/13/2001	Tropical Storm Gabrielle	0/0	$50,000	$0
8/13/2004	Hurricane Charley	0/0	$2,500,000	$0
9/4/2004	Hurricane Frances	0/0	$0	$0
7/8/2005	Hurricane Dennis	0/0	$0	$0
10/24/2005	Hurricane Wilma	1/0	$0	$0
8/30/2006	Tropical Storm Ernesto	0/0	$0	$0
8/18/2008	Tropical Storm Fay	0/0	$20,000	$0
8/26/2012	Tropical Storm Isaac	0/0	$0	$0
	Total	**0/0**	**$2,570,000**	**$0**

Source: NCEI

Storm Surge

Collier County is also vulnerable to Storm Surge caused by Hurricanes and Tropical Storms. Although previously summarized in Section 2.5.1, Table 2.25 further details Storm Surge events that have impacted

Collier County in the 20-year period from 2000 to 2019. Event narratives following this table provide a fuller scope of the impacts from selected events.

Table 2.25 – Recorded Storm Surge events in Collier County, 2000-2019

Date	Storm	Deaths/ Injuries	Property Damage	Crop Damage
10/24/2005	Hurricane Wilma	0/0	$0	$0
8/18/2008	Tropical Storm Fay	0/0	$60,000	$0
8/26/2012	Tropical Storm Isaac	0/0	$6,000,000	$0
6/6/2016	Tropical Storm Colin	0/0	$0	$0
9/10/2017	Hurricane Irma	0/0	$0	$0
	Total	**0/0**	**$2,570,000**	**$0**

September 16, 2000 – Tropical Storm Gordon formed in the Gulf of Mexico about 375 miles west of Naples late on September 15th. It moved northeast, briefly intensified to hurricane strength, then moved ashore in the Big Bend area of Florida as a tropical storm late on September 17th. The outer fringes of Gordon moved across south Florida, producing 3-6 inches of rain, numerous funnel clouds and waterspouts, and at least three tornadoes.

September 13, 2001 – Tropical storm Gabrielle formed in the eastern Gulf of Mexico from a trough of low pressure that had lingered over Florida since September 8. Gabrielle moved east northeast at 7 to 12 mph with the center crossing the Florida west coast near Venice at noon on September 14. The minimum central pressure in Collier County was 999.4 mb at Naples. Maximum winds in Collier County were at Everglades City with sustained winds of 44 knots and peak gusts of 61 knots. Storm surge values of 3 to 5 feet were observed along much of the Collier County coast which caused some coastal flooding and minor to moderate beach erosion. The estimate to repair the beach erosion was $3 million. Flooding by rainfall of 2 to 5 inches along with the storm surge damaged 60 to 70 residences and 12,500 customers lost electrical power.

August 13, 2004 – Early on August 13, Hurricane Charley intensified to Category 4 status and turned to a north-northeast direction before making landfall near Port Charlotte around 3 PM EDT. The first outer rain band, with wind gusts estimated up to 60 mph, impacted the south Florida Peninsula between midnight and 2 AM EDT. In Collier County, a peak wind gust of 84 mph was measured at 2:50 PM EDT on the top of a condominium at Vanderbilt Beach before the equipment failed. The Naples ASOS equipment failed well before the maximum winds or minimum pressure occurred. Wind gusts at La Belle were estimated at 80 mph. Rainfall in most locations in Collier County was around two inches with an unofficial amount of 7.5 inches reported in North Naples. Radar local rainfall estimates of 8 to 10 inches were made in North Naples. Flooding was mostly minimal.

The highest Storm Tide along the southwest Florida Coast was estimated at three feet near Wiggins Pass with heights of one to two feet from Naples to Marco Island to Everglades City. Tidal flooding was minimal. Lake Okeechobee levels increased up to three feet above normal along the north and northeast shores. Hurricane wind damage was greatest in North Naples and Vanderbilt Beach with numerous power poles, trees and signs blown down, and a few roofs damaged. Damage also occurred to screened porches throughout the Naples-Marco Island metropolitan areas. Damage occurred to Gulf-side structures along most of the coastline but beach erosion was mostly minor. Four persons in Naples suffered minor injuries when their vehicle was touched by a downed power line during the storm. Three persons in Collier County died from indirect causes after the hurricane. An estimated 130,000 customers in Collier County lost power. About 2,500 people took refuge in six shelters.

October 24, 2005 – Wilma was a classic October hurricane which struck South Florida as a Category 3 hurricane on October 24th, 2005. The hurricane made landfall as a category 3 storm shortly before 7 AM Monday, October 24th on the southwest Florida coast between Everglades City and Cape Romano with maximum sustained winds of 125 mph and an estimated minimum central pressure of 950 mb. Wilma exhibited a very large 55- to 65-mile-wide eye while crossing the state, and the eye covered large portions of South Florida, including the eastern two-thirds of Collier County. Sustained hurricane force winds (74 mph or greater) were observed over most areas. The highest recorded gusts were in the 100-120 mph range. Rainfall amounts across South Florida generally ranged from 2 to 4 inches across southern sections of the peninsula to 4 to 6 inches across western Collier county and around Lake Okeechobee. A storm surge of around 8 feet was estimated in Marco Island, with 4 feet in Everglades City. One confirmed tornado was observed in rural Collier County around 2:30 AM on the 24th, moving rapidly northwest from the intersection of U.S. 41 and State Road 29 to the town of Copeland three miles to the north. An F1 intensity was assigned to the tornado as it caused snapped power poles, uprooted large trees, and significantly damaged mobile homes.

In Collier, winds caused one direct fatality. While no monetary impacts were reported in NCEI for Collier County, total damage estimates across South Florida range from $9 to $12 billion. Damage was widespread, with large trees and power lines down virtually everywhere, causing widespread power outages. Structural damage was heaviest in Broward and Palm Beach counties where roof damage and downed or split power poles were noted in some areas. High-rise buildings suffered considerable damage, mainly in the form of broken windows. This was observed mainly along the southeast metro areas, but also in Naples, which underscores the higher wind speeds with height commonly observed in hurricanes.

August 18, 2008 - The center of Tropical Storm Fay moved across Key West early in the evening of the 18th and into the mainland of South Florida at Cape Romano shortly before 5 AM on the 19th. Maximum sustained winds were estimated to be around 52 knots (60 MPH) at landfall, however a maximum wind gust of 69 knots (79 MPH) was recorded on a South Florida Water Management gauge on Lake Okeechobee as the storm passed. Wind gusts to tropical storm force were felt area-wide, with sustained tropical storm force winds experienced over portions Collier County. Wind damage was most significant in the areas affected by tropical storm force sustained winds, primarily around Lake Okeechobee and interior sections of southwest Florida, with only minor wind damage elsewhere. Rainfall ranged 6-8 inches in southwest Florida. The height of the storm tide was around 5 feet in the Everglades City and Chokoloskee areas. Minimal storm surge was noted elsewhere. All the associated effects of Tropical Storm Fay in South Florida resulted in 1 fatality, 4 injuries, and $3.949 million in property damage. In Collier County, total wind damages were reported to be $20,000 and total surge damages at $60,000.

August 26, 2012 – The center of Tropical Storm Isaac moved over the Florida Straits south of the Florida Keys on Sunday, August 26th, passing just south of Key West. Rain bands and winds on the north side of the circulation of Isaac affected Southeast Florida throughout the day of the 26th and part of the 27th. Maximum storm tide values were observed at 4.9 feet at Naples, with estimates of 5 to 7 feet along the southern Collier County coast from Goodland to Everglades City. Highest estimated inundation values of up to 3 feet above ground level were noted in Goodland and Everglades City. Major beach erosion was also observed along the Collier County beaches. Flooding caused by storm tides along the coast in Collier County resulted in about $400,000 in damage. Damage from beach erosion in Collier and Broward counties was estimated at $6 million.

September 10, 2017 – Major Hurricane Irma made landfall in Southwest Florida on Marco Island as a Category 3 hurricane around 330 PM EDT on September 10th. The strength and size of Hurricane Irma allowed for impacts to be felt across all of South Florida. Irma brought widespread wind damage, heavy rainfall and storm surge to all areas. Hurricane-force sustained wind were measured in much of Collier

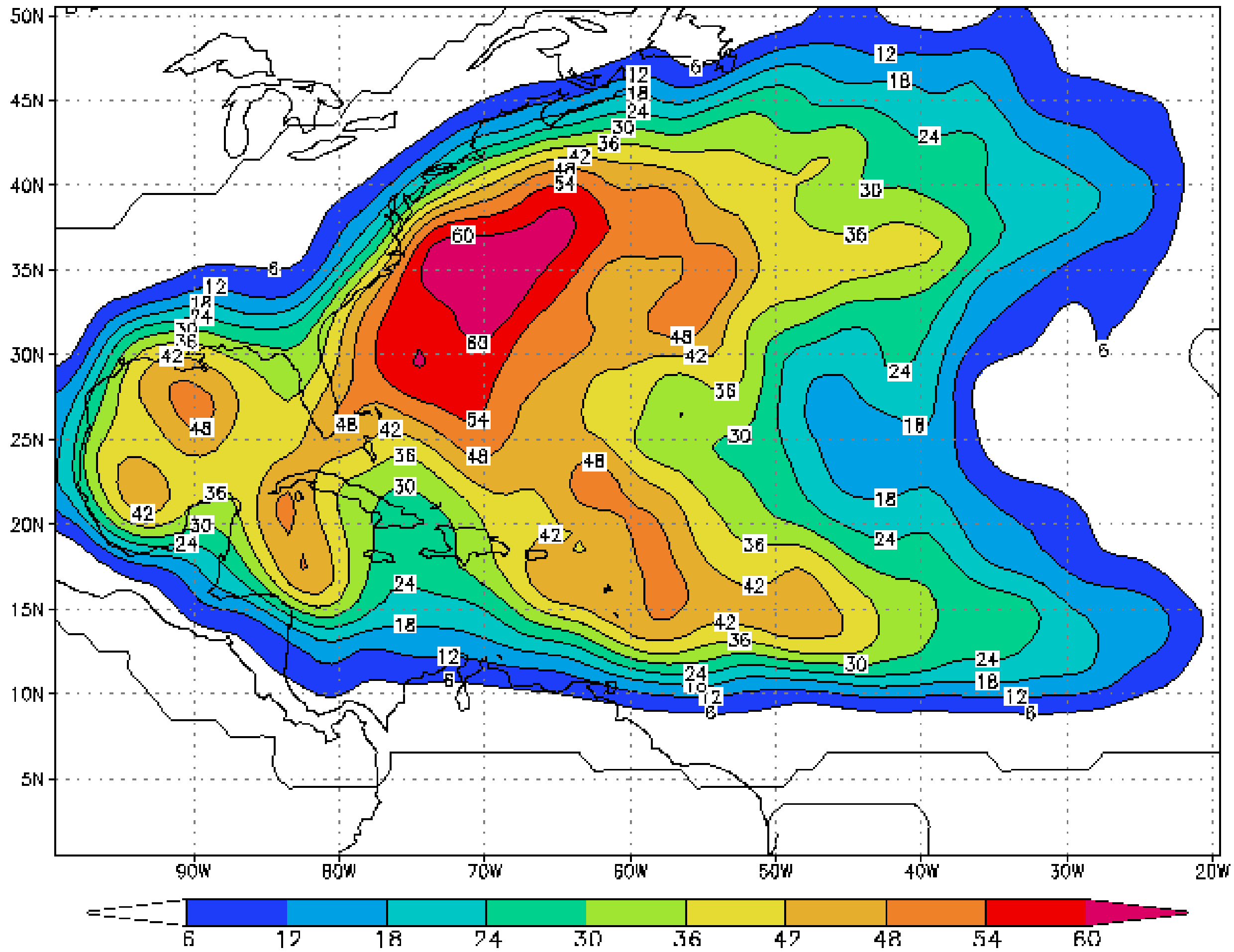
County. Gusts to hurricane force were felt over all South Florida, with the maximum measured wind gust of 142 mph in Naples. Widespread tree damage and some structural damage occurred across all of South Florida, with most structural damage on the minor side. Hurricane Irma brought widespread rainfall and some flooding across the region. From the period between 8 AM EDT September 9th and 8 AM EDT September 11th, 8 to 15 inches of rain were measured over interior portions of Southwest Florida. This rainfall near the end of a wet summer led to significant flooding over these areas. 5 to 10 inches of rain were noted elsewhere across South Florida, with areas of minor to moderate flooding. $222.5 million in damage came in from Collier County. Details about storm surge from Hurricane Irma can be found in section 2.5.1.

Probability of Future Occurrence

In the 20-year period from 2000 through 2019, 9 hurricanes and tropical storms have impacted Collier County, which equates to a 45 percent annual probability of hurricane winds impacting the planning area in any given year. This probability does not account for impacts from hurricane rains or storm surge, which may also be severe. The probability of a hurricane or tropical storm impacting Collier County is likely.

Figure 2.8 shows, for any location, the chance of a hurricane or tropical storm affecting the area sometime during the Atlantic hurricane season. The figure was created by the National Oceanic and Atmospheric Administration's (NOAA) Hurricane Research Division, using data from 1944 to 1999. The figure shows the number of times a storm or hurricane was located within approximately 100 miles (165 kilometers) of a given spot in the Atlantic basin.

Figure 2.8 – Empirical Probability of a Named Hurricane or Tropical Storm



Source: National Oceanic and Atmospheric Administration, Hurricane Research Division

Florida has over 8,000 miles of coastline that often gets hit by direct storms. The state is very vulnerable to the impacts of hurricanes and tropical storms as detailed in this section. Substantial hurricane damage is typically most likely to be expected in the coastal counties of the state; however, hurricane and tropical storm-force winds have significantly impacted areas far inland.

Probability: 3 – Likely

Climate Change

Collier County's coastal location makes it a prime target for hurricane landfalls and changing climate and weather conditions may increase the number and frequency of future hurricane events. Hurricanes and other coastal storms may result in increased flooding, injuries, deaths, and extreme property loss. According to the US Government Accountability Office, national storm losses from changing frequency and intensity of storms is projected to increase anywhere from $4-6 billion soon.

According to NOAA, weather extremes will likely cause more frequent, stronger storms in the future due to rising surface temperatures. NOAA models predict that while there may be less frequent, low-category storm events (Tropical Storms, Category 1 Hurricanes), there will be more, high-category storm events (Category 4 and 5 Hurricanes) in the future. This means that there may be fewer hurricanes overall in any given year, but when hurricanes do form, it is more likely that they will become large storms that can create massive damage.

Vulnerability Assessment

People

The very young, the elderly and the handicapped are especially vulnerable to harm from hurricanes. For those who are unable to evacuate for medical reasons, there should be provision to take care of special-needs patients and those in hospitals and nursing homes. Many of these patients are either oxygen-dependent, insulin-dependent, or in need of intensive medical care. There is a need to provide ongoing treatment for these vulnerable citizens, either on the coast or by air evacuation to upland hospitals. The stress from disasters such as a hurricane can result in immediate and long-term physical and emotional health problems among victims.

Individuals in mobile homes are more vulnerable to hurricane winds, especially if their unit does not have tie downs and other wind safety measures. Overall, there are 10,696 mobile home units in Collier County. Over 20 percent of the housing stock in Everglades City is mobile home units. Additionally, there are over 10,000 mobile home units in unincorporated Collier County. These communities may face more severe impacts from hurricane events as a result. Table 2.26 shows mobile home units by jurisdiction.

Table 2.26 – Mobile Home Units by Jurisdiction, 2018

Jurisdiction	Total Housing Units	Mobile Home Units	Mobile Home Units, Percent of Total
Everglades City	351	74	21.1%
Marco Island	18,742	9	0.1%
Naples	19,801	140	0.7%
Unincorporated Collier County	171,931	10,473	6.1%
Total	**210,825**	**10,696**	**5.1%**

Source: American Community Survey 5-Year Estimates, 2018
Note: Census data is not available for the Immokalee Reservation.

Property

Hurricanes can cause catastrophic damage to coastlines and several hundred miles inland. Hurricanes can produce winds exceeding 157 mph as well as tornadoes and microbursts. Additionally, hurricanes often bring intense rainfall that can result in flash flooding. Floods and flying debris from the excessive winds are often the deadly and most destructive results of hurricanes.

Hazus level 1 analysis was used to determine hurricane risk based on probabilistic parameters for the 100-year and 500-year return periods. This analysis produced estimates of the likelihood of varying levels of damage as well as building-related economic losses. Note that Hazus only assesses hurricane wind and does not account for any other hazards associated with hurricane.

Table 2.27 and Table 2.28 provide the likelihood of damage at varying levels of severity by occupancy type. During the probabilistic hurricane event with a 100-year return period, it's estimated that more than 77% of buildings in the county are likely to sustain damages. During the 500-year return period event, over 90% of the county's buildings are likely to be damaged.

Table 2.27 – Likelihood of Damage by Severity and Occupancy, 100-year Hurricane Event

Occupancy	Buildings at Risk	Value at Risk	Likelihood of Damage (%)				
			None	Minor	Moderate	Severe	Destruction
Agriculture	477	$168,071,000	20.38%	29.43%	26.19%	18.62%	5.38%
Commercial	7,201	$5,628,144,000	21.04%	21.77%	33.59%	23.04%	0.56%
Education	173	$195,401,000	22.68%	21.83%	29.91%	25.56%	0.02%
Government	108	$104,192,000	27.02%	20.24%	28.56%	24.16%	0.01%
Industrial	1,903	$951,068,000	22.64%	20.74%	29.46%	26.27%	0.89%
Religion	610	$495,399,000	21.92%	28.23%	29.65%	20.15%	0.05%
Residential	115,440	$35,361,568,000	24.39%	36.10%	28.92%	8.44%	2.15%
Total	**125,912**	**$42,903,843,000**	**22.87%**	**25.48%**	**29.47%**	**20.89%**	**1.29%**

Source: Hazus

Table 2.28 – Likelihood of Damage by Severity and Occupancy, 500-year Hurricane Event

Occupancy	Buildings at Risk	Value at Risk	Likelihood of Damage (%)				
			None	Minor	Moderate	Severe	Destruction
Agriculture	476	$168,071,000	5.94%	14.45%	27.49%	38.83%	13.30%
Commercial	7,201	$5,628,144,000	5.98%	9.06%	26.95%	54.60%	3.42%
Education	173	$195,401,000	6.62%	9.05%	24.17%	59.55%	0.61%
Government	105	$104,192,000	10.56%	9.74%	22.72%	56.53%	0.45%
Industrial	1,902	$951,068,000	6.31%	8.15%	22.61%	60.41%	2.52%
Religion	610	$495,399,000	5.91%	12.07%	28.39%	51.98%	1.64%
Residential	115,445	$35,361,568,000	6.47%	18.40%	32.74%	29.45%	12.94%
Total	**125,912**	**$42,903,843,000**	**6.83%**	**11.56%**	**26.44%**	**50.19%**	**4.98%**

Source: Hazus

Table 2.29 details estimated property damages from the 100-year and 500-year hurricane wind events by occupancy type.

Table 2.29 – Estimated Property Damages, 100-year and 500-year Hurricane Wind Events

Area	Residential	Commercial	Industrial	Others	Total
100-year Hurricane Event					
Building	$5,040,731,990	$689,821,610	$116,145,490	$99,295,360	$5,945,994,450
Content	$1,578,194,070	$435,101,930	$89,414,120	$60,901,580	$2,163,611,700
Total	**$6,618,926,060**	**$1,124,923,540**	**$205,559,610**	**$160,196,940**	**$8,109,606,150**
500-year Hurricane Event					
Building	$13,872,612,770	$1,903,830,650	$326,316,600	$270,330,950	$16,373,090,960
Content	$5,441,640,710	$1,417,126,940	$286,011,350	$191,043,810	$7,335,822,810
Total	**$19,314,253,480**	**$3,320,957,590**	**$612,327,950**	**$461,374,760**	**$23,708,913,770**

Source: Hazus

Estimated property damages for the 100-year hurricane wind event total $8,109,606,150, which equates to a loss ratio of approximately 19 percent. Estimated property damages for the 500-year event total $23,708,913,770, which represents a loss ratio of over 55 percent. FEMA considers a loss ratio of 10 percent or more to be an indicator that a community will have significant difficulty recovering from an event. The 500-year event will cause significant difficulties for recovery. Damages from an actual hurricane event would likely also involve flood impacts that would raise the damage total. Therefore, even a 100-year hurricane event may cause more serious damages that what is reported here from Hazus.

Due to the limitations of a Hazus level 1 analysis, damage estimates for critical facilities could not be calculated.

Environment

Aquatic species within the lake will either be displaced or destroyed. The velocity of the flood wave will likely destroy riparian and instream vegetation and destroy wetland function. The flood wave will like cause erosion within and adjacent to the stream. Deposition of eroded deposits may choke instream habitat or disrupt riparian areas. Sediments within the lake bottom and any low oxygen water from within the lake will be dispersed, potentially causing fish kills or releasing heavy metals found in the lake sediment layers.

Consequence Analysis

Table 2.30 summarizes the potential negative consequences of hurricanes and tropical storms.

Table 2.30 – Consequence Analysis – Hurricane and Tropical Storm

Category	Consequences
Public	Impacts include injury or death, loss of property, outbreak of diseases, mental trauma and loss of livelihoods. Power outages and flooding are likely to displace people from their homes. Water can become polluted such that if consumed, diseases and infection can be easily spread. Residential, commercial, and public buildings, as well as critical infrastructure such as transportation, water, energy, and communication systems may be damaged or destroyed, resulting in cascading impacts on the public.
Responders	Localized impact expected to limit damage to personnel in the inundation area at the time of the incident.
Continuity of Operations (including Continued Delivery of Services)	Damage to facilities/personnel from flooding or wind may require temporary relocation of some operations. Operations may be interrupted by power outages. Disruption of roads and/or utilities may postpone delivery of some services.

Category	Consequences
	Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Property, Facilities and Infrastructure	Structural damage to buildings may occur; loss of glass windows and doors by high winds and debris; loss of roof coverings, partial wall collapses, and other damages requiring significant repairs are possible in a major (category 3 to 5) hurricane.
Environment	Hurricanes can devastate wooded ecosystems and remove all the foliation from forest canopies, and they can change habitats so drastically that the indigenous animal populations suffer as a result. Specific foods can be taken away as high winds will often strip fruits, seeds and berries from bushes and trees. Secondary impacts may occur; for example, high winds and debris may result in damage to an above-ground fuel tank, resulting in a significant chemical spill.
Economic Condition of the Jurisdiction	Local economy and finances adversely affected, possibly for an extended period, depending on damages. Intangible impacts also likely, including business interruption and additional living expenses.
Public Confidence in the Jurisdiction's Governance	Likely to impact public confidence due to possibility of major event requiring substantial response and long-term recovery effort.

Hazard Summary by Jurisdiction

The following table summarizes extreme heat hazard risk by jurisdiction. Due to its coastal geography, the entire county is susceptible to the impacts of hurricanes, tropical storms, and the associated storm surges and flooding. While hurricanes have the possibility of being catastrophic across all jurisdictions, certain areas have higher vulnerability. Impacts may be greater in more highly developed areas with greater amounts of impervious surface and higher exposure in terms of both property and population density. Areas with more mobile homes are also more vulnerable to damage, while areas with higher property values have greater overall exposure and potential for damages. Despite these differences, all jurisdictions have the possibility for catastrophic impacts.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	3	4	4	1	3	3.3	H
Immokalee Reservation	3	4	4	1	3	3.3	H
Marco Island	3	4	4	1	3	3.3	H
Naples	3	4	4	1	3	3.3	H
Unincorporated Collier County	3	4	4	1	3	3.3	H

2.5.3 Severe Storms and Tornadoes

Hazard Description

Thunderstorm Winds

Thunderstorms result from the rapid upward movement of warm, moist air. They can occur inside warm, moist air masses and at fronts. As the warm, moist air moves upward, it cools, condenses, and forms cumulonimbus clouds that can reach heights of greater than 35,000 ft. As the rising air reaches its dew point, water droplets and ice form and begin falling the long distance through the clouds towards earth's surface. As the droplets fall, they collide with other droplets and become larger. The falling droplets create a downdraft of air that spreads out at earth's surface and causes strong winds associated with thunderstorms.

There are four ways in which thunderstorms can organize: single cell, multi-cell cluster, multi-cell lines (squall lines), and supercells. Even though supercell thunderstorms are most frequently associated with severe weather phenomena, thunderstorms most frequently organize into clusters or lines. Warm, humid conditions are favorable for the development of thunderstorms. The average single cell thunderstorm is approximately 15 miles in diameter and lasts less than 30 minutes at a single location. However, thunderstorms, especially when organized into clusters or lines, can travel intact for distances exceeding 600 miles.

Thunderstorms are responsible for the development and formation of many severe weather phenomena, posing great hazards to the population and landscape. Damage that results from thunderstorms is mainly inflicted by downburst winds, large hailstones, and flash flooding caused by heavy precipitation. Stronger thunderstorms can produce tornadoes and waterspouts. While conditions for thunderstorm conditions may be anticipated within a few hours, severe conditions are difficult to predict. Regardless of severity, storms generally pass within a few hours.

Warning Time: 4 – Less than six hours

Duration: 1 – Less than six hours

Lightning

Lightning is a sudden electrical discharge released from the atmosphere that follows a course from cloud to ground, cloud to cloud, or cloud to surrounding air, with light illuminating its path. Lightning's unpredictable nature causes it to be one of the most feared weather elements.

All thunderstorms produce lightning, which often strikes outside of the area where it is raining and is known to fall more than 10 miles away from the rainfall area. When lightning strikes, electricity shoots through the air and causes vibrations creating the sound of thunder. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Nationwide, lightning kills 75 to 100 people each year. Lightning strikes can also start building fires and wildland fires, and damage electrical systems and equipment.

The watch/warning time for a given storm is usually a few hours. There is no warning time for any given lightning strike. Lightning strikes are instantaneous. Storms that cause lightning usually pass within a few hours.

Warning Time: 4 – minimal or no warning time (less than 6 hours warning)

Duration: 1 – less than six hours

Hail

According to the National Oceanic and Atmospheric Administration (NOAA), hail is precipitation that is formed when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere causing them to freeze. The raindrops form into small frozen droplets and then continue to grow as they encounter super-cooled water which will freeze on contact with the frozen rain droplet. This frozen rain droplet can continue to grow and form hail. If the updraft forces can support or suspend the weight of the hailstone, hail can continue to grow.

At the time when the updraft can no longer support the hailstone, it will fall to the earth. For example, a ¼" diameter or pea sized hail requires updrafts of 24 mph, while a 2 ¾" diameter or baseball sized hail requires an updraft of 81 mph. The largest hailstone recorded in the United States was found in Vivian, South Dakota on July 23, 2010; it measured eight inches in diameter, almost the size of a soccer ball. While soccer-ball-sized hail is the exception, but even small pea sized hail can do damage.

Hailstorms in Florida cause damage to property, crops, and the environment, and kill and injure livestock. In the United States, hail causes more than $1 billion in damage to property and crops each year. Much of the damage inflicted by hail is to crops. Even relatively small hail can shred plants to ribbons in a matter of minutes. Vehicles, roofs of buildings and homes, and landscaping are the other things most commonly damaged by hail. Hail has been known to cause injury to humans; occasionally, these injuries can be fatal.

The onset of thunderstorms with hail is generally rapid. However, advancements in meteorological forecasting allow for some warning. Storms usually pass in a few hours.

Warning Time: 4 – Less than 6 hours

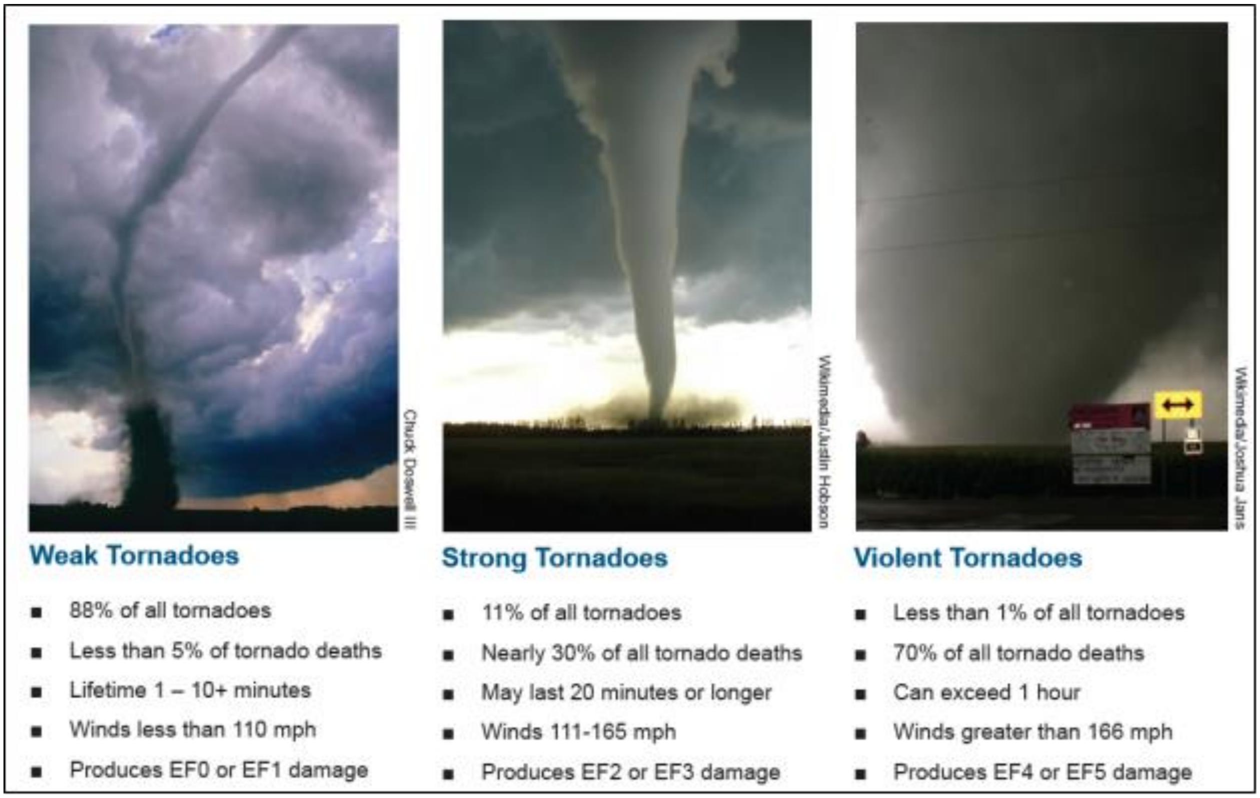
Duration: 1 – Less than 6 hours

Tornado

According to the Glossary of Meteorology (AMS 2000), a tornado is "a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud." Tornadoes can appear from any direction. Most move from southwest to northeast, or west to east. Some tornadoes have changed direction amid path, or even backtracked.

Tornadoes are commonly produced by land falling tropical cyclones. Those making landfall along the Gulf coast traditionally produce more tornadoes than those making landfall along the Atlantic coast. Tornadoes that form within hurricanes are more common in the right front quadrant with respect to the forward direction but can occur in other areas as well. According to the NHC, about 10% of the tropical cyclone-related fatalities are caused by tornadoes. Tornadoes are more likely to be spawned within 24 hours of landfall and are usually within 30 miles of the tropical cyclone's center.

Tornadoes have the potential to produce winds in excess of 200 mph (EF5 on the Enhanced Fujita Scale) and can be very expansive – some in the Great Plains have exceeded two miles in width. Tornadoes associated with tropical cyclones, however, tend to be of lower intensity (EF0 to EF2) and much smaller in size than ones that form in the Great Plains.



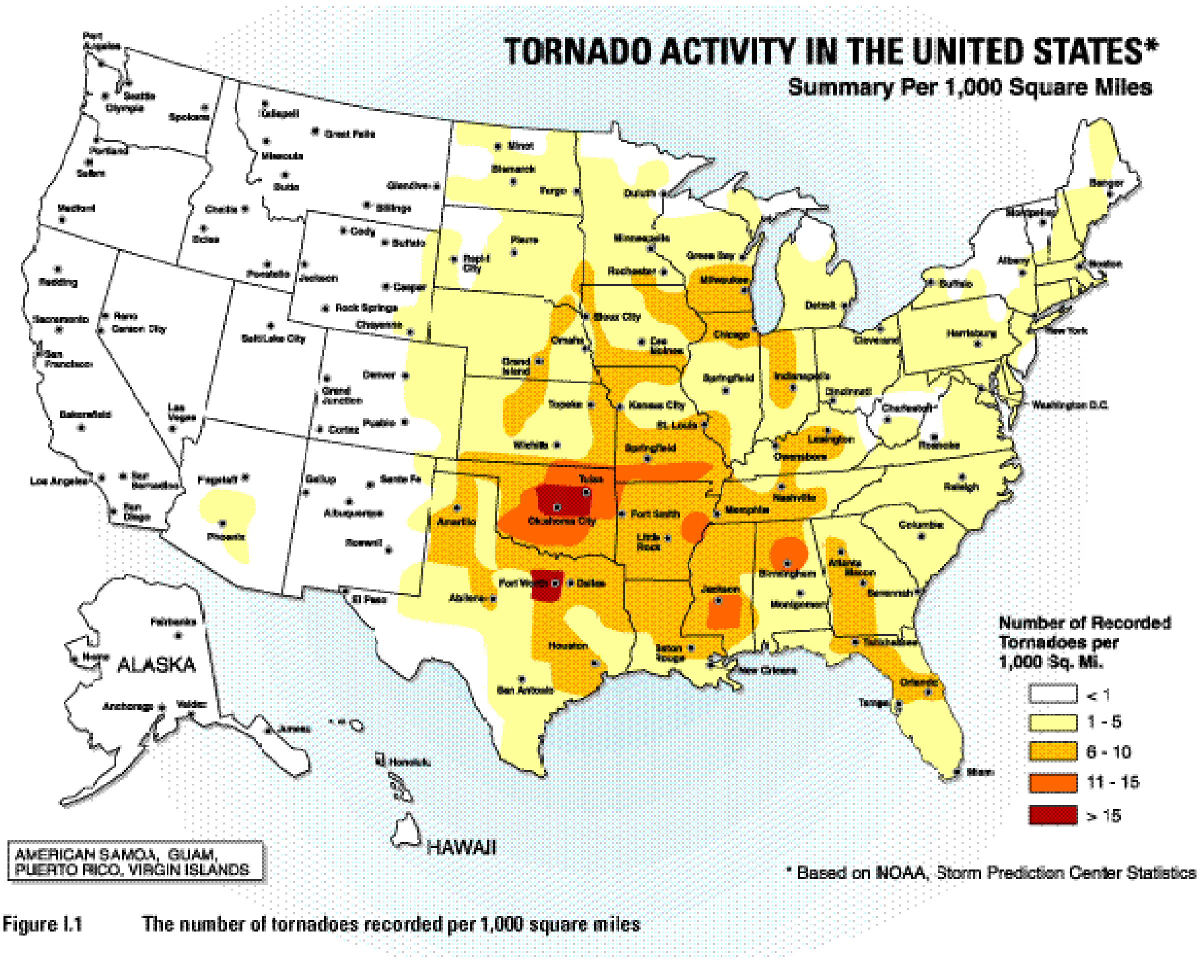
Source: NOAA National Weather Service

Warning Time: 4 – Less than 6 hours

Duration: 1 – Less than 6 hours

According to the NOAA Storm Prediction Center (SPC), the highest concentration of tornadoes in the United States has been in Oklahoma, Texas, Kansas and Florida respectively. Although the Great Plains region of the Central United States does favor the development of the largest and most dangerous tornadoes (earning the designation of “tornado alley”), Florida experiences the greatest number of tornadoes per square mile of all U.S. states (SPC, 2002). The below Figure 2.9 shows tornado activity in the United States based on the number of recorded tornadoes per 1,000 square miles.

Figure 2.9 – Tornado Activity in the U.S.



Source: American Society of Civil Engineers

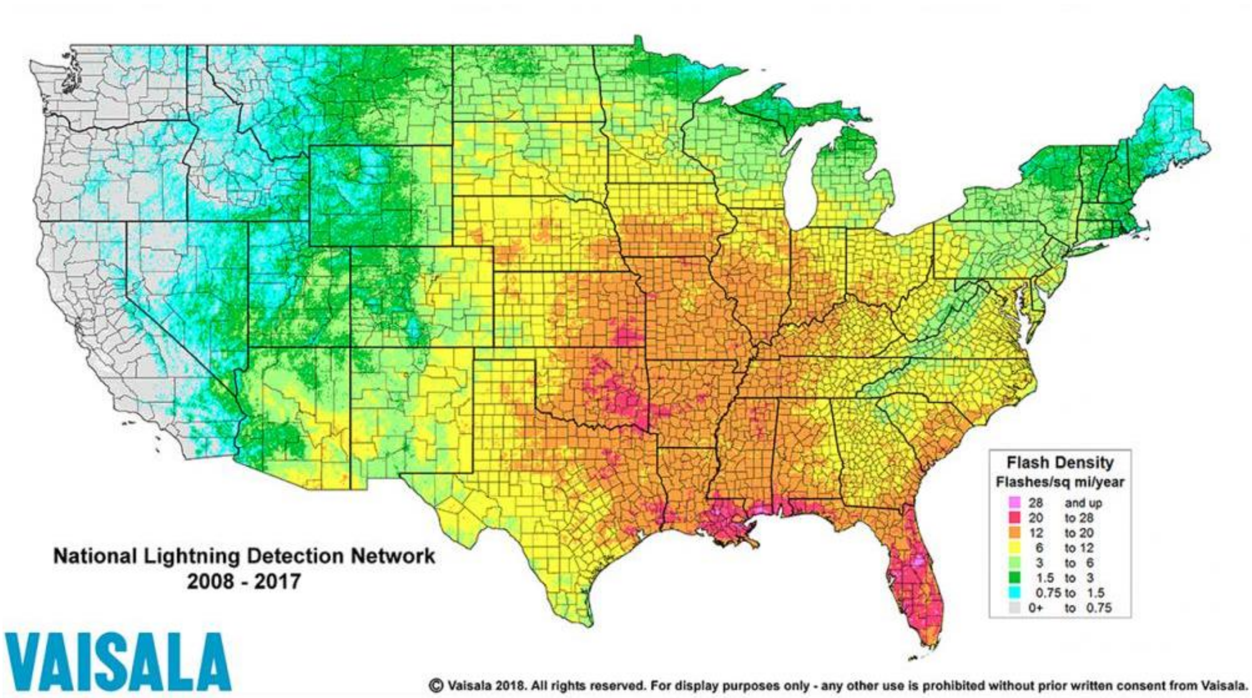
Location

Thunderstorm wind, lightning, and hail events do not have a defined vulnerability zone. The scope of lightning and hail is generally confined to the footprint of its associated thunderstorm. The entirety of Collier County shares equal risk to the threat of severe weather.

According to the Vaisala 2019 Annual Lightning Report, Florida had 228 lightning events per square mile, more than any other state. According to Vaisala's flash density map, shown in Figure 2.10, Collier County is in an area that experiences 20 to 28 lightning flashes per square mile per year.

It should be noted that future lightning occurrences may exceed these figures.

Figure 2.10 – Lightning Flash Density (2008-2017)

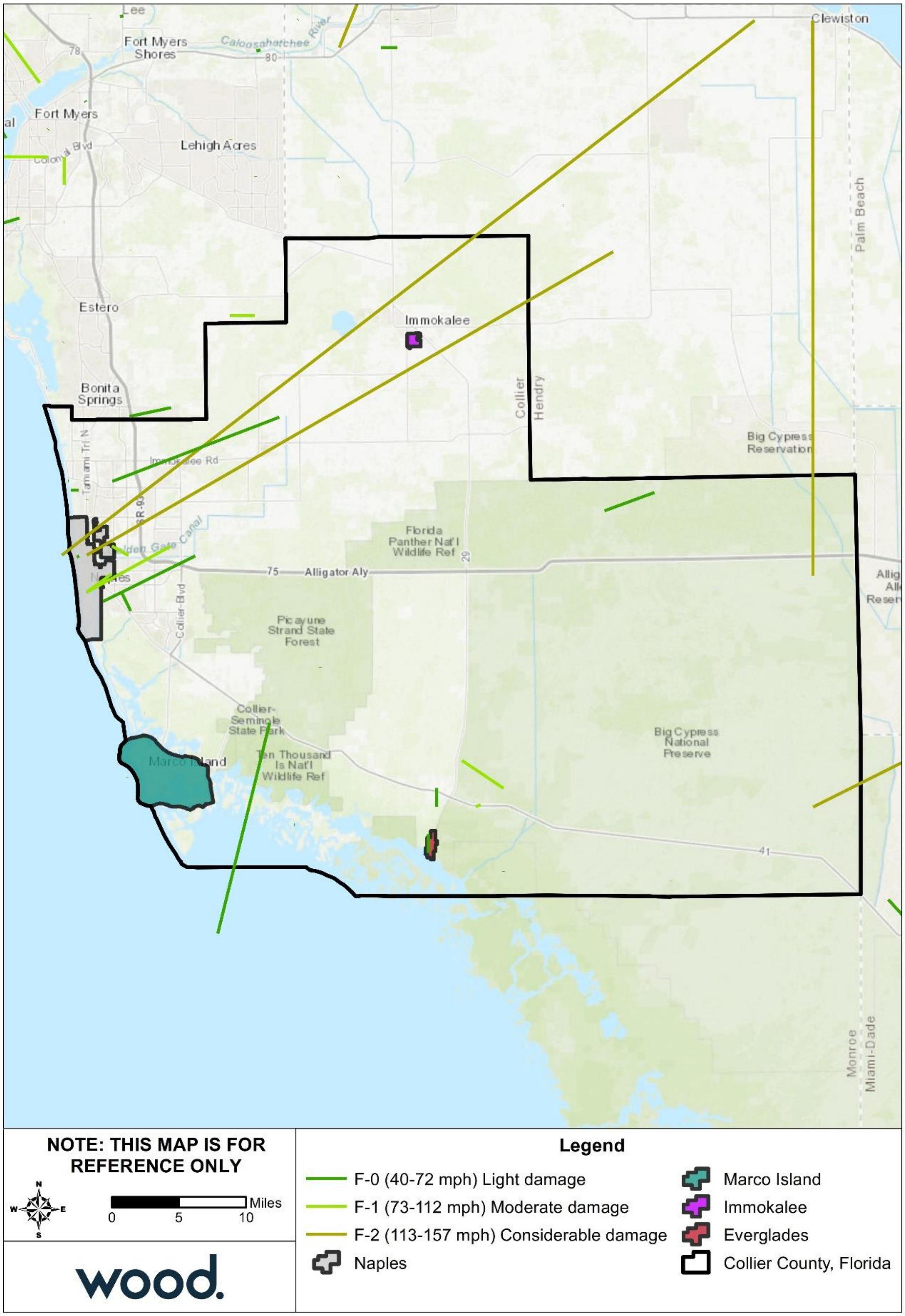


Source: Vaisala

Figure 2.11 reflects the tracks of past tornados that passed through Collier County from 1950 through 2017 according to data from the NOAA/NWS Storm Prediction Center.

Tornados can occur anywhere in the County. Tornadoes typically impact a small area, but damage may be extensive. Tornado locations are completely random, meaning risk to tornado isn't increased in one area of the county versus another. All of Collier County is uniformly exposed to this hazard.

Figure 2.11 – Tornado Paths Through Collier County, 1950-2017



Source: NOAA/NWS Storm Prediction Center

Extent

Thunderstorm Winds

The magnitude of a thunderstorm event can be defined by the storm's maximum wind speed and its impacts. NCEI divides wind events into several types including High Wind, Strong Wind, Thunderstorm Wind, Tornado and Hurricane. For this severe weather risk assessment, High Wind, Strong Wind and Thunderstorm Wind data was collected. Hurricane Wind and Tornadoes are addressed as individual hazards. The following definitions come from the NCEI Storm Data Preparation document.

- **High Wind** – Sustained non-convective winds of 40mph or greater lasting for one hour or longer or winds (sustained or gusts) of 58 mph for any duration on a widespread or localized basis.
- **Strong Wind** – Non-convective winds gusting less than 58 mph, or sustained winds less than 40 mph, resulting in a fatality, injury, or damage.
- **Thunderstorm Wind** – Winds, arising from convection (occurring within 30 minutes of lightning being observed or detected), with speeds of at least 58 mph, or winds of any speed (non-severe thunderstorm winds below 58 mph) producing a fatality, injury or damage.

The strongest recorded thunderstorm wind event in the county occurred on January 17, 2016 with a measured gust of 90 mph in Naples and estimated gusts of 79 to 82 mph elsewhere across the county. The event reportedly caused no fatalities, injuries, or damages.

Impact: 2 – Limited

Spatial Extent: 4 – Large

Lightning

Lightning is measured by the Lightning Activity Level (LAL) scale, created by the NWS to define lightning activity into a specific categorical scale. The LAL is a common parameter that is part of fire weather forecasts nationwide. The scale is shown in Table 2.31.

Table 2.31 – Lightning Activity Level Scale

Lightning Activity Level Scale	
LAL 1	No thunderstorms
LAL 2	Isolated thunderstorms. Light rain will occasionally reach the ground. Lightning is very infrequent, 1 to 5 cloud to ground lightning strikes in a five-minute period
LAL 3	Widely scattered thunderstorms. Light to moderate rain will reach the ground. Lightning is infrequent, 6 to 10 cloud to ground strikes in a five-minute period
LAL 4	Scattered thunderstorms. Moderate rain is commonly produced. Lightning is frequent, 11 to 15 cloud to ground strikes in a five-minute period
LAL 5	Numerous thunderstorms. Rainfall is moderate to heavy. Lightning is frequent and intense, greater than 15 cloud to ground strikes in a five-minute period
LAL 6	Dry lightning (same as LAL 3 but without rain). This type of lightning has the potential for extreme fire activity and is normally highlighted in fire weather forecasts with a Red Flag warning

Source: National Weather Service

With the right conditions in place, the entire county is susceptible to each lightning activity level as defined by the LAL. Most lightning strikes cause limited damage to specific structures in a limited area, and cause very few injuries or fatalities, and minimal disruption on quality of life.

While the total area vulnerable to a lightning strike corresponds to the footprint of a given thunderstorm, a specific lightning strike is usually a localized event and occurs randomly. It should be noted that while lightning is most often affiliated with severe thunderstorms, it may also strike outside of heavy rain and might occur as far as 10 miles away from any rainfall. All of Collier County is exposed to lightning.

Impact: 1 – Minor

Spatial Extent: 1 – Negligible

Hail

The NWS classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 2.32 indicates the hailstone measurements utilized by the NWS.

Table 2.32 – Hailstone Measurement Comparison Chart

Average Diameter	Corresponding Household Object
.25 inch	Pea
.5 inch	Marble/Mothball
.75 inch	Dime/Penny
.875 inch	Nickel
1.0 inch	Quarter
1.5 inch	Ping-pong ball
1.75 inch	Golf ball
2.0 inch	Hen egg
2.5 inch	Tennis ball
2.75 inch	Baseball
3.00 inch	Teacup
4.00 inch	Grapefruit
4.5 inch	Softball

Source: National Weather Service

The Tornado and Storm Research Organization (TORRO) has further described hail sizes by their typical damage impacts. Table 2.33 describes typical intensity and damage impacts of the various sizes of hail.

Table 2.33 – Tornado and Storm Research Organization Hailstorm Intensity Scale

Intensity Category	Diameter (mm)	Diameter (inches)	Size Description	Typical Damage Impacts
Hard Hail	5-9	0.2-0.4	Pea	No damage
Potentially Damaging	10-15	0.4-0.6	Mothball	Slight general damage to plants, crops
Significant	16-20	0.6-0.8	Marble, grape	Significant damage to fruit, crops, vegetation
Severe	21-30	0.8-1.2	Walnut	Severe damage to fruit and crops, damage to glass and plastic structures, paint and wood scored
Severe	31-40	1.2-1.6	Pigeon's egg > squash ball	Widespread glass damage, vehicle bodywork damage
Destructive	41-50	1.6-2.0	Golf ball > Pullet's egg	Wholesale destruction of glass, damage to tiled roofs, significant risk of injuries
Destructive	51-60	2.0-2.4	Hen's egg	Bodywork of grounded aircraft dented, brick walls pitted
Destructive	61-75	2.4-3.0	Tennis ball > cricket ball	Severe roof damage, risk of serious injuries
Destructive	76-90	3.0-3.5	Large orange > softball	Severe damage to aircraft bodywork
Super Hailstorms	91-100	3.6-3.9	Grapefruit	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open
Super Hailstorms	>100	4.0+	Melon	Extensive structural damage. Risk of severe or even fatal injuries to persons caught in the open

Source: Tornado and Storm Research Organization (TORRO), Department of Geography, Oxford Brookes University

Notes: In addition to hail diameter, factors including number and density of hailstones, hail fall speed and surface wind speeds affect severity.

The average hailstone size recorded between 2000 and 2019 in Collier County was a little under 1" in diameter; the largest hailstone recorded was 1.5", recorded on April 6, 2012 and June 26, 2014. The largest hailstone ever recorded in the U.S. fell in Vivian, SD on June 23, 2010, with a diameter of 8 inches and a circumference of 18.62 inches.

Impact: 1 – Minor

Hailstorms frequently accompany thunderstorms, so their locations and spatial extents coincide. Collier County is uniformly exposed to severe thunderstorms; therefore, the entire planning area is equally exposed to hail which may be produced by such storms. However, large-scale hail tends to occur in a more localized area within the storm.

Spatial Extent: 2 – Small

Tornado

Prior to February 1, 2007, tornado intensity was measured by the Fujita (F) scale. This scale was revised and is now the Enhanced Fujita (EF) scale. Both scales are sets of wind estimates (not measurements) based on damage. The new scale provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis, better correlation between damage and wind speed. It is also more precise because it considers the materials affected and the construction of structures damaged by a tornado. Table 2.34 shows the wind speeds associated with the enhanced Fujita scale ratings and the damage that could result at different levels of intensity.

Table 2.34 – Enhanced Fujita Scale

EF Number	3 Second Gust (mph)	Damage
0	65-85	**Light damage.** Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
1	96-110	**Moderate damage.** Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
2	111-135	**Considerable damage.** Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
3	136-165	**Severe damage.** Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
4	166-200	**Devastating damage.** Well-constructed houses and whole frame houses completely leveled; cars thrown, and small missiles generated.
5	Over 200	**Incredible damage.** Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly in excess of 100 m; high-rise buildings have significant structural deformation; incredible phenomena will occur.

The most intense tornado to pass through Collier County in the past 20 years was an EF1 in Ochopee on September 9, 2017. While NCEI reports no property damage occurred, narratives of the event say that it occurred simultaneous to Hurricane Irma and caused damage to multiple trees along its path. The tornado was 0.25 miles long and 50 yards wide.

Impact: 3 – Critical

Spatial Extent: 2 – Small

Historical Occurrences

Thunderstorm Winds

Between January 1, 2000 and December 31, 2019, the NCEI recorded 54 separate incidents of thunderstorm winds, occurring on 35 separate days. These events caused $200,500 in recorded property damage, but no crop damages, injuries, or fatalities were reported. The recorded gusts averaged 54.6 miles per hour, with the highest gusts recorded at 89.8 mph, recorded on January 17, 2016. Of these events, 15 caused property damage. Wind gusts with property damage recorded averaged $11,794 in damage, with one gust causing a reported $50,000 in damage (in East Naples on August 9, 2006). These incidents are aggregated by the date the events occurred and are recorded in Table 2.35 below:

Table 2.35 – Recorded Thunderstorm Winds with Property Damages, Collier County, 2000-2019

Location	Date	Wind Speed (mph)	Fatalities	Injuries	Property Damage
Vanderbilt Beach	6/26/2001	81	0	0	$50,000
Naples	7/17/2002	58	0	0	$0
Naples	2/22/2003	63	0	0	$0
Vanderbilt Beach	7/4/2003	75	0	0	$0
Golden Gate	4/12/2004	63	0	0	$10,000
Immokalee	6/4/2004	62	0	0	$0
Marco Island	8/13/2004	63	0	0	$0
Everglades City	4/7/2005	58	0	0	$5,000
Golden Gate	7/16/2005	58	0	0	$1,000
East Naples	8/9/2006	81	0	0	$50,000
Naples	8/19/2006	63	0	0	$0
Jerome	39207	64	0	0	$0
Immokalee	39208	70	0	0	$10,000
(Apf)Naples Muni Arp	5/14/2007	60	0	0	$0
Golden Gate	6/8/2007	70	0	0	$1,000
East Naples	6/25/2007	64	0	0	$500
(Apf)Naples Muni Arp	9/17/2007	62	0	0	$20,000
Sunniland	6/7/2009	60	0	0	$0
Naples Park	4/26/2010*	58	0	0	$2,000
Immokalee	6/15/2011*	86	0	0	$40,000
(Apf)Naples Muni Arp	4/6/2012	60	0	0	$2,000
Immokalee	5/24/2013	60	0	0	$0
East Naples	3/6/2014*	60	0	0	$0
Corkscrew	3/29/2014	60	0	0	$0
Golden Gate	6/15/2014	60	0	0	$0
Golden Gate	6/11/2015*	60	0	0	$0
(Apf)Naples Muni Arp	9/29/2015	64	0	0	$0
Naples	1/17/2016*	90	0	0	$0
Marco Island Arpt	2/16/2016	60	0	0	$0
Goodland	1/23/2017	60	0	0	$0
(Apf)Naples Muni Arp	7/31/2017	58	0	0	$2,000
(Apf)Naples Muni Arp	12/9/2017	59	0	0	$0
Marco Island	3/20/2018	61	0	0	$0
East Naples	5/30/2018	49	0	0	$5,000
Marco Island	10/19/2019*	45	0	0	$2,000
		Total	**0**	**0**	**$200,500**

Source: NCEI; Note: *Multiple events occurred on these dates. Injury, fatality, and damage stats are totaled; wind speed is highest reported.

In addition to recorded thunderstorm wind events, NCEI reports 2 high wind and strong wind events during this same period that caused $5,000 in property damage. Of all 60 wind events during this period, there were no incidents that directly caused deaths or injuries.

Lightning

According to NCEI data, there were 27 lightning strikes reported between 2000 and 2019. Of these, 17 recorded property damage totaling over $4.7 million. The highest rate of property damage recorded for a single incident was $2,000,000. Three events caused fatalities, and seven events caused a total of 11 injuries. Event narratives indicate in some cases that property damage occurred but was not estimated; therefore, actual property damage amounts are higher. No crop damage was recorded by these strikes. It should be noted that lightning events recorded by the NCEI are only those that are reported; it is certain that additional lightning incidents have occurred in Collier County. Table 2.36 details NCEI-recorded lightning strikes from 2000 through 2019.

Table 2.36 – Recorded Lightning Strikes in Collier County, 2000-2019

Location	Date	Time	Fatalities	Injuries	Property Damage
Naples Park	6/18/2001	18:30	0	0	$2,000
Immokalee	4/28/2003	13:30	1	2	$0
Naples	8/5/2003	14:00	0	1	$5,000
Lelyland	8/7/2006	12:45	0	1	$500,000
Golden Gate	8/15/2006	14:00	0	1	$0
North Naples	7/27/2007	18:55	0	0	$40,000
Collier City	9/17/2008	20:00	0	0	$75,000
Corkscrew	6/23/2009	12:50	0	2	$0
Naples	7/14/2010	14:15	0	0	$10,000
Naples Park	9/26/2010	14:30	0	0	$1,000
Golden Gate	9/23/2011	16:50	0	0	$600
Corkscrew	6/26/2013	12:35	1	0	$0
Marco	7/9/2013	14:00	0	0	$0
Marco	8/18/2013	16:30	0	0	$0
North Naples	9/2/2013	12:10	0	0	$2,000,000
East Naples	9/6/2013	19:30	0	0	$2,000
Vanderbilt Beach	9/7/2013	15:45	0	0	$30,000
Golden Gate	4/17/2014	14:55	0	0	$0
East Naples	7/15/2014	10:20	0	0	$5,000
Naples	6/22/2015	17:00	0	0	$2,000,000
Naples Park	7/1/2015	18:00	0	0	$2,000
North Naples	7/1/2015	18:30	0	0	$10,000
East Naples	8/15/2015	14:00	0	1	$0
Golden Gate	5/28/2016	14:00	1	0	$0
Marco Island	8/24/2016	13:50	0	3	$0
North Naples	6/30/2017	17:00	0	0	$10,000
Naples Park	7/18/2019	12:30	0	0	$80,000
		Total	**3**	**11**	**$4,772,600**

Source: NCEI

The following are a selection of narrative descriptions recorded in NCEI for lightning events that occurred in Collier County:

April 28, 2003 – A 52-year-old was killed while working near a ditch at a farm two miles from Oil Well Road. Two other men standing about 10 feet away were injured by the same lightning strike. It was raining heavily at the time.

June 23, 2009 – Two truck drivers were shocked by a nearby lightning strike as they were loading a dump truck in the Golden Gate Estates area. Both men received minor burns on their thighs and complained that their feet were stinging and burning. The injuries were not believed to be serious. One of the men was 22 years old and the other's age was unclear.

June 26, 2013 – Lightning fatally struck a 35-year-old male construction worker who was working on the exterior of a single-family home on scaffolding.

May 28, 2016 – OSHA reported a fatality due to a lightning strike to a construction worker who was struck while working on a roof. The date of death was reported to be the following day, May 29th, 2016.

August 24, 2016 – A family visiting from out of town was leaving the south beach area of Marco Island as storms approached when lightning struck near their location. A 15-year-old male, as well as his brother and another female fell into the sand. All three were able to recover, but the 15-year-old male reported numbness in the chest, legs, and arms. All three victims and was taken to a local hospital and later released with minor injuries.

Hail

NCEI records 39 separate hail incidents across 30 days between January 1, 2000 and December 31, 2019 in Collier County. Of these, no events were reported to have caused property damage and none caused death, injury or crop damage. However, this damage estimate may be under reported, as damage was reported in the narratives of many events but was not recorded in terms of a monetary value. The largest diameter hail recorded in the County was 1.5 inches, which occurred on two occasions: in Golden Gate on April 6, 2012 and in North Naples on June 26, 2014. The average hail size of all events in the County was just under one inch in diameter. Table 2.37 shows the summary of hail occurrences.

Table 2.37 – Summary of Hail Occurrences by Location

Location	Number of Occurrences	Average Hail Diameter
Copeland	1	1.00”
Everglades City	1	0.75”
Golden Gate	13	0.96”
Immokalee	3	0.88”
Jerome	1	1.00”
Marco Island	3	0.96”
Miles City	1	1.00”
Monroe Station	1	0.75”
Naples	6	0.84”
Naples Park	4	0.85”
North Naples	4	1.13”
Royal Palm	1	1.00”
Total	**42**	**0.93”**

Source: NCEI

The following narratives provide detail on select hailstorms from the above list of NCEI recorded events:

April 6, 2012 – A strong cold front produced a line of strong to severe thunderstorms that moved across South Florida during the morning and early afternoon. Approximately 4,000 customers lost power in

Collier County, with an estimated 5,800 in Broward and Miami-Dade counties. Hail of 1.5-inch diameter was reported near Golden Gate Boulevard about one mile east of Collier Blvd.

June 26, 2014 – A moist and unstable airmass resulted in scattered late afternoon and evening showers and thunderstorms. A Facebook picture showed a 1.5-inch hail diameter in Wilshire Lakes just north of Vanderbilt Beach Road and east of I-75.

June 11, 2018 – Morning storms once again developed along the east coast with the Atlantic sea breeze, with numerous storms across the interior and Gulf coast as sea breeze moved west and collided with the Gulf breeze along the Gulf coast during the afternoon hours. Shower and storm development along these boundaries were enhanced by a lingering upper level low across the northern Florida and the eastern Gulf of Mexico, allowing several strong storms to develop. Hail and a funnel cloud were reported in Palm Beach County with the morning activity, along with a lightning-induced fatality in Broward County. Hail was reported in Collier County during the afternoon hours. A video received via social media shows approximately dime sized hail falling in the Palm River area of North Naples. Time is estimated based on video post time and radar.

Tornado

NCEI storm reports were reviewed from 2000 through 2019 to assess whether recent trends varied from the longer historical record. According to NCEI, Collier County experienced 24 tornado incidents between 2000 and 2019, causing 1 injury, almost $800 thousand in property damage and no fatalities or crop damage. However, this damage estimate may be under reported, as damage was reported in the narratives of many events but was not recorded in terms of a monetary value. Table 2.38 shows historical tornadoes in Collier County during this time period.

Table 2.38 – Recorded Tornadoes in Collier County, 2000-2019

Location	Date	Time	Magnitude	Deaths/Injuries	Property Damage	Crop Damage
Naples	6/16/2001	16:45	F0	0/0	$2,000	$0
Naples	3/27/2003	14:20	F1	0/0	$50,000	$0
Ochopee	3/27/2003	15:00	F0	0/0	$0	$0
Ochopee	7/15/2003	17:59	F0	0/0	$0	$0
Monroe Station	10/29/2003	13:20	F0	0/0	$0	$0
Golden Gate	4/12/2004	17:45	F1	0/0	$100,000	$0
North Naples	7/10/2004	17:00	F0	0/0	$5,000	$0
East Naples	9/19/2004	15:15	F1	0/0	$75,000	$0
East Naples	9/19/2004	15:20	F0	0/0	$10,000	$0
Naples	9/27/2005	16:27	F0	0/0	$0	$0
Copeland	10/24/2005	13:30	F1	0/0	$40,000	$0
Jerome	9/22/2007	19:00	EF0	0/0	$0	$0
North Naples	12/21/2007	20:10	EF0	0/0	$15,000	$0
Everglades City	2/12/2008	21:45	EF0	0/0	$444,590	$0
Naples	4/6/2012	20:43	EF0	0/0	$10,000	$0
East Naples	6/23/2012	14:35	EF0	0/0	$35,000	$0
Naples Park	6/23/2012	15:00	EF0	0/1	$0	$0
Goodland	6/24/2012	10:10	EF0	0/0	$0	$0
Golden Gate	6/24/2012	11:00	EF0	0/0	$0	$0
Corkscrew	6/24/2012	11:25	EF0	0/0	$0	$0
Vanderbilt Beach	9/29/2015	21:00	EF0	0/0	$0	$0
Sunniland	2/16/2016	17:10	EF0	0/0	$0	$0

Location	Date	Time	Magnitude	Deaths/Injuries	Property Damage	Crop Damage
Ochopee	9/9/2017	11:20	EF1	0/0	$0	$0
Corkscrew	11/22/2017	16:40	EF0	0/0	$0	$0
Total				**0/1**	**$786,590**	**$0**

Source: NCEI

Narratives from NCEI illustrate that damage occurred in many of these incidents even if a monetary value was not recorded. Specific incidents with some level of impact include:

April 12, 2004 – A tornado associated with a squall line touched down near I-75 and Santa Barbara Boulevard and lifted near the Golden Gate Parkway. The tornado caused minor roof damage to houses, destroyed sheds and uprooted trees. Minor damage was also reported at Naples Municipal Airport.

September 19, 2004 – A tornado touched down in a vacant construction site just south of the Imperial Wilderness Mobile Home Park then moved northwest through the MHP. Damage was sustained to twenty homes with six suffering major damage.

February 12, 2008 – An EF0 Tornado touched down at the Everglades City Airport, flipping two Cessna Aircrafts while moving northeast. The tornado then moved across western sections of Everglades City producing roof and minor structural damage to a condo, school, and storage building and downing trees and power poles and damaging fences before dissipating on the north side of town.

June 23, 2012 – The outer bands from Tropical Storm Debby located in the northeast Gulf of Mexico spawned two tornadoes in the Naples area both with EF0 intensity. A brief tornado touchdown occurred at the North Collier Hospital in North Naples on the corner of Immokalee and Goodlette-Frank Roads. Damage was reported to trees and light poles broken off, but no structural damage to the hospital. One person was struck by a downed tree limb and was treated on-site. The tornado was likely spawned by the same storm that produced the earlier tornado in East Naples.

Probability of Future Occurrence

Based on historical occurrences recorded by NCEI for the 20-year period from 2000 through 2019, Collier County averages 2.7 thunderstorm wind events per year. Over this same period, 24 lightning events were reported as having caused death, injury, or property damage, which equates to an average of 1.2 damaging lightning strikes per year.

The average hail storm in Collier County occurs in the afternoon and has a hail stone with a diameter of just under one inch. Over the 20-year period from 2000 through 2019, Collier County experienced 39 reported hail incidents; this averages just under two reported incidents per year somewhere in the planning area, or a 100% chance that the County will experience a hail incident each year.

Based on these historical occurrences, there is a 100% chance that the County will experience severe weather each year. The probability of a damaging impacts is highly likely.

In a twenty-year span between 2000 and 2019, Collier County experienced 24 separate tornado incidents over 19 separate days. This correlates to over a 100 percent annual probability that the Region will experience a tornado somewhere in its boundaries. None of these past tornado events was a magnitude EF2 or greater; therefore, the annual probability of a significant tornado event is less than 1 percent.

Probability: 4 – Highly Likely

Climate Change

Higher temperatures and humidity may increase atmospheric variability associated with the origination of severe thunderstorms and tornadoes. Decreases in vertical wind shear can result in fewer or weaker severe thunderstorms and tornadoes. However, this decrease is most likely to occur when convective available potential energy is high in spring and summer, which could result in more frequent severe storms. There has been a surge in the number of severe storms reported over the past 50 years, but this increase could at least be partially attributed to technological developments that allow for better identification and reporting of such storms.

Vulnerability Assessment

People

People and populations exposed to the elements are most vulnerable to severe weather. A common hazard associated with wind events is falling trees and branches. Risk of being struck by lightning is greater in open areas, at higher elevations, and on the water.

Lightning can also cause cascading hazards, including power loss. Loss of power could critically impact those relying on energy to service, including those that need powered medical devices. Additionally, the ignition of fires is always a concern with lightning strikes.

The availability of sheltered locations such as basements, buildings constructed using hail-resistant materials and methods, and public storm shelters, all reduce the exposure of the population. Residents living in mobile homes are more vulnerable to hail events due to the lack of shelter locations and the vulnerability of the housing unit to damages. Overall, the housing stock in Collier County includes 10,696 mobile home units, as detailed in Table 2.26 in Section 2.5.2. Over 20 percent of the housing stock in Everglades City is comprised of mobile home units. Additionally, there are over 10,000 mobile home units in unincorporated Collier County, comprising over 6 percent of the housing stock. These communities may face more severe impacts from hurricane events as a result.

Since 2000, the NCEI records 3 fatalities and 11 injuries attributed to lightning in Collier County. NCEI records no fatalities and no injuries attributed to wind events in Collier County. There are no injuries or fatalities attributed to hail.

People and populations exposed to the elements are most vulnerable to tornados. Since 2000, the NCEI database records no fatalities and one injury attributed to tornadoes in Collier County.

Property

All property, including residential and commercial buildings as well as critical facilities and infrastructure, are vulnerable to impacts from severe storms and tornadoes.

Property damage caused by lightning usually occurs in one of two ways – either by direct damages through fires ignited by lightning, or by secondary impacts due to power loss. According to data collected on lightning strikes in Collier County, most recorded property damage was due to structure fires.

NCEI records lightning impacts over 20 years (2000-2019), with $4,772,600 in property damage recorded (no incidents were recorded in 2000, 2002, 2004, 2005, 2012, or 2018). Based on these records, the planning area experiences an annualized loss of $238,630 in property damage. The average impact from lightning per incident in Collier County is $176,763.

General damages to property from hail are direct, including destroyed windows, dented cars, and building, roof and siding damage in areas exposed to hail. Hail can also cause enough damage to cars to cause them to be totaled. The level of damage is commensurate with both a material's ability to withstand hail impacts, and the size of the hailstones that are falling. Construction practices and building codes can help maximize the resistance of the structures to damage. Large amounts of hail may need to be physically cleared from roadways and sidewalks, depending on accumulation. Hail can cause other cascading impacts, including power loss.

During a 20-year span between January 1, 2000 and December 31, 2019 in Collier County, NCEI reported no property damage as a direct result of hail. It should be noted that property damage due to hail is usually insured loss, with damages covered under most major comprehensive insurance plans. Because of this, hail losses are notoriously underreported by the NCEI. It is difficult to find an accurate repository of hail damages in Collier County, thus the NCEI is still used to form a baseline.

Wind events reported in NCEI for the 20-year period from 2000 through 2019 totaled $200,500 in property damage, which equates to an annualized loss of $10,025 across the planning area.

General damages to property are both direct (what the tornado physically destroys) and indirect, which focuses on additional costs, damages and losses attributed to secondary hazards spawned by the tornado, or due to the damages caused by the tornado. Depending on the size of the tornado and its path, a tornado is capable of damaging and eventually destroying almost anything. Construction practices and building codes can help maximize the resistance of the structures to damage.

Secondary impacts of tornado damage often result from damage to infrastructure. Downed power and communications transmission lines, coupled with disruptions to transportation, create difficulties in reporting and responding to emergencies. These indirect impacts of a tornado put tremendous strain on a community. In the immediate aftermath, the focus is on emergency services.

Since 2000, damaging tornadoes in the County are directly responsible for nearly $786,600 worth of damage to property according to NCEI data. This equates to an annualized loss of $39,330.

Environment

The main environmental impact from wind is damage to trees or crops. Wind events can also bring down power lines, which could cause a fire and result in even greater environmental impacts. Lightning may also result in the ignition of wildfires. This is part of a natural process, however, and the environment will return to its original state in time.

Hail can cause extensive damage to the natural environment, pelting animals, trees and vegetation with hailstones. Melting hail can also increase both river and flash flood risk.

Tornadoes can cause massive damage to the natural environment, uprooting trees and other debris within the tornado's path. This is part of a natural process, however, and the environment will return to its original state in time.

Consequence Analysis

Table 2.39 summarizes the potential negative consequences of severe weather.

Table 2.39 – Consequence Analysis – Severe Weather

Category	Consequences
Public	Injuries; fatalities
Responders	Injuries; fatalities; potential impacts to response capabilities due to storm impacts
Continuity of Operations (including Continued Delivery of Services)	Potential impacts to continuity of operations due to storm impacts; delays in providing services
Property, Facilities and Infrastructure	Possibility of structure fire ignition; potential for disruptions in power and communications infrastructure; destruction and/or damage to any exposed property, especially windows, cars and siding; mobile homes see increased risk.

Category	Consequences
	The weakest tornadoes, EF0, can cause minor roof damage, while strong tornadoes can destroy frame buildings and even badly damage steel reinforced concrete structures. Buildings are vulnerable to direct impact from tornadoes and from wind borne debris. Mobile homes are particularly susceptible to damage during tornadoes.
Environment	Potential fire ignition from lightning; hail damage to wildlife and foliage. Potential devastating impacts in storm's path.
Economic Condition of the Jurisdiction	Lightning damage contingent on target; can severely impact/destroy critical infrastructure and other economic drivers. Contingent on tornado's path; can severely impact/destroy critical infrastructure and other economic drivers.
Public Confidence in the Jurisdiction's Governance	Public confidence is not generally affected by severe weather events if response and recovery are not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes severe weather hazard risk by jurisdiction. Most aspects of severe storm risk do not vary substantially by jurisdiction; however, mobile home units are more vulnerable to wind damage. Over 21 percent of the housing units in Everglades City are mobile home units. Additionally, there are over 10,400 mobile home units in unincorporated Collier County, comprising over 6 percent of the housing stock. These communities may therefore face more severe impacts from wind. Where priority ratings vary between thunderstorm wind, lightning, and hail for impact and spatial extent, these scores represent an average rating with greater weight given to thunderstorm wind because it occurs much more frequently.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	4	2	3	4	1	2.7	H
Immokalee Reservation	4	1	3	4	1	2.4	M
Marco Island	4	1	3	4	1	2.4	M
Naples	4	1	3	4	1	2.4	M
Unincorporated Collier County	4	2	3	4	1	2.7	H

2.5.4 Wildfire

Hazard Description

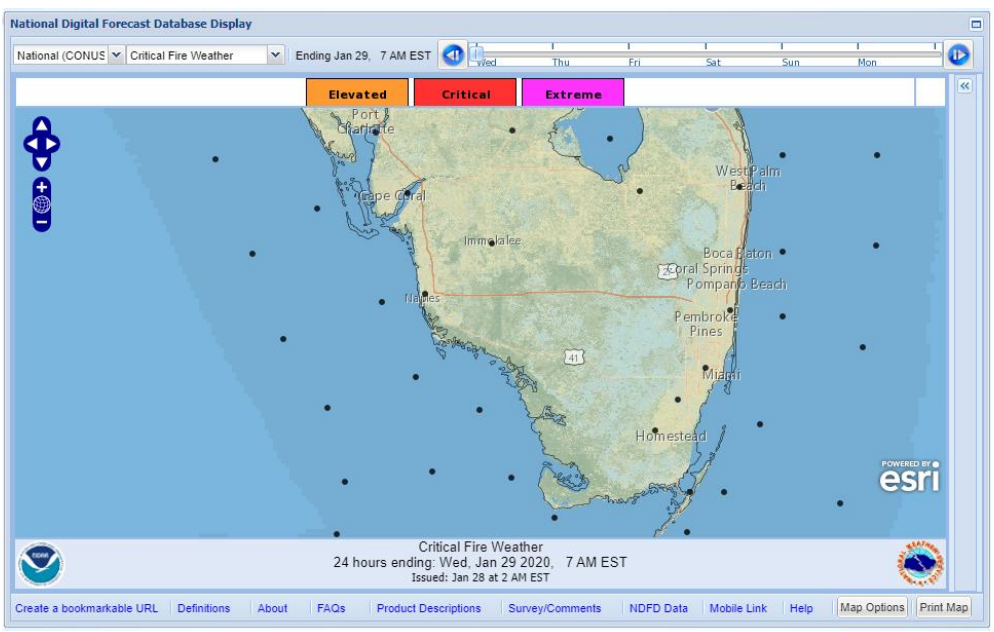
A wildfire is an uncontained fire that spreads through the environment. Wildfires can consume large areas, including infrastructure, property, and resources. When massive fires, or conflagrations, develop near populated areas, evacuations possibly ensue. Not only do the flames impact the environment, but the massive volumes of smoke spread by certain atmospheric conditions also impact the health of nearby populations. There are three general types of fire spread that are recognized.

- **Ground fires** – burn organic matter in the soil beneath surface litter and are sustained by glowing combustion.
- **Surface fires** – spread with a flaming front and burn leaf litter, fallen branches and other fuels located at ground level.
- **Crown fires** – burn through the top layer of foliage on a tree, known as the canopy or crown fires. Crown fires, the most intense type of fire and often the most difficult to contain, need strong winds, steep slopes and a heavy fuel load to continue burning.

Generally, wildfires are started by humans, either through arson or carelessness. Fire intensity is controlled by both short-term weather conditions and longer-term vegetation conditions. During intense fires, understory vegetation, such as leaves, small branches, and other organic materials that accumulate on the ground, can become additional fuel for the fire. The most explosive conditions occur when dry, gusty winds blow across dry vegetation.

Weather plays a major role in the birth, growth and death of a wildfire. In support of forecasting for fire weather, the NWS Fire Weather Program emerged in response to a need for weather support to large and dangerous wildfires. This service is provided to federal and state land management agencies for the prevention, suppression, and management of forest and rangeland fires. As shown in Figure 2.12, the NWS Miami-South Florida Forecast Office provides year-round fire weather forecasts for the region.

Figure 2.12 – Fire Weather Forecast, Collier County Area



Source: National Weather Service

Weather conditions favorable to wildfire include drought, which increases flammability of surface fuels, and winds, which aid a wildfire's progress. The combination of wind, temperature, and humidity affects how fast wildland fires can spread. Rapid response can contain wildfires and limit their threat to property.

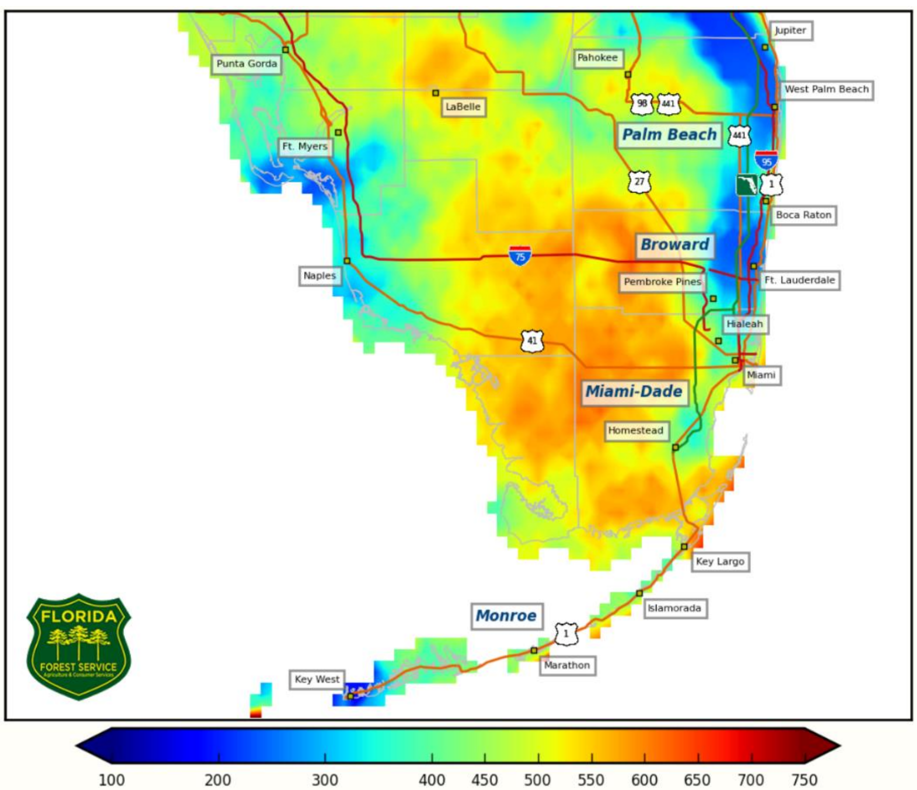
Collier County experiences a variety of wildfire conditions found in the Keetch-Byram Drought Index, which is described in Table 2.40. The Keetch-Byram Drought Index (KBDI) for January 20, 2020 is shown in Figure 2.13 along with a Daily Fire Danger Estimate Adjective Rating for certain points across the state. The KBDI for Collier County and the surrounding areas at this time was between 300 and 600.

Table 2.40 – Keetch-Byram Drought Index Fire Danger Rating System

KBDI	Description
0-200	Soil and fuel moisture are high. Most fuels will not readily ignite or burn. However, with enough sunlight and wind, cured grasses and some light surface fuels will burn in sports and patches.
200-400	Fires more readily burn and will carry across an area with no gaps. Heavier fuels will still not readily ignite and burn. Also, expect smoldering and the resulting smoke to carry into and possibly through the night.
400-600	Fire intensity begins to significantly increase. Fires will readily burn in all directions exposing mineral soils in some locations. Larger fuels may burn or smolder for several days creating possible smoke and control problems.
600-800	Fires will burn to mineral soil. Stumps will burn to the end of underground roots and spotting will be a major problem. Fires will burn through the night and heavier fuels will actively burn and contribute to fire intensity.

Source: United State Forest Service Wildland Fire Assessment System

Figure 2.13 – Keetch-Byram Drought Index, January 2020



Source: Florida Department of Agriculture and Consumer Services

Warning Time: 4 – Less than 6 hours

Duration: 3 – Less than 1 week

Location

The location of wildfire risk can be defined by the acreage of Wildland Urban Interface (WUI). The WUI is described as the area where structures and other human improvements meet and intermingle with undeveloped wildland or vegetative fuels, and thus demarcates the spatial extent of wildfire risk. The WUI is essentially all the land in the county that is not heavily urbanized. The Southern Wildfire Risk Assessment (SWRA) estimates that 91.4 percent of the Collier County population lives within the WUI. The expansion of residential development from urban centers out into rural landscapes increases the potential for wildland fire threat to public safety and the potential for damage to forest resources and dependent industries. Population growth within the WUI substantially increases the risk of wildfire.

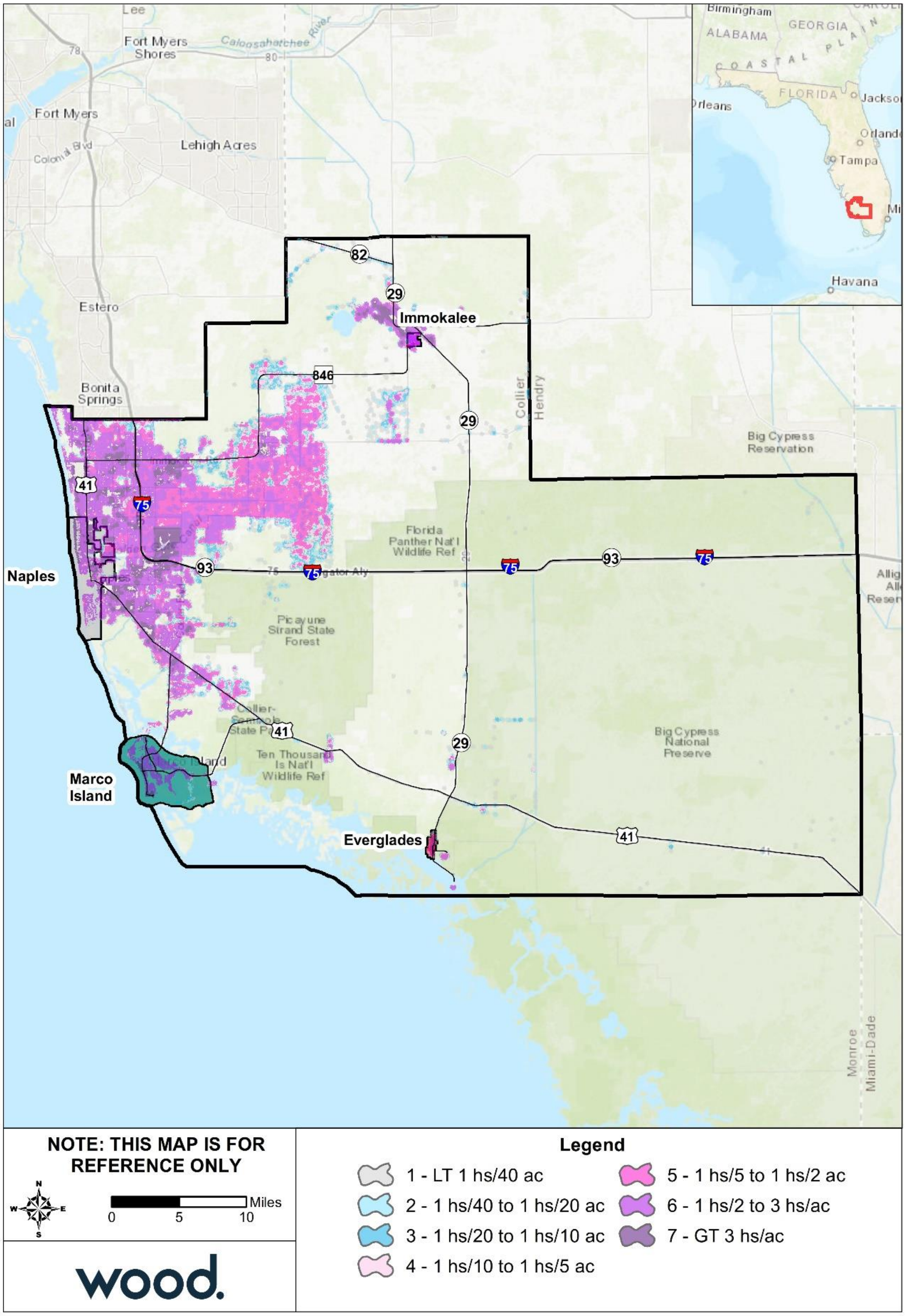
Table 2.41 details the extent of the WUI in Collier County, and Figure 2.14 maps the WUI. It is important to note that as the second largest county in Florida by area, 86.7 percent of the county is classified as outside the WUI and the remaining 13.3 percent is detailed below.

Table 2.41 – Wildland Urban Interface, Population and Acres

	Housing Density	WUI Population	Percent of WUI Population	WUI Acres	Percent of WUI Acres
	LT 1hs/40ac	448	0.2 %	25,836	13.1 %
	1hs/40ac to 1hs/20ac	461	0.2 %	10,613	5.4 %
	1hs/20ac to 1hs/10ac	1,235	0.4 %	14,386	7.3 %
	1hs/10ac to 1hs/5ac	3,313	1.1 %	17,263	8.8 %
	1hs/5ac to 1hs/2ac	22,088	7.5 %	43,798	22.3 %
	1hs/2ac to 3hs/1ac	132,491	45.1 %	68,461	34.8 %
	GT 3hs/1ac	133,981	45.6 %	16,251	8.3 %
	Total	**294,017**	**100.0 %**	**196,618**	**100.0 %**

Source: Southern Wildfire Risk Assessment

Figure 2.14 – Wildland Urban Interface, Collier County



Source: Southern Wildfire Risk Assessment

Extent

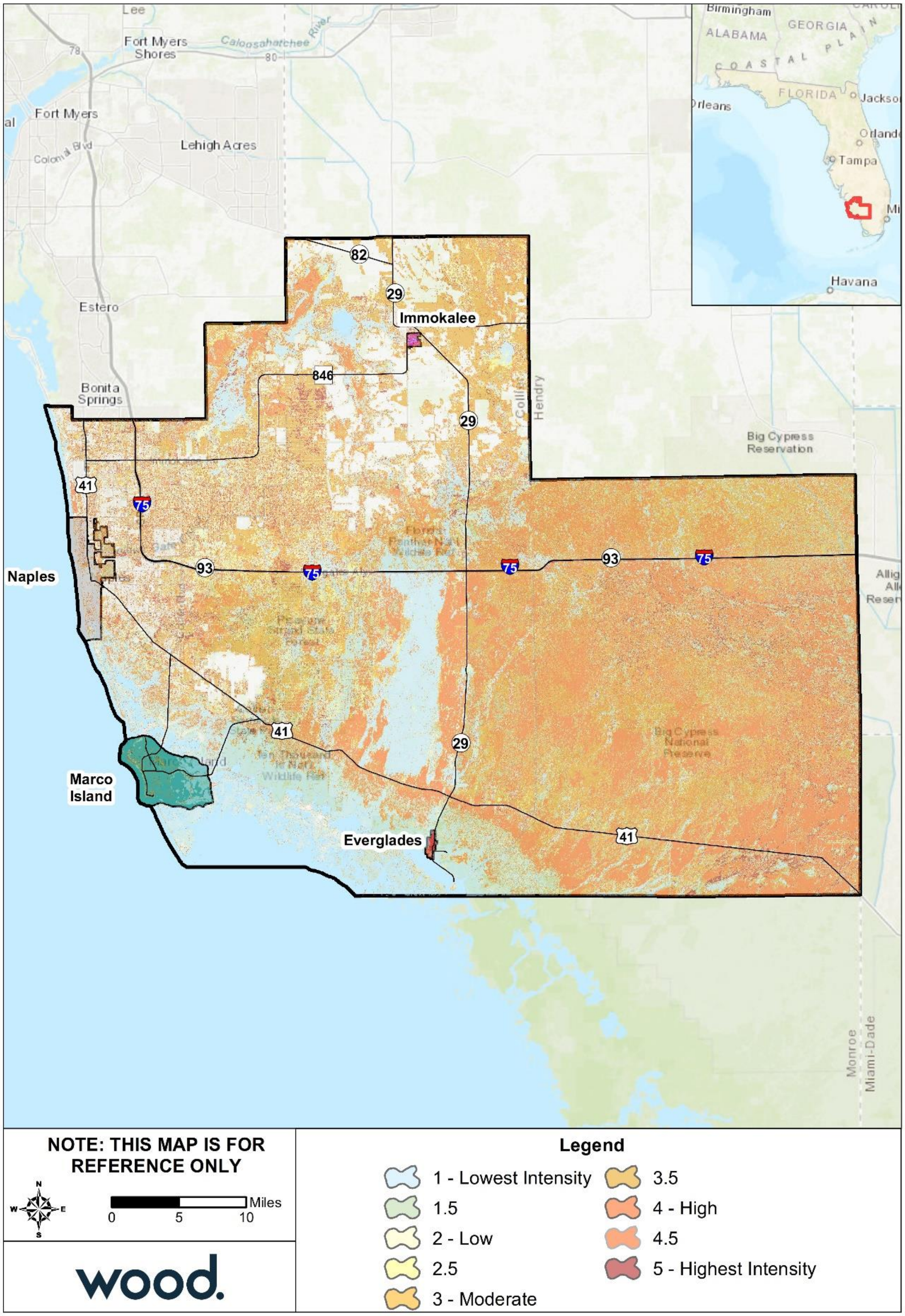
Wildfire extent can be defined by the fire's intensity and measured by the Characteristic Fire Intensity Scale, which identifies areas where significant fuel hazards which could produce dangerous fires exist. Fire Intensity ratings identify where significant fuel hazards and dangerous fire behavior potential exist based on fuels, topography, and a weighted average of four percentile weather categories. The Fire Intensity Scale consists of five classes, as defined by Southern Wildfire Risk Assessment and is shown in Table 2.42. Figure 2.15 shows the potential fire intensity within the WUI across Collier County.

Table 2.42 – Fire Intensity Scale

Class	Description
1, Very Low	Very small, discontinuous flames, usually less than 1 foot in length; very low rate of spread; no spotting. Fires are typically easy to suppress by firefighters with basic training and non-specialized equipment.
2, Low	Small flames, usually less than two feet long; small amount of very short-range spotting possible. Fires are easy to suppress by trained firefighters with protective equipment and specialized tools.
3, Moderate	Flames up to 8 feet in length; short-range spotting is possible. Trained firefighters will find these fires difficult to suppress without support from aircraft or engines, but dozer and plows are generally effective. Increasing potential for harm or damage to life and property.
4, High	Large Flames, up to 30 feet in length; short-range spotting common; medium range spotting possible. Direct attack by trained firefighters, engines, and dozers is generally ineffective, indirect attack may be effective. Significant potential for harm or damage to life and property.
5, Very High	Very large flames up to 150 feet in length; profuse short-range spotting, frequent long-range spotting; strong fire-induced winds. Indirect attack marginally effective at the head of the fire. Great potential for harm or damage to life and property.

Source: Southern Wildfire Risk Assessment

Figure 2.15 – Characteristic Fire Intensity, Collier County



Source: Southern Wildfire Risk Assessment

A significant portion, approximately 29.7 percent, of Collier County may experience a Class 4 or higher Fire Intensity, which poses significant harm or damage to life and property. However, the areas with greatest potential fire intensity are largely outside the WUI. Over 21 percent of the county may experience Class 3 or 3.5 Fire Intensity, which has potential for harm to life and property but is easier to suppress with dozer and plows. The remainder of the region is either non-burnable (22.3%) or would face a Class 1 or Class 2 Fire Intensity (26.4%), which are easily suppressed.

Impact: 2 – Limited

Spatial Extent: 3 – Moderate

Historical Occurrences

NCEI records the following 17 wildfires for Collier County within the 20 year period from 2000 through 2019.

Table 2.43 – Wildfires in Collier County, 2000-2019

Location	Date	Fatalities	Injuries	Property Damage
Golden Gate	4/9/2000	0	0	$200,000
Golden Gate	5/19/2001	0	0	$0
Unknown	5/4/2007	0	0	$0
Unknown	5/7/2007	0	0	$75,000
Unknown	6/1/2007	0	0	$0
Unknown	5/29/2008	0	0	$850,000
Unknown	4/22/2009	0	0	$0
Unknown	5/1/2009	0	0	$0
Unknown	5/8/2009	0	0	$65,000
Unknown	4/26/2011	0	0	$80,000
Unknown	5/1/2011	0	0	$80,000
Unknown	3/5/2017	0	0	$578,000
Unknown	3/18/2017	0	0	$0
Unknown	3/30/2017	0	0	$0
Unknown	4/20/2017	0	1	$3,500,000
Unknown	4/20/2017	0	0	$0
Unknown	3/23/2018	0	0	$0
	Total	**0**	**1**	**$5,428,000**

Source: NCEI

Almost $5.5 million in property damage was accrued in Collier County over 20 years, giving an average of $271,400 per year. The Florida Department of Agriculture and Consumer Services records 40 wildfires throughout the entire State during the same 20-year time period with over one million acres burned, or just over 50,500 acres burned per year.

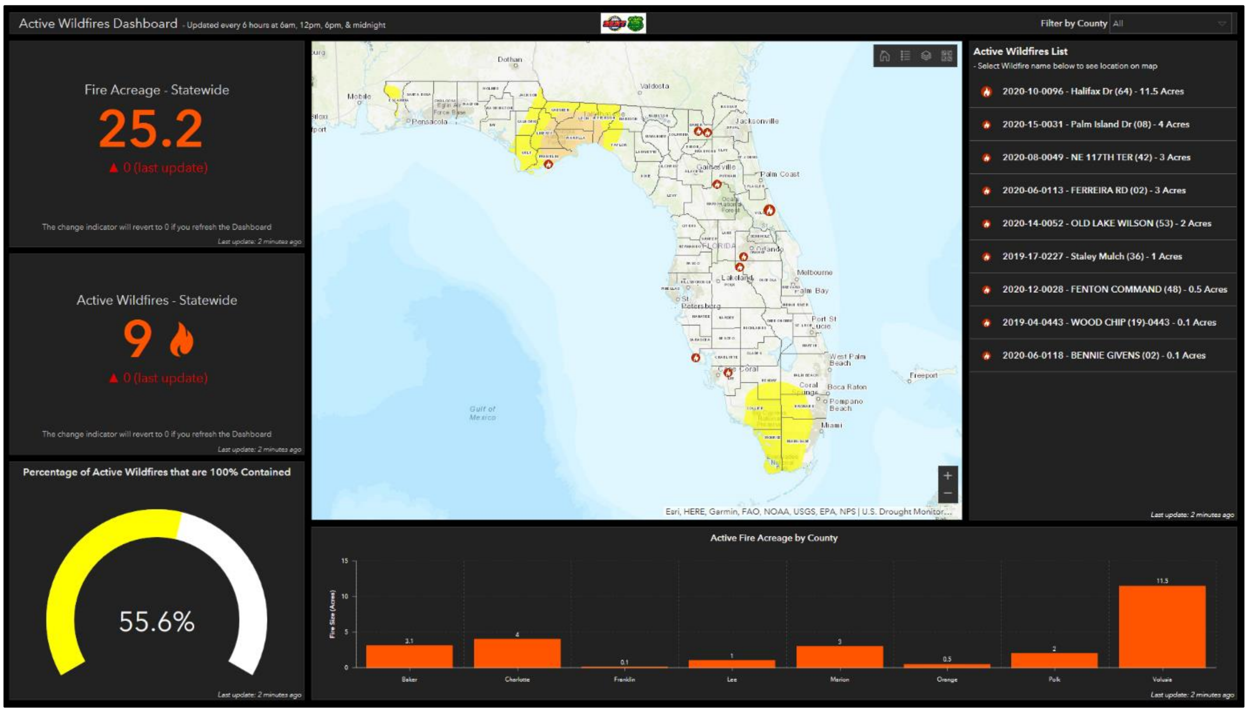
The Florida Department of Agriculture and Consumer Services maintains records of acreage burned and number of fires within the State of Florida. Between January 1st and January 26th, 2020, there were 93 wildfires across the State with a total of 701 acres burned.

Florida participates in the national Ready, Set, Go! program which helps prepare first responders to best address wildfires when they occur. This program is also used as outreach to help citizens understand their risk and how to be prepared. Collier County has addressed fire hazards in their building codes and comprehensive plan. Additionally, The State of Florida crated a State Wildfire Mitigation Plan, in which Collier County is a part of the Caloosahatchee Forestry Center Wildfire Mitigation Plan.

According to the Caloosahatchee Forestry Center Wildfire Mitigation Plan, Collier County is home to many prescribed burn programs due to its abundance of public parks and forests. The largest wildfire hazard area in Collier County is Golden Gates Estates because of its density and location in heavily wooded areas. Between 2005 and 2015, lightning was the main cause of wildfires in the County accounting for 39 percent of the 810 wildfires. One of the many goals of the Wildfire Mitigation Plan is to complete a Community Wildfire Protection Plan for Collier County.

As seen in Figure 2.16, over half of Collier County was abnormally dry at the time this data was collected. The State of Florida uses this Active Wildfires Dashboard to communicate to others where the currently burning wildfires are located.

Figure 2.16 – Active Wildfires, January 27, 2020



Source: Florida Forest Service

The region experienced prolonged periods of severe drought in 1998 and 2001, as well as extreme drought in 2010 to 2012, and again in 2017. These periods of drought may explain some of the annual variation in fires and acreage burned.

On average, Collier County experiences almost 1 fire annually from fires reported by the NCEI database. Actual number of fires is likely higher because smaller fires within jurisdictional boundaries are managed by local fire departments.

Probability of Future Occurrence

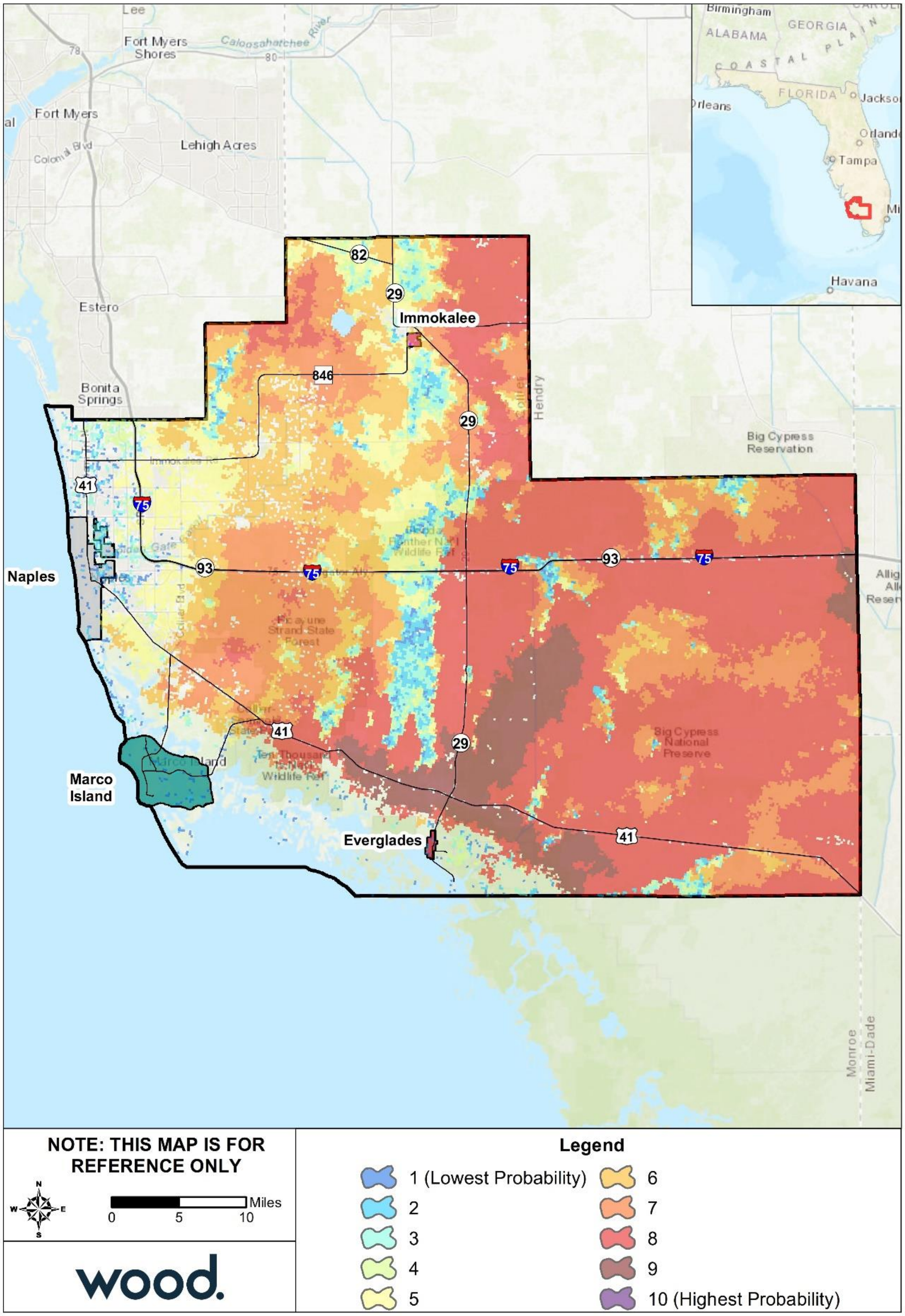
The Southern Wildfire Risk Assessment provides a Burn Probability analysis which predicts the probability of an area burning based on landscape conditions, weather, historical ignition patterns, and historical fire prevention and suppression efforts. Burn Probability data is generated by simulating fires under different weather, fire intensity, and other conditions. Values in the Burn Probability (BP) data layer indicate, for each pixel, the number of times that cell was burned by a modeled fire, divided by the total number of annual weather scenarios simulated. The simulations are calibrated to historical fire size distributions. The Burn Probability for Collier County is presented in Table 2.44 and illustrated in Figure 2.17.

Table 2.44 – Burn Probability, Collier County

	Class	Acres	Percent
	1	11,259	1.0%
	2	25,400	2.2%
	3	36,911	3.2%
	4	28,732	2.5%
	5	91,133	8.0%
	6	152,164	13.3%
	7	236,992	20.7%
	8	482,972	42.2%
	9	79,369	6.9%
	10	0	0.0%
	Total	**1,144,932**	**100.0%**

Source: Southern Wildfire Risk Assessment

Figure 2.17 – Burn Probability, Collier County



Source: Southern Wildfire Risk Assessment

Over 50 percent of Collier County has a burn probability between 6 and 8. The areas of higher burn probability are located along U.S. Highway 41 near Everglades and in the Big Cypress National Preserve. The northwestern corner of the county and areas surrounding lakes have a burn probability of 1 to 5. The probability of wildfire across the county is considered likely, defined as between a 10% and 100% annual chance of occurrence. Everglades, Marco Island, and Naples are largely non-burnable or contain only small areas of very low burn probability. The communities containing a higher burn probability, as noted, have a comparatively higher probability of occurrence.

Probability: 3 – Likely

Climate Change

Climate change could cause increased frequency or intensity of extreme heat or drought events which could affect wildfire behavior. If vegetation type changes, such as reducing moisture of vegetation, soil, or decomposing matter, flammability could increase. Florida currently has weather patterns that create a wet season and a dry season each year. Climate change could cause either season, or both seasons, to increase in occurrence or magnitude.

Vulnerability Assessment

People

Wildfire can cause fatalities and human health hazards. Ensuring procedures are in place for rapid warning and evacuation are essential to reducing vulnerability.

Based on 2012 housing density data, Southern Wildfire Risk Assessment (SWRA) estimates that 294,017 people or 91.4% of the total planning area population live within the WUI and are therefore at risk to wildfire.

Property

Wildfire can cause direct property losses, including damage to buildings, vehicles, landscaped areas, agricultural lands, and livestock. Construction practices and building codes can increase fire resistance and fire safety of structures. Techniques for reducing vulnerability to wildfire include using street design to ensure accessibility to fire trucks, incorporating fire resistant materials in building construction, and using landscaping practices to reduce flammability and the ability for fire to spread.

During the 20-year period from 2000 through 2019, the planning area experienced 17 wildfires causing an annualized loss of $271,400.

Information of critical facility risk to wildfire was not available.

Environment

Wildfires have the potential to destroy forest and forage resources and damage natural habitats. Wildfire can also damage agricultural crops on private land. Wildfire is part of a natural process, however, and the environment will return to its original state in time.

Consequence Analysis

Table 2.45 summarizes the potential detrimental consequences of wildfire.

Table 2.45 – Consequence Analysis - Wildfire

Category	Consequences
Public	In addition to the potential for fatalities, wildfire and the resulting diminished air quality pose health risks. Exposure to wildfire smoke can cause serious health

Category	Consequences
	problems within a community, including asthma attacks and pneumonia, and can worsen chronic heart and lung diseases. Vulnerable populations include children, the elderly, people with respiratory problems or with heart disease. Even healthy citizens may experience minor symptoms, such as sore throats and itchy eyes.
Responders	Public and firefighter safety is the first priority in all wildland fire management activities. Wildfires are a real threat to the health and safety of the emergency services. Most fire-fighters in rural areas are 'retained'. This means that they are part-time and can be called away from their normal work to attend to fires.
Continuity of Operations (including Continued Delivery of Services)	Wildfire events can result in a loss of power which may impact operations. Downed trees, power lines and damaged road conditions may prevent access to critical facilities and/or emergency equipment.
Property, Facilities and Infrastructure	Wildfires frequently damage community infrastructure, including roadways, communication networks and facilities, power lines, and water distribution systems. Restoring basic services is critical and a top priority. Efforts to restore roadways include the costs of maintenance and damage assessment teams, field data collection, and replacement or repair costs. Direct impacts to municipal water supply may occur through contamination of ash and debris during the fire, destruction of aboveground distribution lines, and soil erosion or debris deposits into waterways after the fire. Utilities and communications repairs are also necessary for equipment damaged by a fire. This includes power lines, transformers, cell phone towers, and phone lines.
Environment	Wildfires cause damage to the natural environment, killing vegetation and animals. The risk of floods and debris flows increases after wildfires due to the exposure of bare ground and the loss of vegetation. In addition, the secondary effects of wildfires, including erosion, landslides, introduction of invasive species, and changes in water quality, are often more disastrous than the fire itself.
Economic Condition of the Jurisdiction	Wildfires can have significant short-term and long-term effects on the local economy. Wildfires, and extreme fire danger, may reduce recreation and tourism in and near the fires. If aesthetics are impaired, local property values can decline. Extensive fire damage to trees can significantly alter the timber supply, both through a short-term surplus from timber salvage and a longer-term decline while the trees regrow. Water supplies can be degraded by post-fire erosion and stream sedimentation.
Public Confidence in the Jurisdiction's Governance	Wildfire events may cause issues with public confidence because they have very visible impacts on the community. Public confidence in the jurisdiction's governance may be influenced by actions taken pre-disaster to mitigate and prepare for impacts, including the amount of public education provided; efforts to provide warning to residents; response actions; and speed and effectiveness of recovery.

Hazard Summary by Jurisdiction

The following table summarizes flood hazard risk by jurisdiction. Wildfire warning time and duration do not vary by jurisdiction. Spatial extent ratings were estimated based on the proportion of area within the WUI; all jurisdictions have between 10% and 50% of their area in the WUI and were assigned a spatial extent rating of 3, except for the City of Everglades which has close to 100% of its area in the WUI and was thus given a rating of 4. Impact ratings were based on fire intensity data from SWRA. Jurisdictions with significant clusters of moderate to high fire intensity were assigned a rating of 3; all other jurisdictions were assigned a rating of 2. Probability ratings were determined based on burn probability data from SWRA. Jurisdictions with clusters of moderate burn probability or higher were assigned a rating of 3; the remaining jurisdictions have minimal to no burn probability and were assigned a probability of 1.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	1	3	4	4	3	2.7	H
Immokalee Reservation	2	3	3	4	3	2.8	H
Marco Island	1	2	3	4	3	2.2	M
Naples	1	2	3	4	3	2.2	M
Unincorporated Collier County	3	3	3	4	3	3.1	H

2.5.5 Coastal Erosion

Hazard Description

Coastal Erosion

Coastal erosion is a process whereby large storms, flooding, strong wave action, sea level rise, and human activities, such as inappropriate land use, alterations, and shore protection structures, wear away the beaches and bluffs along the coast. Erosion undermines and often destroys homes, businesses, and public infrastructure and can have long-term economic and social consequences. According to NOAA, coastal erosion is responsible for approximately $500 million per year in coastal property loss in the United States, including damage to structures and loss of land. To mitigate coastal erosion, the federal government spends an average of $150 million each year on beach nourishment and other shoreline erosion control measures.

Coastal erosion has both natural causes and causes related to human activities. Gradual coastal erosion and accretion results naturally from the impacts of tidal longshore currents. Severe coastal erosion can occur over a short period when the state is impacted by hurricanes, tropical storms and other weather systems. Sand is continually removed by longshore currents in some areas, but it is also continually replaced by sand carried in by the same type of currents. Structures such as piers or sea walls, jetties, and navigational inlets may interrupt the movement of sand. Sand can become “trapped” in one place by these types of structures. The currents will, of course, continue to flow, though depleted of sand trapped elsewhere. With significant amounts of sand trapped in the system, the continuing motion of currents (now deficient in sand) results in erosion. In this way, human construction activities that result in the unnatural trapping of sand have the potential to result in significant coastal erosion.

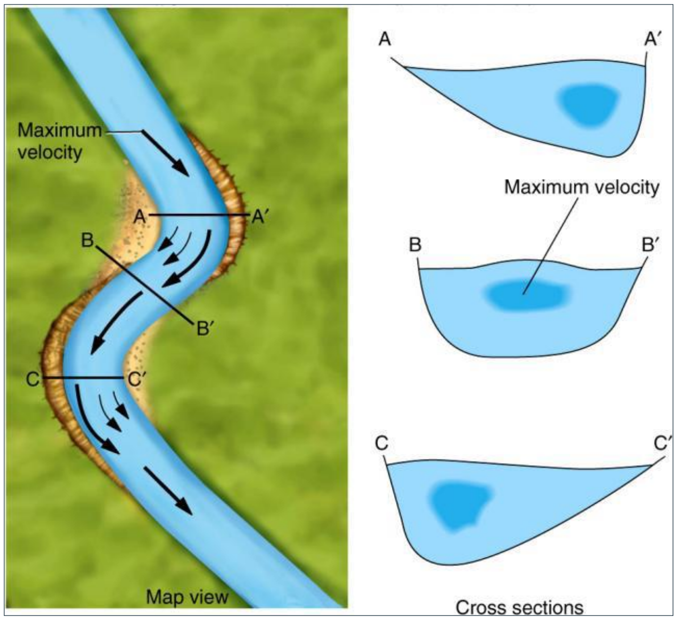
Erosion rates and potential impacts are highly localized. Severe storms can remove wide beaches, along with substantial dunes, in a single event. In undeveloped areas, these high recession rates are not likely to cause significant concern, but in some heavily populated locations, one or two feet of erosion may be considered catastrophic (NOAA, 2014).

Estuaries are partially enclosed, coastal water bodies where freshwater meats saltwater from the ocean. They are influenced by tides but still protected from the full force of ocean waves. Estuaries are often referred to as bays or sounds. Estuarine coastlines can experience erosion through short-term processes, such as tides, storms, wind, and boat wakes, as well as long-term processes, such as sea level rise. Many variables determine the rate of estuarine erosion including shoreline type, geographic location and size of the associated estuary, the type and abundance of vegetation, and the frequency and intensity of storms. Estuarine erosion is problematic as more development occurs along estuarine shorelines.

Stream Bank Erosion

Stream banks erode by a combination of direct stream processes, like down cutting and lateral erosion, and indirect processes, like mass-wasting accompanied by transportation. When the channel bends, water on the outside of the bend (the cut-bank) flows faster and water on the inside of the bend (the point) flows slower as shown in Figure 2.18 This distribution of velocity results in erosion occurring on the outside of the bend and deposition occurring on the inside of the bend.

Figure 2.18 – Stream Meanders



Stream bank erosion is a natural process, but acceleration of this natural process leads to a disproportionate sediment supply, stream channel instability, land loss, habitat loss and other adverse effects. Stream bank erosion processes, although complex, are driven by two major components: stream bank characteristics (erodibility) and hydraulic/gravitational forces. Many land use activities can affect both components and lead to accelerated bank erosion. The vegetation rooting characteristics can protect banks from fluvial entrainment and collapse and provide internal bank strength. When riparian vegetation is changed from woody species to annual grasses and/or forbs, the internal strength is weakened, causing acceleration of mass wasting processes. Stream bank aggradation or degradation is often a response to stream channel instability. Since bank erosion is often a symptom of a larger, more complex problem, the long-term solutions often involve much more than just bank stabilization. Numerous studies have demonstrated that stream bank erosion contributes a large portion of the annual sediment yield.

Determining the cause of accelerated streambank erosion is the first step in solving the problem. When a stream is straightened or widened, streambank erosion increases. Accelerated streambank erosion is part of the process as the stream seeks to re-establish a stable size and pattern. Damaging or removing streamside vegetation to the point where it no longer provides for bank stability can cause a dramatic increase in bank erosion. A degrading streambed results in higher and often unstable, eroding banks. When land use changes occur in a watershed, such as clearing land for agriculture or development, runoff increases. With this increase in runoff the stream channel will adjust to accommodate the additional flow, increasing streambank erosion. Addressing the problem of streambank erosion requires an understanding of both stream dynamics and the management of streamside vegetation.

Warning Time: 1 – More than 24 hours

Duration: 3 – Less than 1 week

Location

Erosion can occur along any shoreline in the region. Erosion is likely to be more frequent and severe along the Atlantic coast, but erosion of estuarine and streambank shorelines can also occur. In Collier County, erosion is typically caused by coastal tides, ocean currents, and storm events. Erosion rates are dependent on many characteristics, including soil type. According to the existing Collier County Hazard Mitigation Plan, coastal soils are composed of fine-grained particles such as sand while inland soils tend to have greater organic matter content. This makes coastal areas more susceptible to erosion. More developed areas, such as Marco Island and the City of Naples, are more susceptible to erosion.

Extent

The magnitude of erosion can be measured as a rate of change from a measured previous condition. Erosion rates can vary significantly across the region due to several factors including fetch, shoreline orientation, and soil composition. To account for these variations, long-term erosion can also be measured by land cover changes and increases in open water. While a small fraction of the shoreline may exhibit accretion over a short period of time, cumulative impacts can still indicate an overall loss of estuarine coastline and marsh habitat. Table 2.46 provides from the NOAA Coastal Change Analysis Program (C-CAP) Land Cover Atlas showing land cover changes in the Region from 1996 to 2010.

Table 2.46 – Land Cover Changes, 1996-2010

Land Cover Type	Collier Net Change
Developed, High Intensity	11.16 sq. mi
Developed, Low Intensity	12.95 sq. mi
Developed, Open Space	10.83 sq. mi
Grassland/Herbaceous	1.42 sq. mi
Agriculture	-18.02 sq. mi
Forested	0.56 sq. mi
Scrub/Shrub	-5.15 sq. mi
Woody Wetland	-29.18 sq. mi
Emergent Wetland	7.82 sq. mi
Bare Land	2.05 sq. mi
Open Water	5.56 sq. mi

Source: https://coast.noaa.gov/digitalcoast/data/ccapregional.html

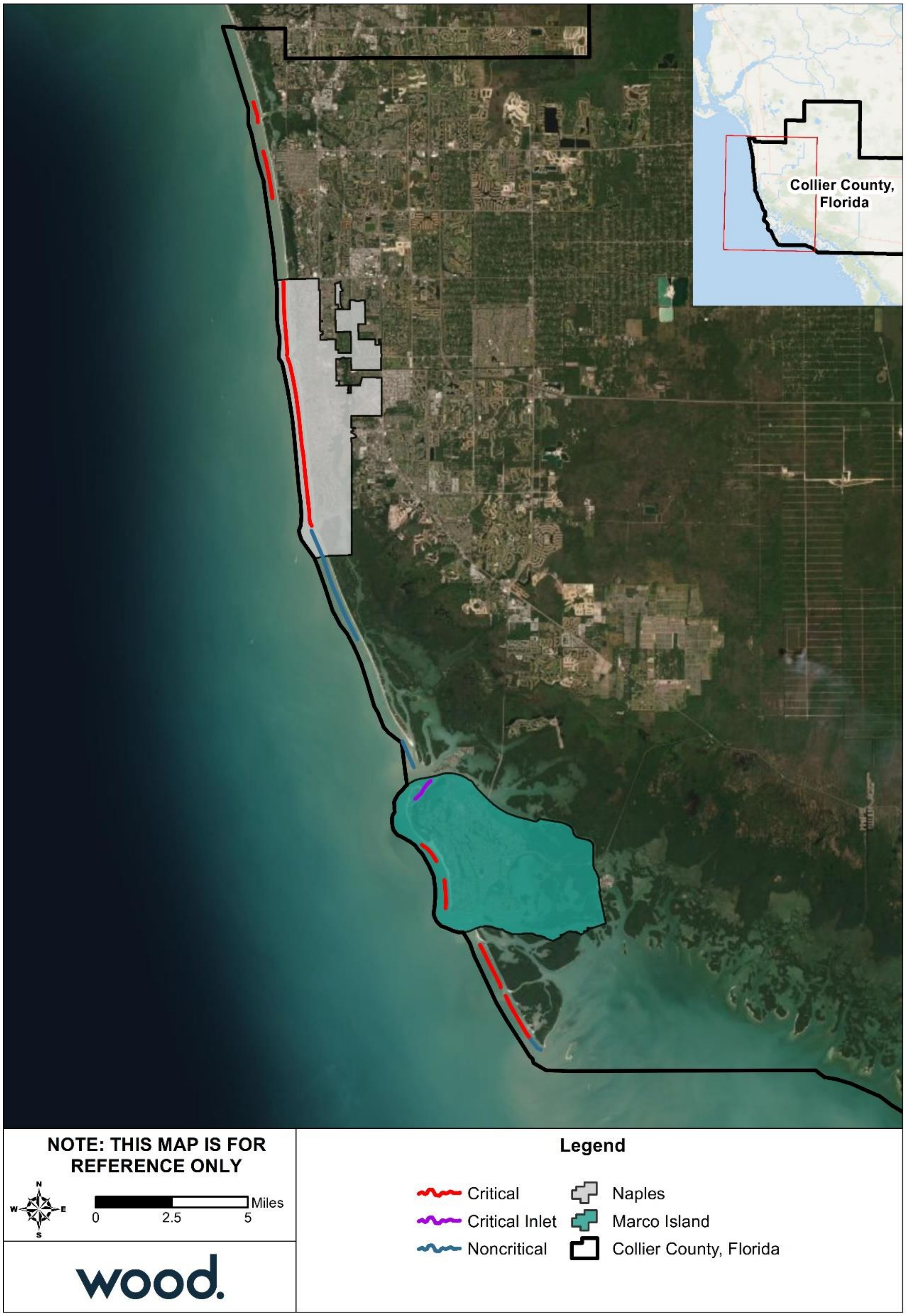
The C-CAP data indicates a net increase in open water, a smaller net increase in forested land, and an overall net decrease in wetlands in the County. Additionally, Collier County saw a large increase in development. Increases in developed land likely result in increased impervious surfaces, which may increase stormwater runoff, alter drainage patterns, and further exacerbate erosion and flood issues.

In terms of the magnitude of impacts, erosion may cause property damage when severe but is unlikely to cause injury or death.

Impact: 2 – Limited

Spatial Extent: 2 – Small

Figure 2.19 – Erosional Hotspots, Collier County



Source: NOAA

Historical Occurrences

As Figure 2.19 shows, shoreline erosion is occurring along ocean coastlines throughout Collier County. Erosion is typically an ongoing process; however, it can be intensified during storm events, particularly hurricane storm tides. Per an examination of event narratives in NCEI records for hurricanes, tropical storms, storm surges, and coastal floods, the following instances of major erosion are noted in Collier County:

September 13, 2001 (Tropical Storm) – Tropical Storm Gabrielle crossed the west Florida coast near Venice on September 14th. Storm surge values of 3 to 5 feet were observed along much of the Collier County coast, causing some coastal flooding and minor to moderate beach erosion

October 24, 2005 (Storm Surge) – Hurricane Wilma produced a maximum measured storm tide of 8 feet at the USGS tide gauge at the Turner River near Chokoloskee in southern Collier County, equating to a storm surge of 7 feet after subtracting a one-foot astronomical tide. A storm tide estimated at 7 feet Marco Island was estimated to cause significant beach erosion by Collier County Emergency Management.

September 19, 2008 (Tropical Storm) – Due to Fay remaining at tropical storm strength and the rather limited nature of its wind field, storm surge and coastal flooding impacts were rather minor. The highest storm tide was estimated to be in the Everglades City/Chokoloskee areas, where the maximum storm tide was in the 5 foot range according to tide gauge data and estimates from local officials. Minimal storm surge was noted elsewhere, although moderate to locally severe beach erosion occurred in Naples.

August 26-27, 2012 (Tropical Storm) – The center of Tropical Storm Isaac moved over the Florida Straits south of the Florida Keys on Sunday, August 26th, passing just south of Key West. Severe beach erosion and coastal flooding occurred on Monday, August 27th as the center of Tropical Storm Isaac moved into the Gulf of Mexico. Maximum storm tide values were observed at 4.9 feet at Naples, with estimates of 5 to 7 feet along the southern Collier County coast from Goodland to Everglades City. Highest estimated inundation values of up to 3 feet above ground level were noted in Goodland and Everglades City. Major beach erosion was also observed along the Collier County beaches. Severe beach erosion in the Naples and Marco Island areas led to damage estimated at $5.6 million.

Probability of Future Occurrence

Erosion and accretion are natural processes that are likely to continue to occur. The likelihood of significant instances of erosion will likely be tied to the occurrence of hurricane, tropical storm, and nor'easter events. According to NCEI, 7 events caused reported erosion in the region over the 20-year span between 1999-2018. This equates to a 35 percent chance of erosion occurring every year. Additionally, drawing from the likelihood of hurricanes, tropical storms, and Nor'easters, erosion is likely to occur.

Probability: 3 – Likely

Climate Change

As discussed under Climate Change in Section 2.5.2, climate change is expected to make heavy rain events and tropical storms and hurricanes more frequent and intense. As a result, the erosion typically caused by these storms can be expected to occur more frequently. Coastal erosion is also expected to increase as a result of rising seas. A 2018 study found that globally, between 1984 and 2015 erosion outweighed accretion. However, the study could not conclude the degree to which erosion during this period is attributed to climate changes or increased coastal development. Nonetheless, increases in erosion have been observed and are expected to continue.

Vulnerability Assessment

People

Erosion is unlikely to have any direct impact on the health or safety of individuals. However, it may cause indirect harm by weakening structures and by changing landscapes in ways that increase risk of other hazard impacts. For example, erosion of dune systems causes areas protected by those dunes to face higher levels of risk.

Property

Property damage due to erosion typically only results in conjunction with large storm events which also bring wind and water damages. These events can cause scour and weaken foundations, which may undermine affected buildings' structural integrity.

Data is not available on specific property or critical facility risk to erosion.

Environment

Erosion can change the shape and characteristics of coastal shorelines and riverine floodplains. Eroded material may clog waterways and decrease drainage capacity. Erosion can also negatively impact water quality by increasing sediment loads in waterways.

Consequence Analysis

Table 2.47 summarizes the potential negative consequences of erosion.

Table 2.47 – Consequence Analysis – Erosion

Category	Consequences
Public	Erosion is unlikely to impact public health and safety.
Responders	Erosion is unlikely to require immediate response or rescue operations.
Continuity of Operations (including Continued Delivery of Services)	Erosion is unlikely to impact public continuity of operations.
Property, Facilities and Infrastructure	Erosion can result in property damage if it is severe enough or if scour occurs that undermines the integrity of structural foundations.
Environment	Erosion can increase sediment loads in waterbodies and change riverine and coastal topography.
Economic Condition of the Jurisdiction	Beach re-nourishment projects to counter erosion are extremely costly. Water dependent industries may suffer from lost shoreline and degraded water quality.
Public Confidence in the Jurisdiction's Governance	Erosion is unlikely to impact public confidence.

Hazard Summary by Jurisdiction

The following table summarizes erosion hazard risk by jurisdiction. Exposure to erosion varies across jurisdictions, therefore probability and spatial extent are dependent upon the area at risk. Jurisdictions with shoreline at risk were assigned a probability of 3 (likely), an impact of 2 (limited), and a spatial extent of 2 (small). Jurisdictions with little to no shoreline at risk were assigned a probability score of 1 (unlikely), an impact of 1 (minor), and a spatial extent of 1 (negligible). Warning time and duration are inherent to the hazard and remain constant across jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	3	2	2	1	3	2.3	M

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Immokalee Reservation	1	1	1	1	3	1.2	L
Marco Island	3	2	2	1	3	2.3	M
Naples	3	2	2	1	3	2.3	M
Unincorporated Collier County	3	2	2	1	3	2.3	M

2.5.6 Drought

Hazard Description

Drought is a deficiency in precipitation over an extended period. It is a normal, recurrent feature of climate that occurs in virtually all climate zones. The duration of a drought varies widely. There are cases when drought develops relatively quickly and lasts a very short period, exacerbated by extreme heat and/or wind, and there are other cases when drought spans multiple years, or even decades. Studying the paleoclimate record is often helpful in identifying when long-lasting droughts have occurred. Common types of drought are detailed below in Table 2.48.

Table 2.48 – Types of Drought

Type	Details
Meteorological Drought	Meteorological Drought is based on the degree of dryness (rainfall deficit) and the length of the dry period.
Agricultural Drought	Agricultural Drought is based on the impacts to agriculture by factors such as rainfall deficits, soil water deficits, reduced ground water, or reservoir levels needed for irrigation.
Hydrological Drought	Hydrological Drought is based on the impact of rainfall deficits on the water supply such as stream flow, reservoir and lake levels, and ground water table decline.
Socioeconomic Drought	Socioeconomic drought is based on the impact of drought conditions (meteorological, agricultural, or hydrological drought) on supply and demand of some economic goods. Socioeconomic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related deficit in water supply.

The wide variety of disciplines affected by drought, its diverse geographical and temporal distribution, and the many scales drought operates on make it difficult to develop both a definition to describe drought and an index to measure it. Many quantitative measures of drought have been developed in the United States, depending on the discipline affected, the region being considered, and the application. Several indices developed by Wayne Palmer, as well as the Standardized Precipitation Index, are useful for describing the many scales of drought.

The U.S. Drought Monitor provides a summary of drought conditions across the United States and Puerto Rico. Often described as a blend of art and science, the Drought Monitor map is updated weekly by combining a variety of data-based drought indices and indicators and local expert input into a single composite drought indicator.

The **Palmer Drought Severity Index** (PDSI) devised in 1965, was the first drought indicator to assess moisture status comprehensively. It uses temperature and precipitation data to calculate water supply and demand, incorporates soil moisture, and is considered most effective for unirrigated cropland. It primarily reflects long-term drought and has been used extensively to initiate drought relief. It is more complex than the Standardized Precipitation Index (SPI) and the Drought Monitor.

The **Standardized Precipitation Index** (SPI) is a way of measuring drought that is different from the Palmer Drought Severity Index (PDSI). Like the PDSI, this index is negative for drought, and positive for wet conditions. But the SPI is a probability index that considers only precipitation, while Palmer's indices are water balance indices that consider water supply (precipitation), demand (evapotranspiration) and loss (runoff).

The State of Florida adopted a Drought Action Plan in 2007 that specifies response strategies to varying levels of declared drought. These rules provide the framework to coordinate statewide response to drought.

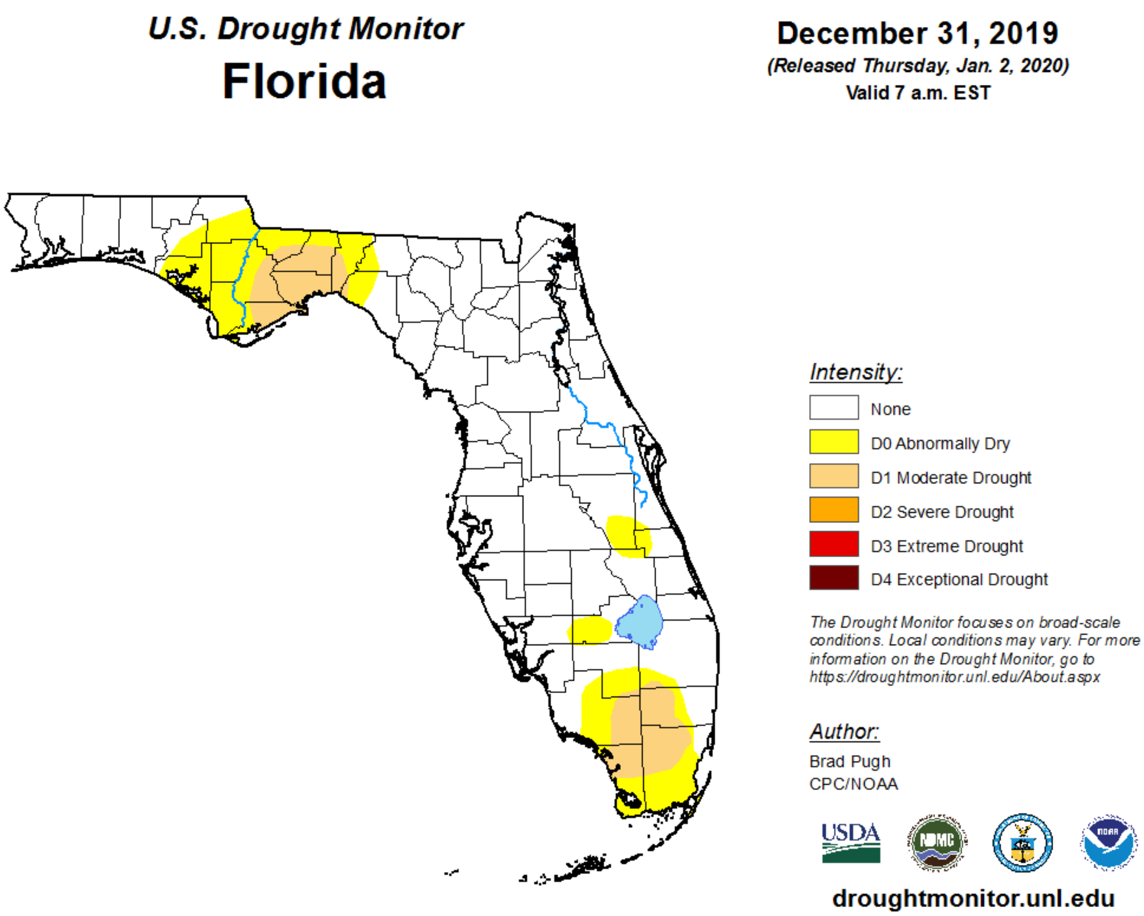
Warning Time: 1 – More than 24 hours

Duration: 4 – More than one week

Location

Drought is a regional hazard that can cover an entire the entire planning area, and in some cases the entire state. Figure 2.20 below notes the U.S. Drought Monitor's drought ratings for Florida as of December 31, 2019; as of that date, Collier County was experiencing some abnormally dry land and moderate drought on the eastern side of the county.

Figure 2.20 – US Drought Monitor for Week of December 31, 2019



Source: U.S. Drought Monitor

Extent

Drought extent can be defined in terms of intensity, using the U.S. Drought Monitor scale. The Drought Monitor Scale measures drought episodes with input from the Palmer Drought Severity Index, the Standardized Precipitation Index, the Keetch-Byram Drought Index, soil moisture indicators, and other inputs as well as information on how drought is affecting people. Figure 2.21 details the classifications used by the U.S. Drought Monitor. A category of D2 (severe) or higher on the U.S. Drought Monitor Scale can typically result in crop or pasture losses, water shortages, and the need to institute water restrictions.

Figure 2.21 – US Drought Monitor Classifications

Category	Description	Possible Impacts	Ranges				
			Palmer Drought Severity Index (PDSI)	CPC Soil Moisture Model (Percentiles)	USGS Weekly Streamflow (Percentiles)	Standardized Precipitation Index (SPI)	Objective Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: ▪ short-term dryness slowing planting, growth of crops or pastures Coming out of drought: ▪ some lingering water deficits ▪ pastures or crops not fully recovered	-1.0 to -1.9	21 to 30	21 to 30	-0.5 to -0.7	21 to 30
D1	Moderate Drought	▪ Some damage to crops, pastures ▪ Streams, reservoirs, or wells low, some water shortages developing or imminent ▪ Voluntary water-use restrictions requested	-2.0 to -2.9	11 to 20	11 to 20	-0.8 to -1.2	11 to 20
D2	Severe Drought	▪ Crop or pasture losses likely ▪ Water shortages common ▪ Water restrictions imposed	-3.0 to -3.9	6 to 10	6 to 10	-1.3 to -1.5	6 to 10
D3	Extreme Drought	▪ Major crop/pasture losses ▪ Widespread water shortages or restrictions	-4.0 to -4.9	3 to 5	3 to 5	-1.6 to -1.9	3 to 5
D4	Exceptional Drought	▪ Exceptional and widespread crop/pasture losses ▪ Shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0 to 2	0 to 2	-2.0 or less	0 to 2

Source: US Drought Monitor

Drought in Florida occurs on a regular, cyclical basis. The different areas of Florida are randomly affected and sometimes equally affected. Counties that are expected to experience the most weeks of drought each year are the northern and central counties.

Impact: 1 – Minor

Spatial Extent: 4 – Large

Historical Occurrences

The worst drought in Florida's recorded history was from 1954-1956. Lots of crops and timber were lost. The Northern Counties got the worst part of the drought but most of the State was in drought for all of 1956. Another major drought occurred in 1981-1982 when rain was scarce, and Lake Okeechobee reached the lowest water level ever recorded. All the State was in moderate or severe drought, but many regions were out of drought by the end of 1981.

Florida had a severe drought from 1998 to 2001. During this, crops were destroyed, lake levels were at an all-time low, and wildfires raged. This drought caused the water management districts to restrict water use, municipalities to hike water rates, and many restaurants were ordered to stop serving water except for to customers who asked. Several wildfires also occurred in 2007 because of a drought from 2006 to 2007. This period saw the largest rainfall deficit since the 1950s and was considered a one in 25-year drought event.

From 2010 to 2012, the State saw a drought that affected most counties, but the northern central and Panhandle regions were classified as in "extreme drought" for an extended period. Again in 2016, drought conditions developed and lasted into 2017 causing many wildfires.

There has never been a Presidential Major Disaster Declaration for drought in Florida. However, the USDA has declared agricultural disasters because of drought. Disaster designations help producers get loans and emergency assistance in these situations.

U.S. Drought Monitor records drought intensity weekly throughout the country. Table 2.49 presents the number of weeks that Collier County spent in drought by intensity over the period from 2000 through 2019, for which the Drought Monitor has records for 1,043 weeks.

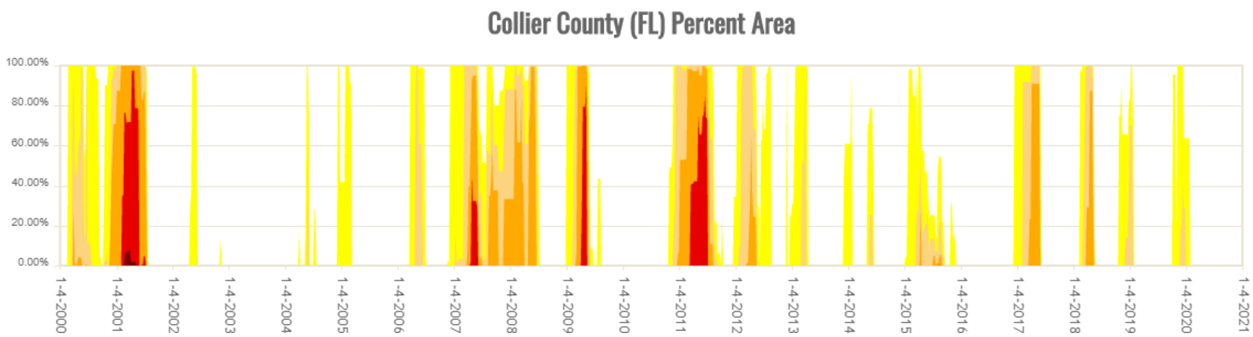
Table 2.49 – Weeks in Drought, 2000-2019

	Weeks in Drought						% of time in Severe Drought or Worse
County	**Total**	**D0**	**D1**	**D2**	**D3**	**D4**	
Collier	415	195	100	83	37	0	28.9%

Source: U.S. Drought Monitor History

Figure 2.22 shows the historical periods where the State was considered in some level of drought condition. The color key shown in Figure 2.21 indicates the intensity of the drought.

Figure 2.22 – US Drought Monitor Historical Trends, Collier County



Source: U.S. Drought Monitor

The National Drought Mitigation Center (NDMC), located at the University of Nebraska in Lincoln, provides a clearinghouse for information on the effects of drought, based on reports from media, observers, impact records, and other sources.

According to the National Drought Mitigation Center's Drought Impact Reporter, during the 10-year period from 2010 through 2019, 389 county level drought impacts were noted for the State of Florida, of which 36 were reported to affect Collier County. Table 2.50 summarizes the number of impacts reported by category and the years impacts were reported for each category. Note that the Drought Impact Reporter assigns multiple categories to each impact.

Table 2.50 – Drought Impacts Reported for Collier County, January 2010 through 2019

Category	Impacts	Years Reported
Agriculture	5	2010, 2011, 2015, 2017
Business & Industry	2	2010, 2011
Fire	18	2010, 2011, 2016, 2017, 2018, 2019
Plants & Wildlife	8	2011, 2012, 2013, 2017, 2018
Relief, Response & Restrictions	22	2010, 2011, 2012, 2015, 2016, 2017, 2018, 2019
Society & Public Health	3	2011, 2012, 2018
Tourism & Recreation	1	2012
Water Supply & Quality	12	2011, 2012, 2013, 2017

Source: Drought Impact Reporter, http://droughtreporter.unl.edu

Probability of Future Occurrence

Over the 20-year period, for which the U.S. Drought Monitor reported on 1,043 weeks, from 2000 to 2019, Collier County had 415 weeks of drought conditions ranging from abnormally dry to exceptional drought. This equates to a 40 percent chance of drought in any given week. Of this time, approximately 120 weeks were categorized as a severe (D2) drought or greater; which equates to a 12 percent chance of severe drought in any given week.

Central and southern Florida is likely to experience 0 to 13 weeks of drought each year. This hazard was determined to occur about every 5 to 10 years.

Probability: 3 – Likely

Climate Change

The Fourth National Climate Assessment reports that average and extreme temperatures are increasing across the country and average annual precipitation is decreasing in the Southeast. Heavy precipitation events are becoming more frequent, meaning that there will likely be an increase in the average number of consecutive dry days. As temperature is projected to continue rising, evaporation rates are expected to increase, resulting in decreased surface soil moisture levels. Together, these factors suggest that drought will increase in intensity and duration in the Southeast.

Vulnerability Assessment

People

Drought can affect people’s physical and mental health. For those economically dependent on a reliable water supply, drought may cause anxiety or depression about economic losses, reduced incomes, and other employment impacts. Conflicts may arise over water shortages. People may be forced to pay more for water, food, and utilities affected by increased water costs.

Drought may also cause health problems due to poorer water quality from lower water levels. If accompanied by extreme heat, drought can also result in higher incidents of heat stroke and even loss of human life.

Property

Drought is unlikely to cause damages to the built environment, including private property or critical facilities. However, in areas with shrinking and expansive soils, drought may lead to structural damages.

Drought may cause severe property loss for the agricultural industry in terms of crop and livestock losses. The USDA’s Risk Management Agency (RMA) maintains a database of all paid crop insurance claims, however no claims were made in Collier County between 2007-2018 as a result of drought.

Environment

Drought can affect local wildlife by shrinking food supplies and damaging habitats. Sometimes this damage is only temporary, and other times it is irreversible. Wildlife may face increased disease rates due to limited access to food and water. Increased stress on endangered species could cause extinction.

Another concern during a drought is that contaminants such as pesticides and fertilizers may concentrate in the soil as precipitation wanes and then enter waterways during heavy rains and flooding. Given the cultural and economic importance of water access in Collier County, any increase in contaminant load of the river could adversely affect the planning area.

Drought conditions can also provide a substantial increase in wildfire risk. As plants and trees die from a lack of precipitation, increased insect infestations, and diseases—all of which are associated with drought—they become fuel for wildfire. Long periods of drought can result in more intense wildfires, which bring additional consequences for the economy, the environment, and society. Drought may also increase likelihood of wind and water erosion of soils.

Consequence Analysis

Table 2.51 summarizes the potential negative consequences of drought.

Table 2.51 – Consequence Analysis - Drought

Category	Consequences
Public	Can cause anxiety or depression about economic losses, conflicts over water shortages, reduced incomes, fewer recreational activities, higher incidents of heat stroke, and fatality.
Responders	Impacts to responders are unlikely. Exceptional drought conditions may impact the amount of water immediately available to respond to wildfires.
Continuity of Operations (including Continued Delivery of Services)	Drought would have minimal impacts on continuity of operations due to the relatively long warning time that would allow for plans to be made to maintain continuity of operations.
Property, Facilities and Infrastructure	Drought has the potential to affect water supply for residential, commercial, institutional, industrial, and government-owned areas. Drought can reduce water supply in wells and reservoirs. Utilities may be forced to increase rates.
Environment	Environmental impacts include strain on local plant and wildlife; increased probability of erosion and wildfire.
Economic Condition of the Jurisdiction	Farmers may face crop losses or increased livestock costs. Businesses that depend on farming may experience secondary impacts. Extreme drought has the potential to impact local businesses in landscaping, recreation and tourism, and public utilities.
Public Confidence in the Jurisdiction's Governance	When drought conditions persist with no relief, local or State governments must often institute water restrictions, which may impact public confidence.

Hazard Summary by Jurisdiction

The following table summarizes drought hazard risk by jurisdiction. Drought risk is uniform across the planning area. Warning time, duration, and spatial extent are inherent to the hazard and remain constant across jurisdictions. Most damages that result from drought are to crops and other agriculture-related activities as well as water-dependent industries; therefore, the magnitude of the impacts is typically greater in unincorporated areas. In more heavily developed areas, the magnitude of drought is less severe, with lawns and local gardens affected and potential impacts on local water supplies during severe, prolonged drought.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	3	1	4	1	4	2.5	H
Immokalee Reservation	3	1	4	1	4	2.5	H
Marco Island	3	1	4	1	4	2.5	H
Naples	3	1	4	1	4	2.5	H
Unincorporated Collier County	3	1	4	1	4	2.5	H

2.5.7 Extreme Heat

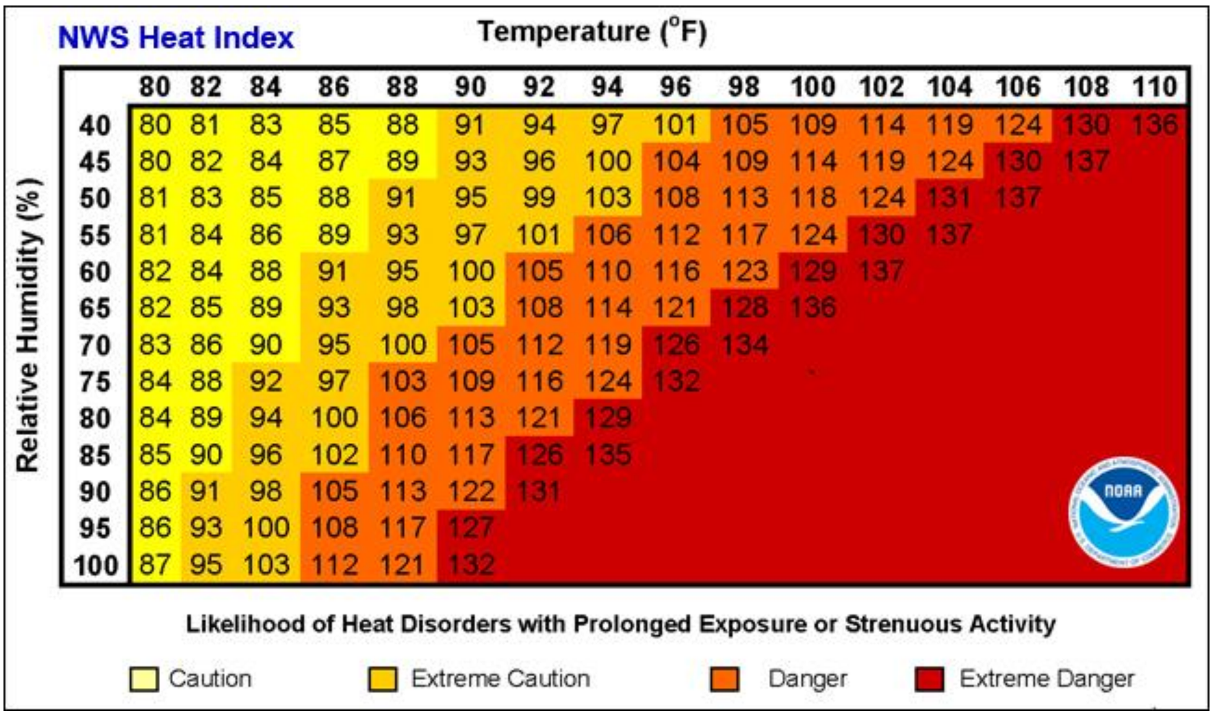
Hazard Description

Per information provided by FEMA, in most of the United States extreme heat is defined as a long period (2 to 3 days) of high heat and humidity with temperatures above 90 degrees. In extreme heat, evaporation is slowed, and the body must work extra hard to maintain a normal temperature, which can lead to death by overwork of the body. Extreme heat often results in the highest annual number of deaths among all weather-related disasters. Per Ready.gov:

- Extreme heat can occur quickly and without warning
- Older adults, children, and sick or overweight individuals are at greater risk from extreme heat
- Humidity increases the feeling of heat as measured by heat index

Ambient air temperature is one component of heat conditions, with relative humidity being the other. The relationship of these factors creates what is known as the apparent temperature. The Heat Index Chart in Figure 2.23 uses both factors to produce a guide for the apparent temperature or relative intensity of heat conditions.

Figure 2.23 – Heat Index Chart


NWS Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Source: National Weather Service (NWS) https://www.weather.gov/safety/heat-index

Note: Exposure to direct sun can increase Heat Index values by as much as 15°F. The shaded zone above 105°F corresponds to a heat index that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

During these conditions, the human body has difficulties cooling through the normal method of the evaporation of perspiration. Health risks rise when a person is overexposed to heat. The most dangerous place to be during an extreme heat incident is in a permanent home, with little or no air conditioning. Those at greatest risk for heat-related illness include people 65 years of age and older, young children, people with chronic health problems such as heart disease, people who are obese, people who are socially isolated, and people who are on certain medications, such as tranquilizers, antidepressants, sleeping pills, or drugs for Parkinson's disease. However, even young and healthy individuals are susceptible if they participate in strenuous physical activities during hot weather or are not acclimated to hot weather. Table 2.52 lists typical symptoms and health impacts of heat exposure.

Table 2.52 – Typical Health Impacts of Extreme Heat

Heat Index (HI)	Disorder
80-90° F (HI)	Fatigue possible with prolonged exposure and/or physical activity
90-105° F (HI)	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and/or physical activity
105-130° F (HI)	Heatstroke/sunstroke highly likely with continued exposure

Source: National Weather Service Heat Index Program, www.weather.gov/os/heat/index.shtml

The NWS has a system in place to initiate alert procedures (advisories or warnings) when the Heat Index is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for issuing excessive heat alerts is when the maximum daytime Heat Index is expected to equal or exceed 105 degrees Fahrenheit (°F) and the night time minimum Heat Index is 80°F or above for two or more consecutive days. A heat advisory is issued when temperatures reach 105 degrees and a warning is issued at 115 degrees.

Impacts of extreme heat are not only focused on human health, as prolonged heat exposure can have devastating impacts on infrastructure as well. Prolonged high heat exposure increases the risk of pavement deterioration, as well as railroad warping or buckling. High heat also puts a strain on energy systems and consumption, as air conditioners are run at a higher rate and for longer; extreme heat can also reduce transmission capacity over electric systems.

Warning Time: 1 – More than 24 hours

Duration: 3 – Less than one week

Location

The entire planning area is susceptible to high temperatures and incidents of extreme heat.

Extent

The extent of extreme heat can be defined by the maximum apparent temperature reached. Apparent temperature is a function of ambient air temperature and relative humidity and is reported as the heat index. The NWS Southern Region sets the following criteria for heat advisory and excessive heat warning:

- **Heat Advisory** – Heat Index of 108°F or higher or temperature of 103°F or higher
- **Excessive Heat Warning** – Heat Index of 113°F or higher for any duration or temperature of 103°F or higher

Table 2.53 notes the highest temperature on record at nine weather stations in Collier County according to the Southeast Regional Climate Center, which maintains temperature records for the highest maximum temperature each month.

Table 2.53 – Highest Temperature by Location

Temperature	Location	Date
99°F	Chokoloskee	June 2007
100°F	Everglades	May 1991
102°F	Immokalee	June 1998
98°F	Marco Island	July 2011
99°F	Miles City Twr	May 1967

Temperature	Location	Date
99°F	Naples	September 1986
98°F	Naples Municipal Airport	June 2019
103°F	Oasis Ranger Station	June 1981
97°F	Sunniland	May 1953

Source: Southeast Regional Climate Center

Impact: 2 – Limited

Spatial Extent: 4 – Large

Historical Occurrences

NCEI records zero incidents of heat or excessive heat for Collier County between 2000-2019.

Heat index records maintained by the North Carolina Climate Office for the Southeastern United States indicate that the Region regularly experiences heat index temperatures above 100°F. Table 2.54 provides counts of heat index values by threshold recorded from 2002-2019, the only year for which data was available, at the Naples Municipal Airport weather station (KAPF). This location is used as an indicator for Collier County overall. Counts are provided as the number of hours in a given year where the heat index reached or exceeded 100°F.

Table 2.54 – Historical Heat Index Counts, Naples Municipal Airport (KAPF), 2002-2019

Year	Heat Index Value				Total
	100-104°F	105-109°F	110-114°F	≥115°F	
2002	171	4	0	0	175
2003	133	2	0	0	135
2004	253	23	0	0	276
2005	141	10	0	0	151
2006	94	2	0	0	96
2007	249	26	0	0	275
2008	110	5	0	0	115
2009	319	36	0	0	355
2010	407	109	3	0	519
2011	273	24	0	0	297
2012	190	4	0	0	194
2013	131	14	2	0	147
2014	300	100	18	0	418
2015	288	64	5	2	359
2016	273	26	0	0	299
2017	240	21	1	0	262
2018	370	112	15	0	497
2019	467	182	21	2	672
Sum	**4,409**	**764**	**65**	**4**	**5,242**
Average	**245**	**42**	**4**	**0**	**291**

Source: North Carolina Climate Office, Heat Index Climatology Tool

According to this data, Collier County averages approximately 291 hours per year with heat index values above 100°F.

Probability of Future Occurrence

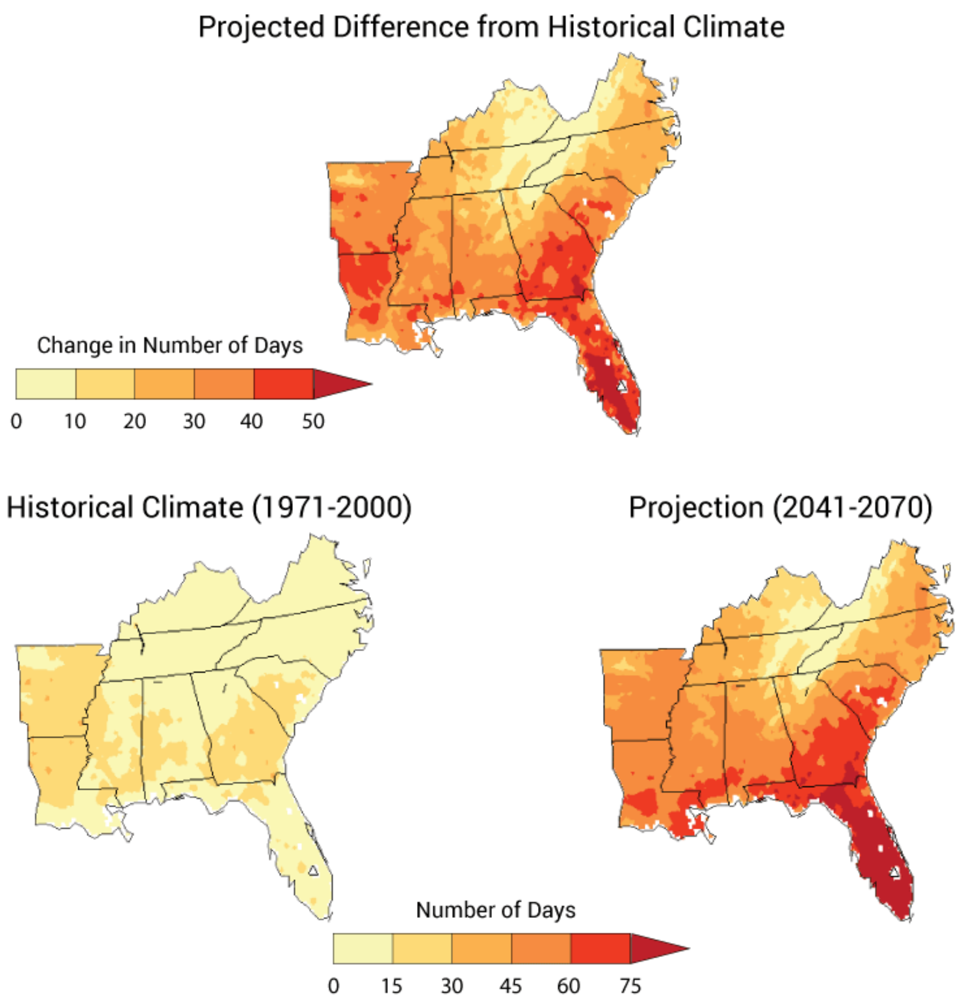
Data was gathered from the North Carolina State Climate Office's Heat Index Climatology Tool using the Naples Municipal Airport weather station as an approximation for Collier County. Based on 17 years of available data, the Region averages 291 hours per year with heat index temperatures above 100°F. Heat index temperatures surpassed 100°F every year, occurring for at least 94 hours per year.

Probability: 4 – Highly Likely

Climate Change

Research shows that average temperatures will continue to rise in the Southeast United States and globally, directly affecting Collier County. Per the Fourth National Climate Assessment, "extreme temperatures are projected to increase even more than average temperatures. Cold waves are projected to become less intense and heat waves more intense." The number of days over 95°F is expected to increase by between 20 and 30 days annually, as shown in Figure 2.24.

Figure 2.24 – Projected Change in Number of Days Over 95°F



Source: NOAA NCDC from 2014 National Climate Assessment

Vulnerability Assessment

Methodologies and Assumptions

No data is available to assess the vulnerability of people or property in the planning area to extreme heat.

People

Extreme heat can cause heat stroke and even loss of human life. The elderly and the very young are most at risk to the effects of heat. People who are isolated are also more vulnerable to extreme heat.

Property

Extreme heat is unlikely to cause significant damages to the built environment. However, road surfaces can be damaged as asphalt softens, and concrete sections may buckle under expansion caused by heat. Train rails may also distort or buckle under the stress of head induced expansion. Power transmission lines may sag from expansion and if contact is made with vegetation the line may short out causing power outages. Additional power demand for cooling also increases power line temperature adding to heat impacts.

Extreme heat can also cause significant agricultural losses. Between 2007-2018, the USDA Risk Management Agency reports one crop insurance claim due to heat in Collier County in the amount of $39,330. This equates to an average annual loss of $3,278.

Environment

Wild animals are vulnerable to heat disorders like humans, including mortality. Vegetation growth will be stunted, or plants may be killed if temperatures rise above their tolerance extremes.

Consequence Analysis

Table 2.55 summarizes the potential negative consequences of extreme heat.

Table 2.55 – Consequence Analysis – Extreme Heat

Category	Consequences
Public	Extreme heat may cause illness and/or death.
Responders	Consequences may be greater for responders if their work requires exertion and/or wearing heavy protective gear.
Continuity of Operations (including Continued Delivery of Services)	Continuity of operations is not expected to be impacted by extreme heat because warning time for these events is long.
Property, Facilities and Infrastructure	Minor impacts may occur, including possible damages to road surfaces and power lines.
Environment	Environmental impacts include strain on local plant and wildlife, including potential for illness or death.
Economic Condition of the Jurisdiction	Farmers may face crop losses or increased livestock costs.
Public Confidence in the Jurisdiction's Governance	Extreme heat is unlikely to impact public confidence.

Hazard Summary by Jurisdiction

The following table summarizes extreme heat hazard risk by jurisdiction. Extreme heat risk does not vary significantly by jurisdiction.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	4	2	4	1	3	3.0	H
Immokalee Reservation	4	2	4	1	3	3.0	H
Marco Island	4	2	4	1	3	3.0	H
Naples	4	2	4	1	3	3.0	H
Unincorporated Collier County	4	2	4	1	3	3.0	H

2.5.8 Sea Level Rise and other Climate Change Characteristics

Hazard Description

Sea level rise is the increase in sea levels as a result of atmospheric and oceanic warming which causes water expansion as well as ice melt from ice sheets and glaciers. Sea level rise is a result of global climate change. Climate change may be due to natural internal processes or external forces such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014). Climate change is a natural occurrence in which the earth has warmed and cooled periodically over geologic time. The recent and rapid warming of the earth over the past century has been cause for concern, as this warming is very likely due to the accumulation of human-caused greenhouse gases, such as CO_2, in the atmosphere (IPCC, 2007). This warming is occurring almost everywhere in the world which suggests a global cause rather than changes in localized weather patterns. In 2018, the Intergovernmental Panel on Climate Change (IPCC) reported with high confidence that warming due to such emissions will cause long-term changes in the climate system such as sea level rise and its associated impacts.

There are generally two separate mechanics involved in global sea level rise. The first is directly attributed to global temperature increases, which warm the oceans waters and cause them to expand. The second is attributed to the melting of ice over land which simply adds water to the oceans. Global sea level rise is likely caused by a combination of these two mechanics and can be exasperated on the local level by factors such as erosion and subsidence. The rate of sea level rise has varied throughout geologic history, and studies have shown that global temperature and sea level are strongly correlated.

Due to sea-level rise projected throughout the 21st century and beyond, coastal systems and low-lying areas will increasingly experience adverse impacts such as submergence, coastal flooding, and coastal erosion. The population and assets projected to be exposed to coastal risks as well as human pressures on coastal ecosystems will increase significantly in the coming decades due to population growth, economic development, and urbanization (IPCC, 2014). Collier County is particularly vulnerable to the effects of sea level rise, due to its coastal location, subtropical environment, low topography and tourism economy.

Warning Time: 1 – More than 24 hours

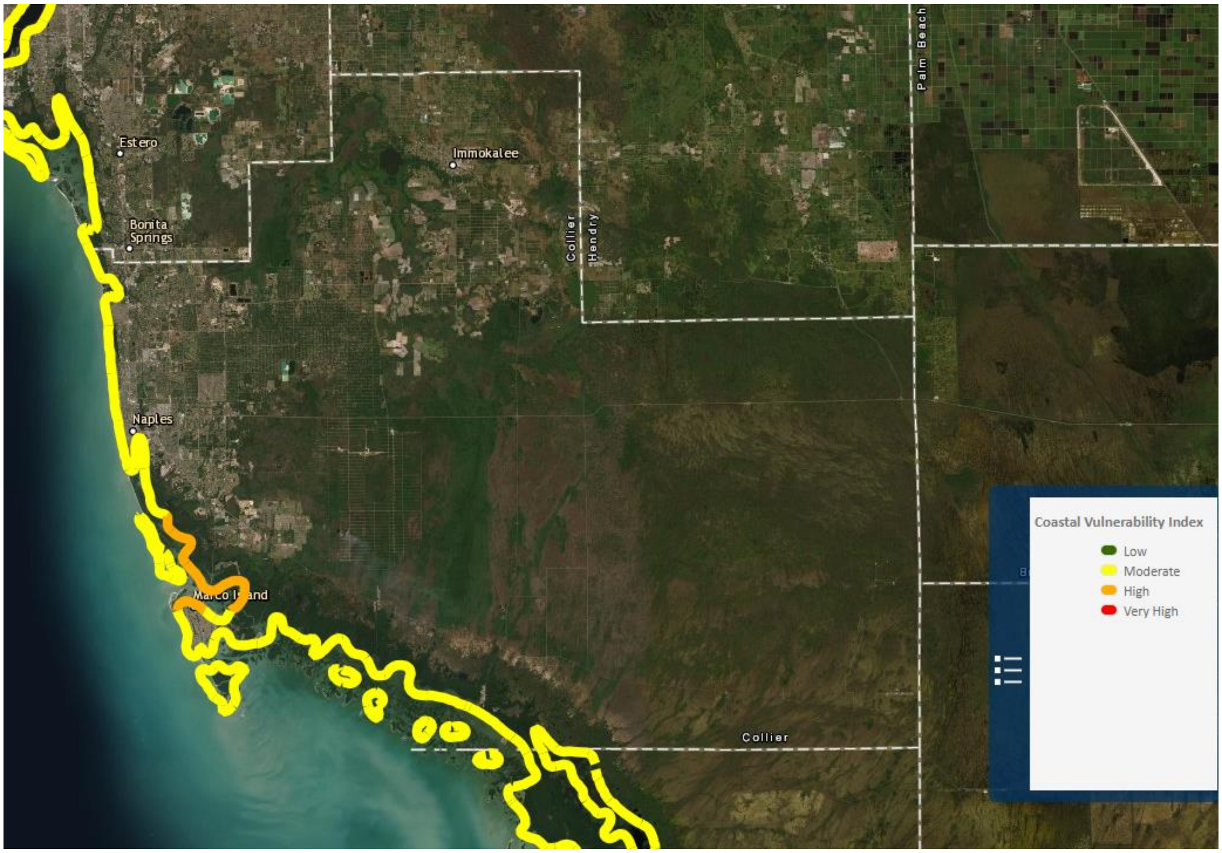
Duration: 4 – More than one week

Location

Sea level rise can occur anywhere along the coast and along major waterways in Collier County. The Coastal Vulnerability Index (CVI), developed by United States Geological Survey (USGS), provides a preliminary overview of the relative susceptibility of the United States coast to sea level rise. The CVI is based on geomorphology, regional coastal slope, tide range, wave height, relative sea level rise, and shoreline erosion and acceleration rates. For each study area, each variable is scored on a 1-5 scale based on defined parameters, where “1” indicates low contribution to coastal vulnerability and “5” indicates high contribution to vulnerability. These scores are then aggregated into a single index through a mathematical formula. The resulting index gives an overview of where physical changes may occur due to sea-level rise.

Figure 2.25 shows the CVI for Collier County. The Gulf of Mexico Coastline between Naples and Marco Island is the most vulnerable area in the region, rated high. Shorelines along the remainder of the Coastline are all rated moderate vulnerability.

Figure 2.25 – Coastal Vulnerability Index, Collier County

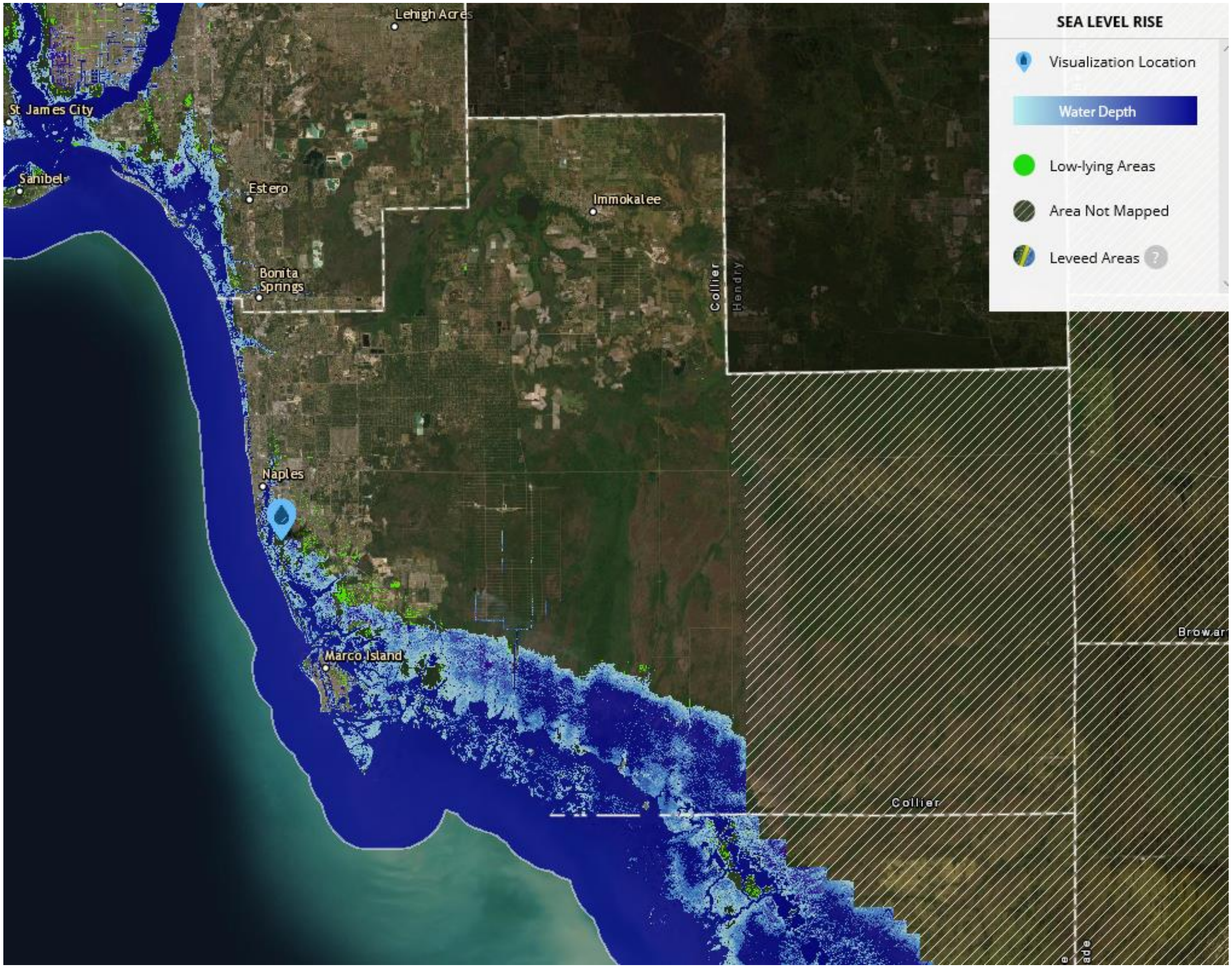


Source: USGS Coastal Change Hazards Portal

Extent

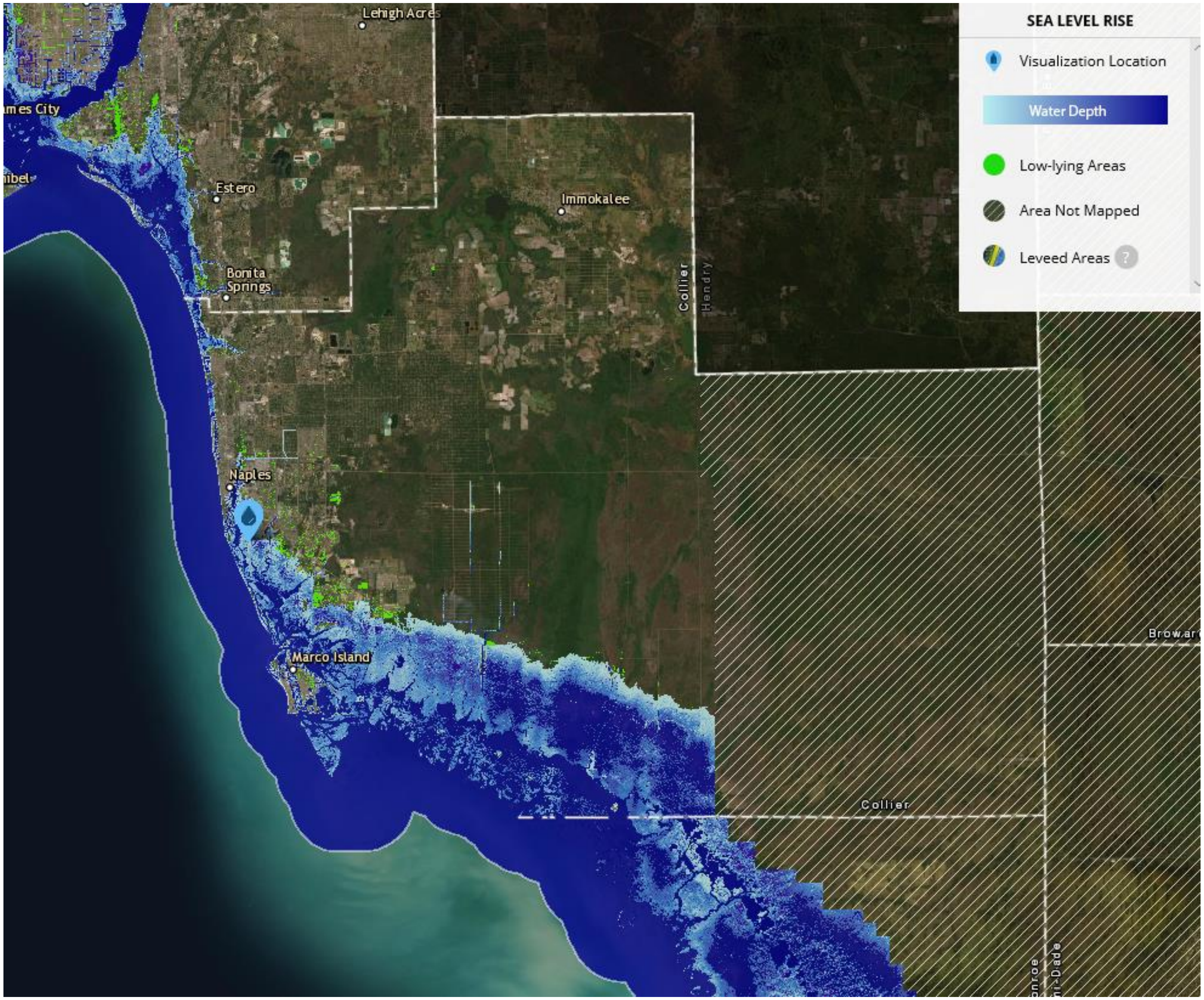
Sea level rise is measured by the number of feet of relative rise and the areas that such rise would inundate. The estimated impacts of 1-foot, 2-foot, and 3-foot, sea level rise (SLR) are shown in Figure 2.26 through Figure 2.28. The SLR estimate maps show inundation above mean higher high water (the average of each day's higher high tide line). SLR will likely affect coastal marsh lands as well as land along rivers, canals, and their tributaries. Additionally, SLR will likely increase future risk of flooding from the other flood hazards discussed later in this plan, as more land will have a lower elevation relative to sea level. For example, with much of the barrier islands and wetlands inundated, inland areas will lose their natural protection and may become susceptible to coastal flooding with velocity wave action.

Figure 2.26 – Estimated Impact of 1 Foot SLR on Collier County



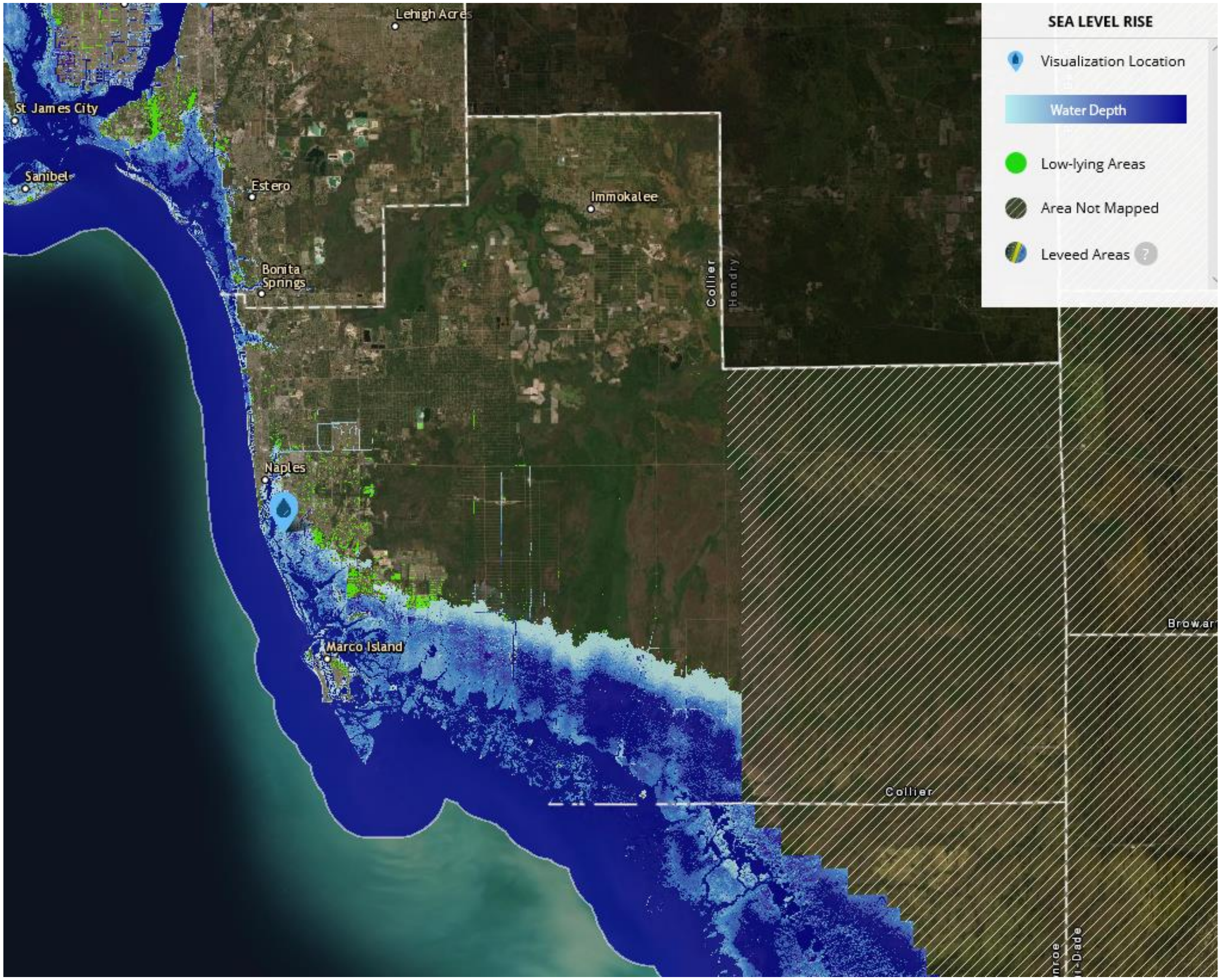
Source: NOAA Sea Level Rise View

Figure 2.27 – Estimated Impact of 2 Foot SLR on Collier County



Source: NOAA Sea Level Rise Viewer

Figure 2.28 – Estimated Impact of 3 Foot SLR on Collier County



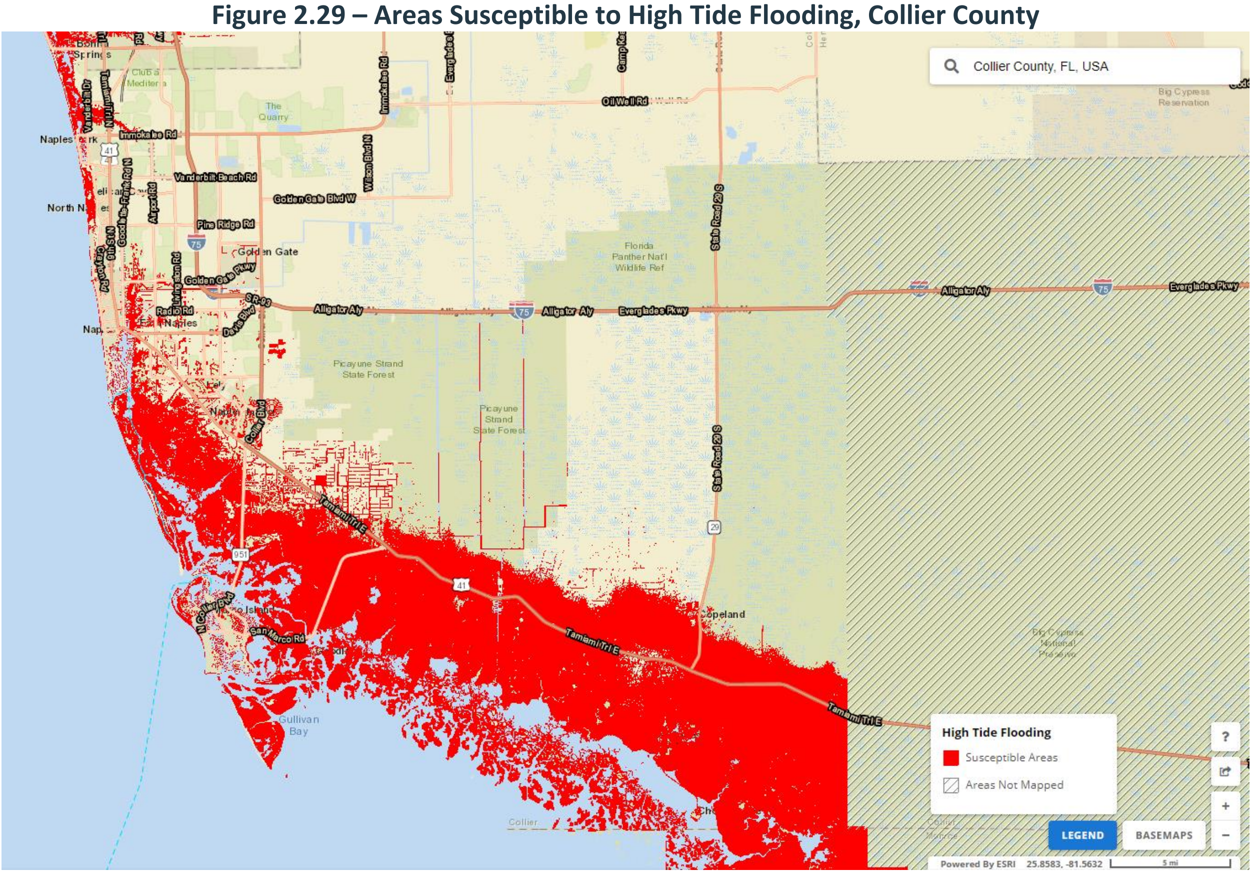
Source: NOAA Sea Level Rise Viewer

Sea level rise is a slow onset hazard, and because the full extent of anticipated sea level rise has not yet been realized, the effects of sea level rise have not yet been fully felt. However, sea level rise has already begun to cause "clear sky" or "nuisance" flooding, which is brought on by high tidewaters rather than storm or rain events. Tidal flooding causes temporary inundation of low-lying areas during high-tide events. While tidal flooding is not caused by sea level rise itself, a 2015 tidal flooding report published by NOAA notes that tidal flood rates are steadily increasing, and daily highest tides surpass fixed elevations increasingly frequently, due in part to sea level rise. According to NOAA, annual occurrences of high tide flooding have increased 5- to 10-fold since the 1960s. Sea level rise may cause flooding to occur more frequently and last for longer durations of time. Climate Central's Surging Seas Risk Finder data will be very useful to the County while planning for sea level rise. As sea level continues to rise, tidal flooding will continue to occur more frequently and over a greater inland area. Figure 2.29 shows areas in Collier County that are susceptible to high tide flooding as defined by NOAA based on derived national flood thresholds from NOAA Technical Report NOS CO-OPS 086: Patterns and Projections of High Tide Flooding along the U.S. Coastline Using a Common Impact Threshold.

Impact: 3 – Critical

Spatial Extent: 3 – Moderate

Figure 2.29 – Areas Susceptible to High Tide Flooding, Collier County

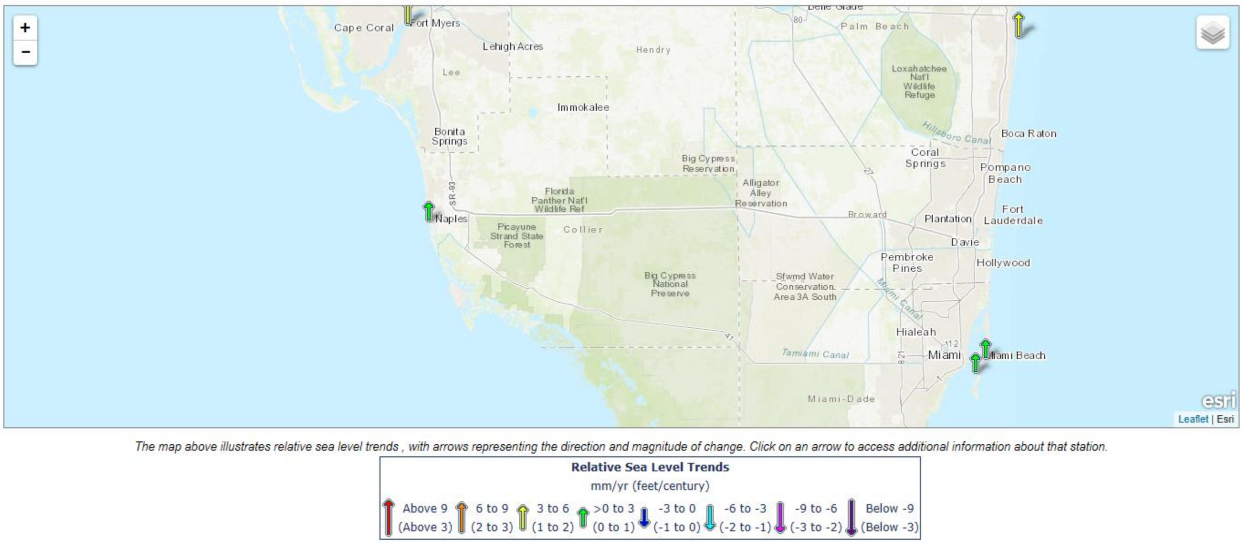


Source: NOAA Coastal Flood Exposure Mapper

Historical Occurrences

Historic trends in local MSL are best determined from tide gauge records. The Center for Operational Oceanographic Products and Services (CO-OPS) has been measuring sea level for over 150 years, with tide stations operating on all U.S. coasts. Changes in Mean Sea Level (MSL), either a sea level rise or sea level fall, have been computed at 128 long-term water level stations using a minimum span of 30 years of observations at each location. These measurements have been averaged by month to remove the effect of higher frequency phenomena (e.g. storm surge) in order to compute an accurate linear sea level trend. Figure 2.30 illustrates regional trends in sea level from NOAA. At the Naples, FL station (indicated by the green arrow in Collier County), the relative sea level trend is 2.85 mm/year with a 95% confidence interval of +/- 0.44 mm/year based on monthly mean sea level data from 1965 to 2018 which is equivalent to a change of 0.94 feet in 100 years.

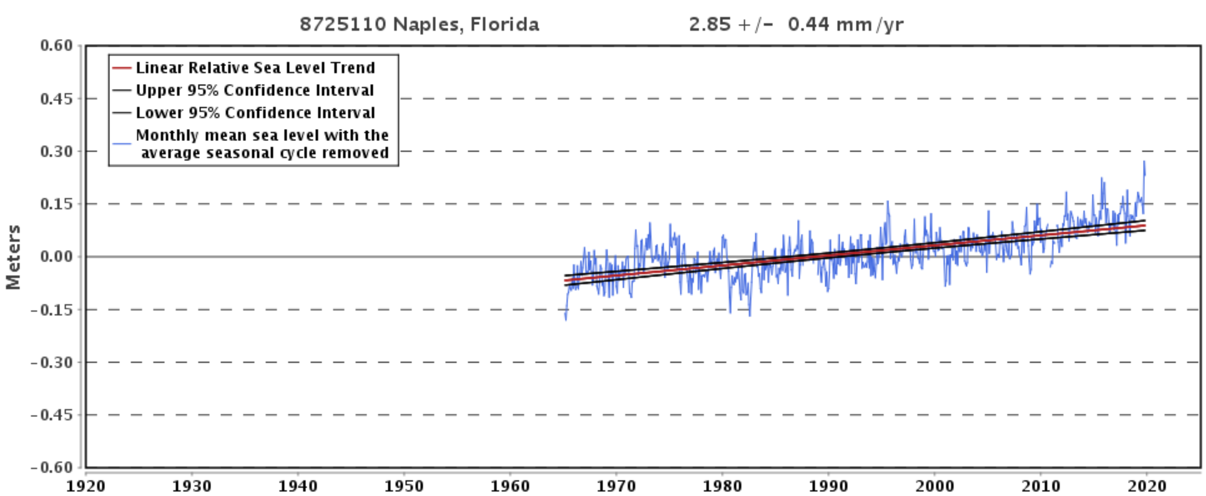
Figure 2.30 – Sea Level Trends, Collier County



Source: http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml

Figure 2.31 shows the monthly mean sea level at NOAA's Naples, FL station without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The long-term linear trend is also shown, including its 95% confidence interval. The plotted values are relative to the most recent Mean Sea Level datum established by CO-OPS.

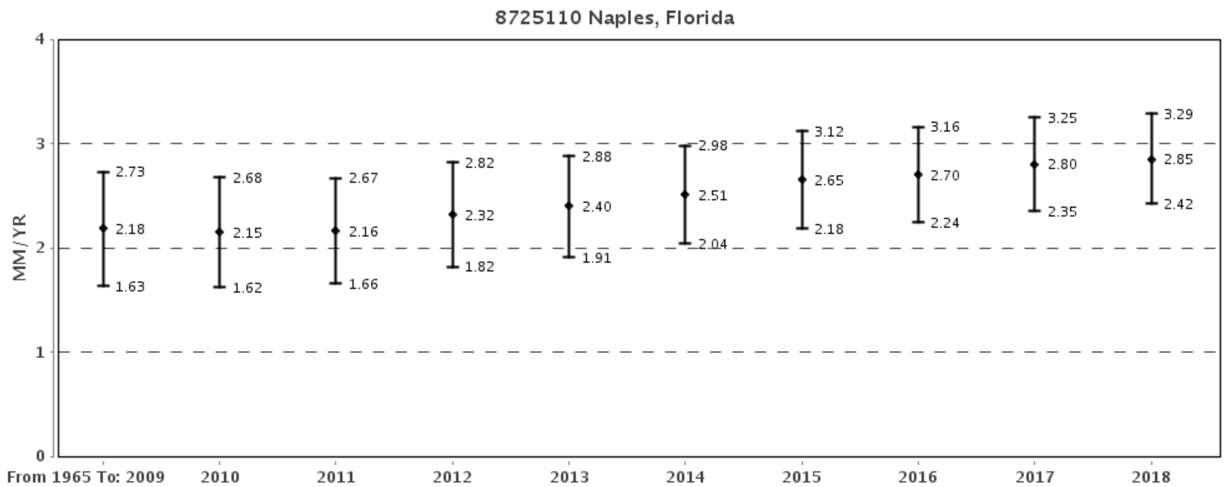
Figure 2.31 – Mean Sea Level Trends, Naples, FL



Source: NOAA Tides and Currents, January 2020

Figure 2.32 shows this trend compared with previous mean sea level trends. The values indicate the trend of the entire data period up to the given year. As such, each year's trend estimate is more precise than previous years' estimates. The sea level trend through 2018 at the Naples, FL tide gauge is 2.85 mm/year with a 95% confidence interval of 2.42 mm/year to 3.29 mm/year.

Figure 2.32 – Previous Mean Sea Level Trends for Naples, FL



Source: NOAA Tides and Currents, January 2020

Probability of Future Occurrence

The U.S. Army Corps of Engineers (USACE) has provided guidance to evaluate designs over a project's life cycle in order to account for the rise of global mean sea level (USACE, 2014). The USACE guidance is based on original guidance by the National Research Council (NRC, 1987). The 1987 NRC report recommended that feasibility studies for coastal projects consider the high probability of accelerating global mean sea level (GMSL) rise and provided three different acceleration scenarios through the year 2100. The NRC committee provided an equation for calculating sea level rise and recommended "projections be updated approximately every decade to incorporate additional data."

The USACE guidance adjusted the NRC equation to include the historic GMSL change rate of 1.7 mm/year as presented by the IPCC (IPCC, 2007) and the start date of 1992 (which corresponds to the midpoint of the National Tidal Datum Epoch of 1983-2001), instead of 1986 (the start date for NRC's equation). These changes resulted in values for the variable *b* being equal to 2.71E-5 for modified NRC Curve I, 7.00E-5 for modified NRC Curve II, and 1.13E-4 for modified NRC Curve III. The resulting equation is as follows:

$$E(t) = 0.0017m/yr*t + bt^2$$

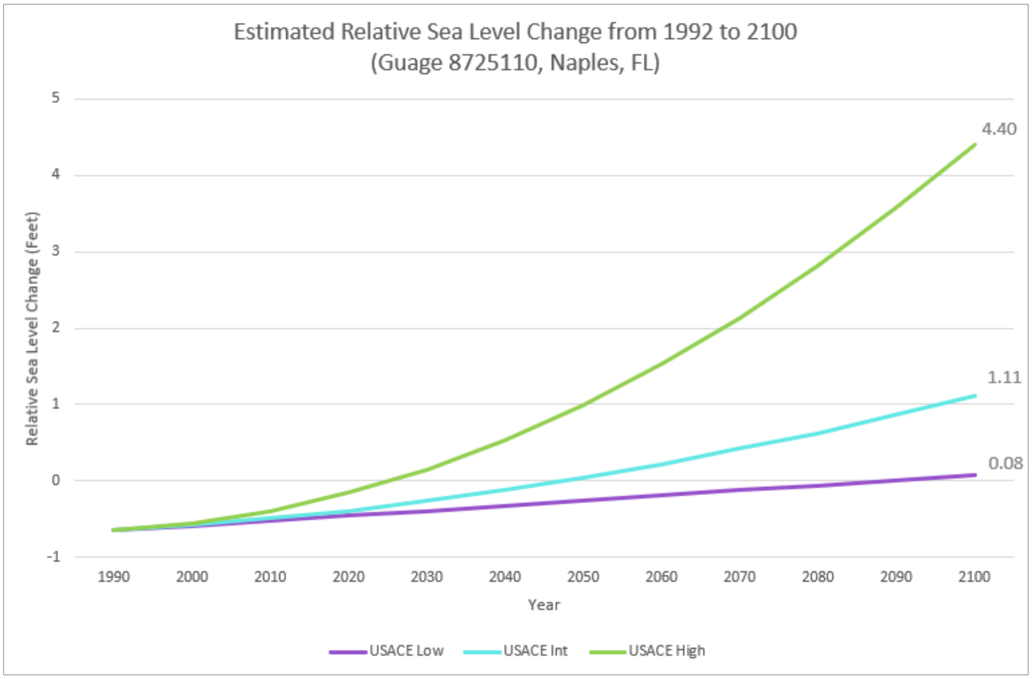
In the above equation, t represents years, b is a constant, and E(t) is the relative sea-level change, in meters, as a function of t. The three updated GMSL rise acceleration scenarios are depicted in Figure 2.33 on the following page.

Based on the USACE guidance and data from the Oregon Inlet Marina, NC NOAA gauge, a projected sea level rise to be used for future planning decisions can be calculated. Figure 2.33 shows sea level rise projections for three scenarios from the USACE. The USACE Low curve uses the historic rate of sea level change as the rate, the USACE Intermediate curve uses the NRC Curve I modified by recent IPCC low emissions projections and the local rate of vertical land movement, and the USACE High curve uses the NRC Curve II modified by recent IPCC higher emissions projections and the local rate of vertical land movement. Given that the USACE Low curve does not consider further climate change, the USACE

Intermediate and High curves are more likely. However, which of the curves is the more likely scenario depends on future emissions levels. Based on the more conservative estimate of the Intermediate curve, Collier County should plan for 0.04 feet of sea level rise from 1992 levels by 2050.

Probability: 3 – Likely

Figure 2.33 – Sea Level Rise Projections for Collier County (1992-2100)



Source: USACE, 2020

Climate Change

Sea level rise is a direct result of global climate change. Estimates for sea level rise are based on projected greenhouse gas emission levels and their associated impacts on global temperature change. Most sea level rise models do not fully account for ice melt, and therefore actual sea level rise may be significantly higher than current estimates suggest. As such, these projections contain substantial variability but are nonetheless important to consider when planning for coastal areas because they indicate where flooding can be expected should actual sea level rise meet estimated levels.

Vulnerability Assessment

Methodologies and Assumptions

Vulnerability to Sea Level Rise was assessed based on past occurrences nationally and internationally as well as data from NOAA, USGS, the Intergovernmental Panel on Climate Change (IPCC), and other sources.

In addition to the data presented below, the forthcoming Southeast Coastal Assessment from the USACE South Atlantic Division will provide supplementary data and details through a comprehensive coastal shoreline risks and needs assessment. This tool will look at four hazards (hurricanes and storms, long-term erosion, flooding, and potential sea level rise) and how they will impact population, the built environment, and the natural environment.

People

Sea level rise will lead to increased flooding and the associated harms to humans, such as illness, or injury or death from driving into flooded waters and drowning.

Property

The increased number of flood days and general encroachment of shoreline associated with sea level rise will likely cause property damage, although it is unclear exactly what this will look like. Homes, businesses and vehicles will be susceptible to increased water damage. Homes within the areas that may be inundated will potentially be uninhabitable. Additionally, rising seas, and associated increased flood days, can overwhelm and undermine the effectiveness of stormwater drainage system and other infrastructure, such as roads and bridges.

Data was not available to estimate potential property and critical facility losses as a result of sea level rise.

Environment

Sea level rise can have numerous negative consequences on the environment including increased erosion and all impacts associated with that. Another concern is the inundation of normally dry land, which could lead to the loss of marshes and wetlands and the positive benefits associated with those areas. These areas buffer against waves and storm surge, protect from erosion and even encourage accretion, and provide natural wildlife habitats. Finally, sea level rise may lead to saltwater intrusion as the groundwater table may also rise, potentially leading to contaminated drinking and agriculture water.

Consequence Analysis

Table 2.56 summarizes the potential negative consequences of Sea Level Rise.

Table 2.56 – Consequence Analysis – Sea Level Rise

Category	Consequences
Public	Sea Level Rise may cause increased flooding which may lead to illness, injury, or death. Additionally, sea level rise may cause psychological stress from loss of home, economy, and culture.
Responders	Sea Level Rise induced flooding may cause increased burden on responders.
Continuity of Operations (including Continued Delivery of Services)	As sea levels rise and cause more regular, chronic flooding, continuity of operations, such as delivery of services may be interrupted due to localized disruption of roads, facilities, and/or utilities.
Property, Facilities and Infrastructure	Sea level rise can cause damage to property as flooding becomes more regular in the short term and as sea levels continue to rise in the long term. SLR can also compromise infrastructure such as drainage systems and roads.
Environment	Sea level rise can lead to increased erosion, salt water intrusion, and inundation of wetlands and previous dry land.
Economic Condition of the Jurisdiction	Sea level rise can severely disrupt the economy, particularly in a region that relies so heavily on tourism.
Public Confidence in the Jurisdiction’s Governance	Sea level rise is unlikely to impact public confidence.

Hazard Summary by Jurisdiction

The following table summarizes sea level rise risk by jurisdiction. Most jurisdictions face at least some risk from sea level rise, but coastal and waterfront areas have greater exposure. Spatial extent was varied by jurisdiction depending on the area exposed to sea level rise impacts, with a rating of negligible for Immokalee Reservation, large for Marco Island and Naples, and moderate for the remaining jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	3	3	3	1	4	2.9	H
Immokalee Reservation	3	3	1	1	4	2.5	H
Marco Island	3	3	4	1	4	3.1	H
Naples	3	3	4	1	4	3.1	H
Unincorporated Collier County	3	3	3	1	4	2.9	H

2.5.9 Sink Holes

Hazard Background

Sinkholes are a natural and common geologic feature in areas with underlying limestone and other rock types that are soluble in natural water. Most limestone is porous, allowing the acidic water of rain to percolate through their strata, dissolving some limestone and carrying it away in solution. Over time, this persistent erosional process can create extensive underground voids and drainage systems in much of the carbonate rocks. Collapse of overlying sediments into the underground cavities produces sinkholes.

The three general types of sinkholes are: subsidence, solution, and collapse. Collapse sinkholes are most common in areas where the overburden (the sediments and water contained in the unsaturated zone, surficial aquifer system, and the confining layer above an aquifer) is thick, but the confining layer is breached or absent. Collapse sinkholes can form with little warning and leave behind a deep, steep sided hole. Subsidence sinkholes form gradually where the overburden is thin and only a veneer of sediments is overlying the limestone. Solution sinkholes form where no overburden is present, and the limestone is exposed at land surface.

Sinkholes occur in many shapes, from steep-walled holes to bowl or cone shaped depressions. Sinkholes are dramatic because the land generally stays intact for a while until the underground spaces get too big. If there is not enough support for the land above the spaces, then a collapse of the land surface can occur. Under natural conditions, sinkholes form slowly and expand gradually. However, human activities such as dredging, constructing reservoirs, diverting surface water, and pumping groundwater can accelerate the rate of sinkhole expansions, resulting in the abrupt formation of collapse sinkholes.

Although a sinkhole can form without warning, specific signs can signal potential development:

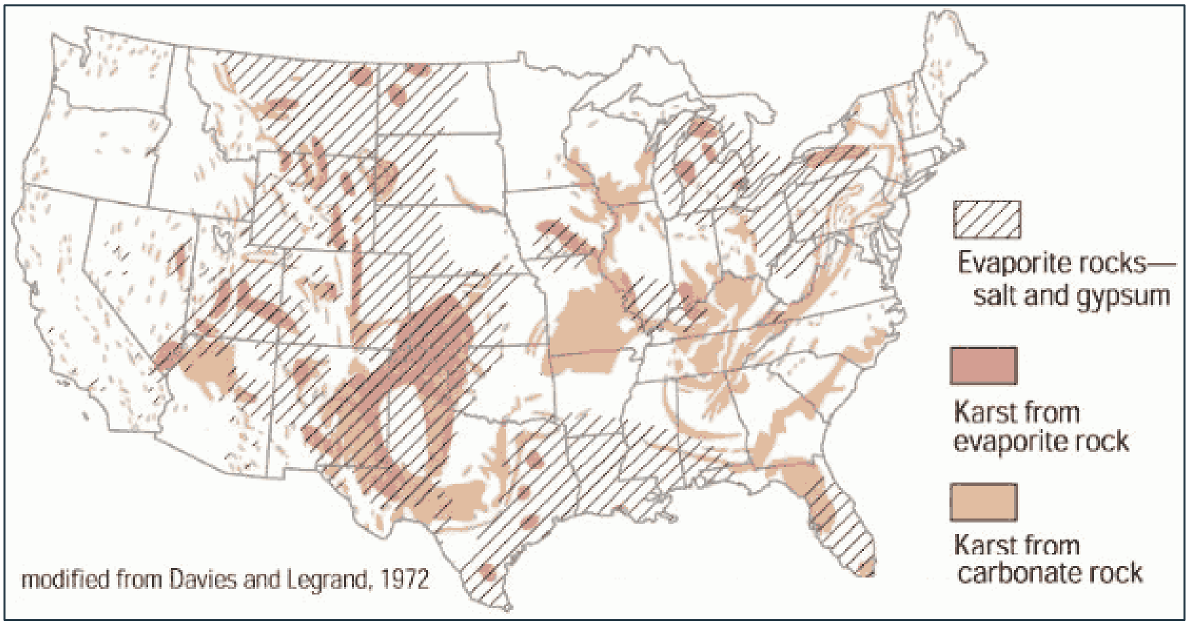
- Slumping or falling fenceposts, trees, or foundations;
- Sudden formation of small ponds;
- Wilting vegetation;
- Discolored well water; and/or
- Structural cracks in walls, floors.

Sinkhole formation is aggravated and accelerated by urbanization. Development increases water usage, alters drainage pathways, overloads the ground surface, and redistributes soil. According to FEMA, the number of human-induced sinkholes has doubled since 1930, insurance claims for damages as a result of sinkholes has increased 1,200 percent from 1987 to 1991, costing nearly $100 million.

Warning Time: 4 – Less than six hours

Duration: 4 – More than 1 week

Figure 2.34 – Rock Formations in the United States



Source: USGS Groundwater Information

Location

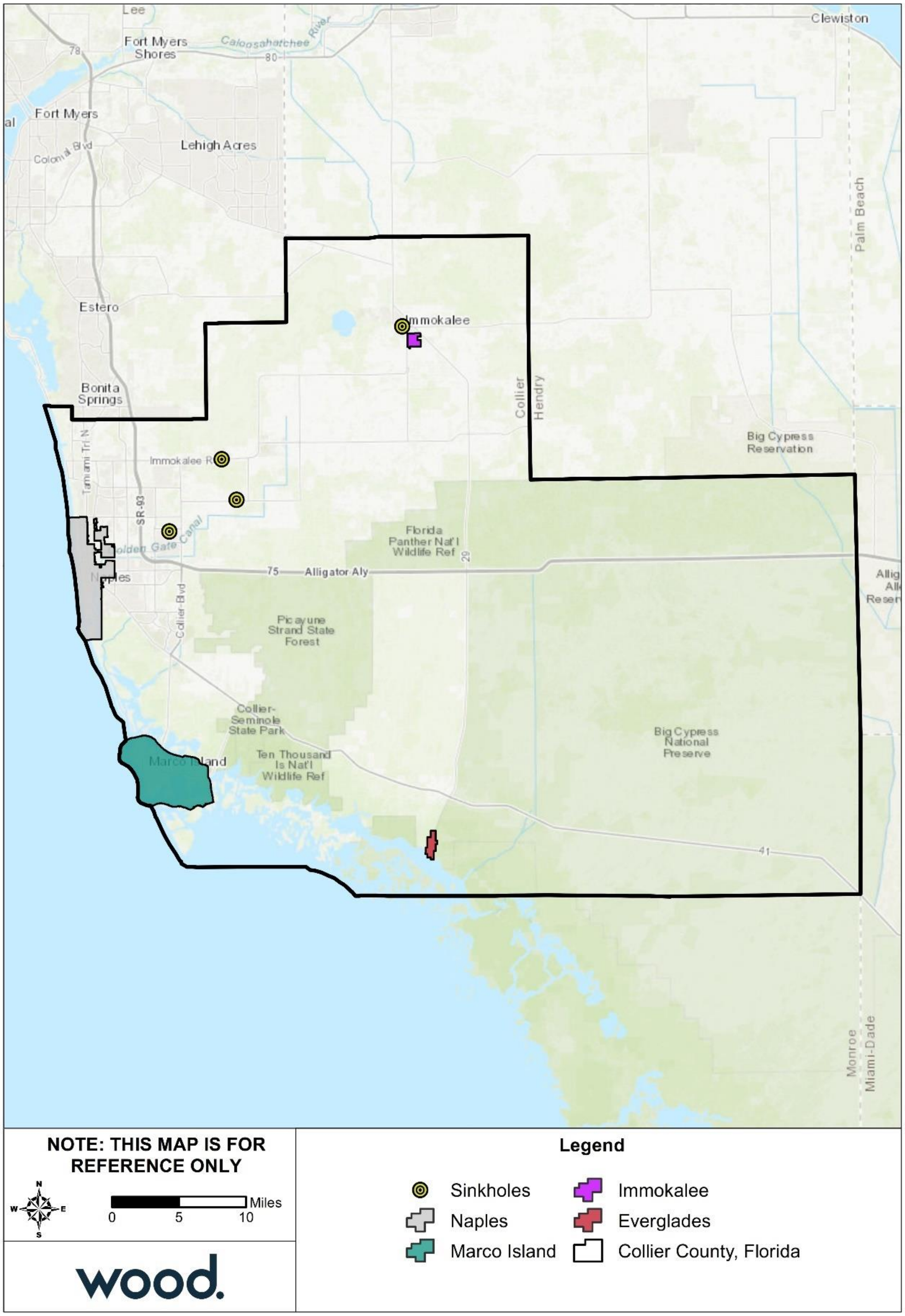
Existing soil types in Collier County are conducive to the formation of natural sinkholes. Limestone, which is easily eroded away and can create sinkholes, is prevalent in Collier County. There is also a potential for soil piping and/or erosion caused by leakage from drainage pipes, collapsed water mains or sewer lines, failed culverts and the effects of other human infrastructure activity. The extent of sinkhole activity is measured in terms of the dimensions of the sinkhole. There have been four recorded sinkholes in Collier County and only three subsidence events between 2000 and 2019. The largest known sinkhole in the County was 12 feet deep recorded in 2000. Past subsidence incidents reported by the Florida Geological Survey for Collier County are recorded below in Table 2.57.

Table 2.57 – Sink Holes in Collier County, 2000-2019

Date	Location	Length	Width	Depth	Note
7/18/2000	Immokalee	4 ft	4 ft	12 ft	No structures threatened. Sink hole appears to be stable.
2/23/2003	Collier County	5 ft	6 ft	4 ft	Sink hole developed in roadway after a sprinkler system malfunction.
3/22/2017	Collier County	4 ft	4 ft	1 ft	Sink hole is in swale maintained by the County.
9/3/2018	Collier County	1 ft	1 ft	0 ft	N/A

Source: Florida Geological Survey

Figure 2.35 – Sink Hole Locations in Collier County



Source: Florida Geological Survey

Extent

Sinkholes are relatively unpredictable, causing greater impacts when they do occur. They can range dramatically in size, from a few feet wide to hundreds of acres wide and from less than 1 foot to more than 100 feet deep. Sinkholes can also vary in shape. Some are shaped like shallow bowls or saucers while others have vertical walls. In Florida, sinkholes sometimes hold water and form natural ponds. There is no formal scale for measuring the extent of sinkholes.

Sinkholes can have dramatic effects if they occur in urban settings, particularly when infrastructure, such as roads, or buildings are on top of the cavity, causing catastrophic damage. The can also contaminate water resources and have been known to swallow up vehicles, swimming pools, parts of roadways, and even buildings.

In some cases, sinkholes in Florida have measured up to 35 feet in depth with similar widths.

Impact: 2 – Limited

Spatial Extent: 1 – Negligible

Past Occurrences

Collier County has experienced sinkhole activity in the past; however, these events are uncommon occurrences and very few have caused any reported property damages. In May 2000, there was an increase in sinkhole development which was believed to be caused by lowered groundwater as a result of the 1998 drought. The most recent reported sinkhole occurred in September 2018 but was small and no information was given on the situation. Local news reports from 2018 claim that there was a large sinkhole in July 2018 that formed from a pipe burst and caused a roadway, U.S. 41 in East Naples, to collapse.

Many underground pipes may be vulnerable to cracks and leaks due to age, which could cause erosion, subsidence, or sinkholes.

Probability of Future Occurrence

Sinkholes remain a possible occurrence in localized areas of Collier County and are caused by both human activity and as naturally occurring events. Impacts from such events would likely cause minimal localized damage, though potentially significant service interruptions caused by infrastructure damage and road closures.

Probability: 1 – Unlikely

Climate Change

Direct effects from global warming and climate change such as an increase in droughts, floods and hurricanes could contribute to an increase in sinkholes. Climate change raises the likelihood of extreme weather, meaning the torrential rain and flooding conditions which often lead to the exposure of sinkholes are likely to become increasingly common. Certain events such as a hurricane following a period of drought can trigger a sinkhole due to low levels of groundwater combined with a heavy influx of rain. As discussed in Sections 2.5.6 Drought, 2.5.1 Flood, and 2.5.2 Tropical Cyclones, potential increases in these contributing events are possible. Therefore, an increase in the occurrence of sinkholes in the future is possible.

Vulnerability Assessment

People

A person's vulnerability is directly related to the speed in which the sinkhole opens and the person being above the sinkhole. Records exist for deaths associated with sinkholes opening beneath homes while occupants were present or from motor vehicle deaths when drivers could not avoid driving into the sinkhole before protective barriers were in place.

Property

Like people, property vulnerability to a sinkhole is dependent on a variety of factors including the speed at which the sinkhole develops. Property above a large sinkhole that collapses can suffer catastrophic damages ranging from cracked foundations to damaged roadways and totaled vehicles.

Data was not available to estimate potential property or critical facility losses from sink holes.

Environment

Sinkholes are generally naturally occurring events; thus, a sinkhole is unlikely to cause substantial impacts to the natural environment. Natural areas that are damaged will recover quickly.

Consequence Analysis

Table 2.58 summarizes the potential negative consequences of sinkhole.

Table 2.58 – Consequence Analysis – Sinkhole

Category	Consequences
Public	Impacts are expected to be minimal to the larger population. Impacts for those effected could cause anxiety or depression about economic and property losses and personal injury.
Responders	First responders will be impacted similarly to other events that have no advance warning.
Continuity of Operations (including Continued Delivery of Services)	Continuity of operations is generally not disrupted by sinkholes.
Property, Facilities and Infrastructure	Although sinkhole extents are localized, buildings located on or adjacent to a sinkhole are susceptible to foundation damage or building collapse. If the building is located close enough to the sinkhole it can be destroyed or in worst cases, completely collapse into the sinkhole. Remediation costs can be high due to costly foundation shoring or cost of stabilization of the sinkhole itself.
Environment	Sinkholes are natural occurring process and local plants and animals adjust quickly. Many naturally occurring sinkholes fill with rainwater creating new aquatic habitat.
Economic Condition of the Jurisdiction	Sinkholes located in open areas or that impact only small numbers of buildings, while having a high impact to the local property owner, do not have substantial impacts to the economy. Sinkholes that open in major traffic thoroughfares can include significant impact to daily work traffic and flow of goods.
Public Confidence in the Jurisdiction's Governance	Sinkholes are relatively unpredictable, however if a sinkhole occurs after a recent inspection and causes harm to people or property, the public may lose confidence in the jurisdiction's ability to manage a future sinkhole event.

Hazard Summary by Jurisdiction

The following table summarizes sinkhole hazard risk by jurisdiction. Sinkhole hazard risk does not vary substantially by jurisdiction.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	1	2	1	4	4	1.9	L
Immokalee Reservation	1	2	1	4	4	1.9	L
Marco Island	1	2	1	4	4	1.9	L
Naples	1	2	1	4	4	1.9	L
Unincorporated Collier County	1	2	1	4	4	1.9	L

2.5.10 Winter Storms and Freeze

Hazard Description

A winter storm can range from a moderate snow over a period of a few hours to blizzard conditions with blinding wind-driven snow that lasts for several days. Events may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Some winter storms might be large enough to affect several states, while others might affect only localized areas. Occasionally, heavy snow might also cause significant property damages, such as roof collapses on older buildings.

All winter storm events have the potential to present dangerous conditions to the affected area. Larger snowfalls pose a greater risk, reducing visibility due to blowing snow and making driving conditions treacherous. A heavy snow event is defined by the National Weather Service as an accumulation of 4 of more inches in 12 hours or less. A blizzard is the most severe form of winter storm. It combines low temperatures, heavy snow, and winds of 35 miles per hour or more, which reduces visibility to a quarter mile or less for at least 3 hours. Winter storms are often accompanied by sleet, freezing rain, or an ice storm. Such freeze events are particularly hazardous as they create treacherous surfaces.

Ice storms are defined as storms with significant amounts of freezing rain and are a result of cold air damming (CAD). CAD is a shallow, surface-based layer of relatively cold, stably-stratified air entrenched against the eastern slopes of the Appalachian Mountains. With warmer air above, falling precipitation in the form of snow melts, then becomes either super-cooled (liquid below the melting point of water) or re-freezes. In the former case, super-cooled droplets can freeze on impact (freezing rain), while in the latter case, the re-frozen water particles are ice pellets (or sleet). Sleet is defined as partially frozen raindrops or refrozen snowflakes that form into small ice pellets before reaching the ground. They typically bounce when they hit the ground and do not stick to the surface. However, it does accumulate like snow, posing similar problems and has the potential to accumulate into a layer of ice on surfaces. Freezing rain, conversely, usually sticks to the ground, creating a sheet of ice on the roadways and other surfaces. All the winter storm elements – snow, low temperatures, sleet, ice, etcetera – have the potential to cause significant hazard to a community. Even small accumulations can down power lines and trees limbs and create hazardous driving conditions and disrupt communication and power for days.

Advancements in meteorology and forecasting usually allow for mostly accurate forecasting a few days in advance of an impending storm. Most storms have a duration of a few hours; however, impacts can last a few days after the initial incident until cleanup is completed.

Warning Time: 1 – More than 24 hours

Duration: 3 – Less than 1 week

Location

Severe winter storms are usually a countywide or regional hazard, impacting the entire county at the same time. The risk of a severe winter storm occurring is uniform across Collier County.

Extent

NOAA uses the Regional Snowfall Index (RSI) to assess the societal impact of winter storms in the six easternmost regions in the United States. The index makes use of population and regional differences to assess the impact of snowfall. It is shown in Table 2.59. For example, areas which receive very little snowfall on average may be more adversely affected than other regions, resulting in a higher severity. For central and southern Florida, a Winter Storm Warning is issued when any snow or sleet amount to more than a half inch. However, amounts as small as 0.1 inch can significantly impact transportation and agriculture among other things. According to official National Weather Service records, there has never been any snowfall or accumulation of snow in Collier County, Florida.

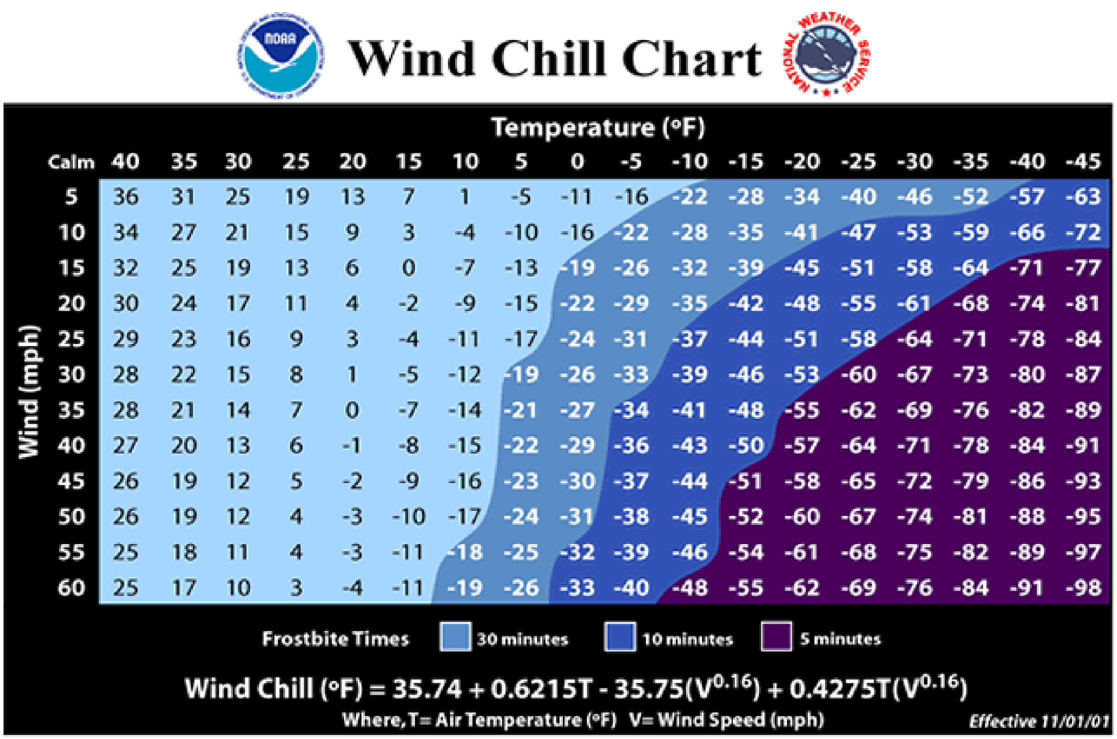
Table 2.59 – Regional Snowfall Index (RSI) Values

Category	RSI Value	Description
1	1-3	Notable
2	3-6	Significant
3	6-10	Major
4	10-18	Crippling
5	18+	Extreme

Source: NOAA

Severe winter storms often involve a mix of hazardous weather conditions. The magnitude of an event can be defined based on the severity of each of the involved factors, including precipitation type, precipitation accumulation amounts, temperature, and wind. The NWS Wind Chill Temperature Index, shown in Figure 2.36, provides a formula for calculating the dangers of winter winds and freezing temperatures.

Figure 2.36 – NWS Wind Chill Temperature Index


Wind Chill Chart

Temperature (°F)

Wind (mph) / Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

Wind Chill (°F) = $35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: http://www.nws.noaa.gov/om/winter/windchill.shtml

Impact: 2 – Limited

Spatial Extent: 4 – Large

The entirety of Florida is susceptible to winter storm and freeze events. Some ice and winter storms may be large enough to affect several states, while others might affect limited, localized areas. The degree of exposure typically depends on the normal expected severity of local winter weather. Collier County is not accustomed to severe winter weather conditions and often receives little to no winter weather during the winter months. Given the atmospheric nature of the hazard, the entire County has uniform exposure to a winter storm.

Historical Occurrences

To get a full picture of the range of impacts of a severe winter storm, data for the following weather types as defined by the National Weather Service (NWS) and tracked by NCEI were collected:

- **Blizzard** – A winter storm which produces the following conditions for 3 consecutive hours or longer: (1) sustained winds or frequent gusts 30 knots (35 mph) or greater, and (2) falling and/or blowing snow reducing visibility frequently to less than 1/4 mile.
- **Cold/Wind Chill** – Period of low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined advisory conditions of 0°F to -14°F with wind speeds 10 mph (9 kt) or greater.
- **Extreme Cold/Wind Chill** – A period of extremely low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined warning criteria, defined as wind chill -15°F or lower with wind speeds 10 mph (9 kt) or greater.
- **Frost/Freeze** – A surface air temperature of 32°F or lower, or the formation of ice crystals on the ground or other surfaces, for a period long enough to cause human or economic impact, during the locally defined growing season.
- **Heavy Snow** – Snow accumulation meeting or exceeding 12 and/or 24-hour warning criteria of 3 and 4 inches, respectively.
- **Ice Storm** – Ice accretion meeting or exceeding locally/regionally defined warning criteria of ¼ inch or greater resulting in significant, widespread power outages, tree damage and dangerous travel. Issued only in those rare instances where just heavy freezing rain is expected and there will be no "mixed bag" precipitation meaning no snow, sleet or rain.
- **Sleet** – Sleet accumulations meeting or exceeding locally/regionally defined warning criteria of ½ inch or more.
- **Winter Storm** – A winter weather event that has more than one significant hazard and meets or exceeds locally/regionally defined 12 and/or 24-hour warning criteria for at least one of the precipitation elements. Defined by NWS Raleigh Forecast Office as snow accumulations 3 inches or greater in 12 hours (4 inches or more in 24 hours); Freezing rain accumulations ¼ inch (6 mm) or greater; Sleet accumulations ½ inch (13 mm) or more. Issued when there is at least a 60% forecast confidence of any one of the three criteria being met.
- **Winter Weather** – A winter precipitation event that causes a death, injury, or a significant impact to commerce or transportation, but does not meet locally/regionally defined warning criteria.

Table 2.60 summarizees the recorded severe winter storm events that have impacted Collier County according to the NCEI Storm Events Database for the 20-year period from 2000 through 2019. As reported in NCEI, severe winter weather did not cause any fatalities, injuries, or property damage, but did cause some crop damage. Some of these types of impacts may not have been reported and are possible in future events. Impacts in Collier County by incident are recorded in Table 2.61.

Table 2.60 – Total Severe Winter Storm Impacts in Collier County, 2000-2019

Event Type	Number of Recorded Incidents	Total Fatalities	Total Injuries	Total Property Damage	Total Crop Damage
Extreme Cold/ Wind Chill	7	0	0	$0	$34,030,000
Frost/Freeze	22	0	0	$0	$301,030,000
Total	**29**	**0**	**0**	**$0**	**$335,060,000**

Source: NCEI

Table 2.61 – Recorded Severe Winter Storm Impacts in Collier County, 2000-2019

Location	Date	Event Type	Fatalities/ Injuries	Property Damage	Crop Damage
Inland Collier (Zone)	12/21/2000	Extreme Cold/Wind Chill	0/0	$0	$0
Inland Collier (Zone)	12/31/2000	Extreme Cold/Wind Chill	0/0	$0	$0
Inland Collier (Zone)	1/1/2001	Extreme Cold/Wind Chill	0/0	$0	$30,000
Inland Collier (Zone)	1/5/2001	Extreme Cold/Wind Chill	0/0	$0	$34,000,000
Inland Collier (Zone)	1/10/2001	Extreme Cold/Wind Chill	0/0	$0	$0
Inland Collier (Zone)	12/27/2001	Extreme Cold/Wind Chill	0/0	$0	$0
Inland Collier (Zone)	1/9/2002	Extreme Cold/Wind Chill	0/0	$0	$0
Inland Collier (Zone)	1/19/2003	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	1/24/2003	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	12/21/2003	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	1/24/2005	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	2/12/2005	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	1/8/2006	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	2/14/2006	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	2/17/2007	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	2/19/2007	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	1/3/2008	Frost/Freeze	0/0	$0	$20,000
Inland Collier (Zone)	1/22/2009	Frost/Freeze	0/0	$0	$50,000
Inland Collier (Zone)	2/5/2009	Frost/Freeze	0/0	$0	$0
Coastal Collier (Zone)	2/5/2009	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	1/6/2010	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	1/10/2010	Frost/Freeze	0/0	$0	$300,000,000
Coastal Collier (Zone)	1/10/2010	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	12/7/2010	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	12/14/2010	Frost/Freeze	0/0	$0	$0
Coastal Collier (Zone)	12/15/2010	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	12/28/2010	Frost/Freeze	0/0	$0	$960,000
Coastal Collier (Zone)	12/28/2010	Frost/Freeze	0/0	$0	$0
Inland Collier (Zone)	1/3/2012	Frost/Freeze	0/0	$0	$0
		Total	**0/0**	**$0**	**$335,060,000**

Source: NCEI

According to NOAA, 2 people died from exposure to the cold in 2009 and 2 more in 2010 within the State of Florida. This does not include additional deaths related to carbon monoxide poisoning from using improper heating sources. A freeze in January 2010 led to agricultural losses of over $200 million. The USDA declared 59 out of 67 counties in a state of natural disaster for agricultural production during this freeze. Storm impacts from NCEI are summarized below:

January 5, 2001 – A freeze occurred throughout the interior sections of south Florida, causing damage to certain crops. Hardest hit were certain vegetable crops with 75% losses in Hendry and east Collier counties and 30% losses in the farming areas of south Miami-Dade County. Other crops that were damaged included newly planted sugar cane, ornamentals, and tropical fruits. A heavy frost occurred in the western suburbs of Miami-Dade, Broward and Palm Beach metropolitan areas. Several daily minimum temperature records were broken. Selected minimum temperatures included 27 degrees at Belle Glade, 29 degrees in the Homestead agricultural area, 31 degrees in Naples, 39 degrees at Miami International Airport and 43 degrees in Miami Beach.

January 22, 2009 – An arctic cold front moved through South Florida on January 20th. High pressure of arctic origin settled over the region behind the cold front, bringing freezing temperatures to much of South Florida on the mornings of January 21 and 22. Temperatures dropped to below freezing over most of interior South Florida on the morning of January 22. Temperatures bottomed out as low as the mid-20s over portions of Glades, Hendry and Collier counties where a hard freeze was noted, with a low of 22 recorded at Palmdale in Glades County. Readings in the upper 20s to around 30 were observed over inland sections of Palm Beach county, with near freezing temperatures of 30-32 degrees over inland sections of Broward and Miami-Dade counties. In addition to the freezing temperatures, widespread heavy frost formed over most of interior and northern sections of South Florida. Crop damage was extensive in some areas, with total losses to bean and corn crops in parts of western Palm Beach county. Losses to tomato and strawberry crops were also noted in Hendry and Collier counties.

December 28, 2010 – Temperatures across inland sections of Collier County fell into the upper 20s to low 30s with the coldest temperatures reported across far north and east sections on the morning of the 28th. The coldest temperatures during this period were: The Florida Panther NWR 26, Golden Gate Estates 27, and Immokalee hit 29. Extensive damage to crops was reported. Frost was also reported. What cold sensitive crops were left in the area from the previous two events faced more severe damage with some crops being frozen out in the Immokalee area. Crop damage amount estimate of $0.96 million is for all of Collier County and represents the combined total of all three December freeze events.

Collier County has never received an emergency declaration for incidents related to severe winter storms. As a state, Florida has also never received any disaster declarations related to severe winter storms.

Probability of Future Occurrence

NCEI records 29 severe winter storm related events during the 20-year period from 2000 through 2019, which is an average of 1.45 events per year or about a 145 percent probability in any given year.

It is concluded that a freeze may be expected in Florida every one to two years. Severe freezes in which the most crops are lost can be expected about once every five years. Southern Florida is likely to have between 2 and 4 days of winter weather annually.

Probability: 3 – Likely

Climate Change

Climate change is not expected to increase the frequency or magnitude of winter storms and freezes in Florida. However, climate change does not mean that winter storms would not continue to occur in the State. Climate change could cause more variability in daily temperature and thus create a prolonged winter storm or freeze.

Vulnerability Assessment

People

Winter storms are considered deceptive killers because most deaths are indirectly related to the storm event. The leading cause of death during winter storms is from automobile or other transportation accidents due to poor visibility and/or slippery roads. Additionally, exhaustion and heart attacks caused by overexertion may result from winter storms.

Power outages during very cold winter storm conditions can also create potentially dangerous situations. Elderly people account for the largest percentage of hypothermia victims. In addition, if the power is out for an extended period, residents are forced to find alternative means to heat their homes. The danger arises from carbon monoxide released from improperly ventilated heating sources such as space or kerosene heaters, furnaces, and blocked chimneys. House fires also occur more frequently in the winter due to lack of proper safety precautions when using an alternative heating source.

Property

No property damage was reported in association with any winter weather events recorded by the NCEI between 2000 and 2019 for Collier County. Therefore, no annualized loss estimate could be calculated for this hazard. However, $335,060,000 in crop damage was reported over the 20-year period, which equates to an average annual loss estimate of $16,753,000.

Environment

Winter storm events may include ice or snow accumulation on trees which can cause large limbs, or even whole trees, to snap and potentially fall on buildings, cars, or power lines. This potential for winter debris creates a dangerous environment to be outside in; significant injury or fatality may occur if a large limb snaps while a local resident is out driving or walking underneath it.

Consequence Analysis

Table 2.62 summarizes the potential negative consequences of severe winter storm.

Table 2.62 – Consequence Analysis – Severe Winter Storm

Category	Consequences
Public	Localized impact expected to be severe for affected areas and moderate to light for other less affected areas.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations (including Continued Delivery of Services)	Localized disruption of roads and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities and Infrastructure	Localized impact to facilities and infrastructure in the areas of the incident. Power lines and roads most adversely affected.
Environment	Environmental damage to trees, bushes, crops, etc.
Economic Condition of the Jurisdiction	Local economy and finances may be adversely affected, depending on damage.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes severe winter storm hazard risk by jurisdiction. Severe winter storm risk does not vary substantially by jurisdiction because these events are typically regional in nature.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	3	2	4	1	3	2.7	H
Immokalee Reservation	3	2	4	1	3	2.7	H
Marco Island	3	2	4	1	3	2.7	H
Naples	3	2	4	1	3	2.7	H
Unincorporated Collier County	3	2	4	1	3	2.7	H

2.5.11 Earthquake

Hazard Description

An earthquake is a movement or shaking of the ground. Most earthquakes are caused by the release of stresses accumulated as a result of the rupture of rocks along opposing fault planes in the Earth's outer crust. These fault planes are typically found along borders of the Earth's 10 tectonic plates. The areas of greatest tectonic instability occur at the perimeters of the slowly moving plates, as these locations are subjected to the greatest strains from plates traveling in opposite directions and at different speeds. Deformation along plate boundaries causes strain in the rock and the consequent buildup of stored energy. When the built-up stress exceeds the rocks' strength a rupture occurs. The rock on both sides of the fracture is snapped, releasing the stored energy and producing seismic waves, generating an earthquake.

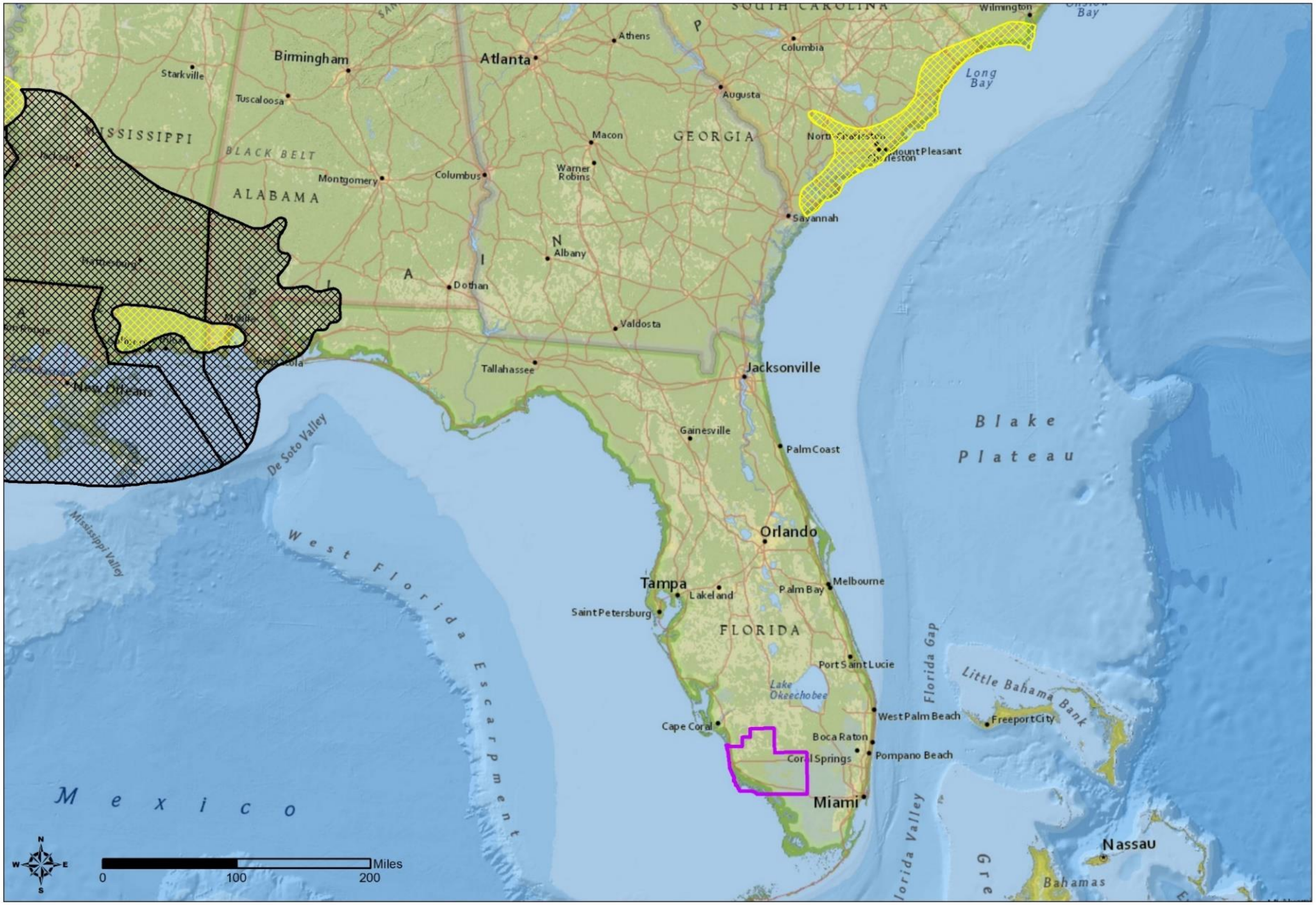
Warning Time: 4 – Less than 6 hours

Duration: 1 – Less than 6 hours

Location

The United State Geological Survey's Quaternary faults database was consulted to define the location of potential earthquakes within range of Collier County. Quaternary faults are active faults recognized at the surface which have evidence of movement in the past 2.58 million years. The Gulf-Margin normal faults, the Charleston liquefaction feature, and the Wiggins uplift are the closest to Collier County and they are 450 miles, 415 miles, and 485 miles away respectively. These three fault areas could potentially produce an earthquake affecting Collier County. Figure 2.37 reflects the location of these three faults in relation to Collier County based on data from the USGS Earthquake Hazards Program. Additionally, there is a fault about the same distance south of Florida on the Caribbean Plate.

Figure 2.37 – US Quaternary Faults



Source: USGS U.S. Quaternary Faults

All of Florida is subject to earthquakes, with the northwestern region most vulnerable to a damaging earthquake. The state is affected by the Charleston liquefaction feature in South Carolina, the Gulf-Margin normal faults stretching from the edge of Florida through Louisiana, and the Wiggins uplift in Alabama and Mississippi. The Charleston Liquefaction feature has generated an earthquake greater than 8.0 on the Richter Scale in the last 200 years.

Extent

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude. A detailed description of the Richter Scale is given in Table 2.63. Although the Richter scale is usually used by the news media when reporting the intensity of earthquakes and is the scale most familiar to the public, the scale currently used by the scientific community in the United States is called the Modified Mercalli Intensity (MMI) scale. The MMI scale is an arbitrary ranking based on observed effects. Table 2.64 shows descriptions for levels of earthquake intensity on the MMI scale compared to the Richter scale. Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

Table 2.63 – Richter Scale

Magnitude	Effects
Less than 3.5	Generally, not felt, but recorded.
3.5 – 5.4	Often felt, but rarely causes damage.
5.4 – 6.0	At most slight damage to well-designed buildings. Can cause major damage to poorly constructed buildings over small regions.
6.1 – 6.9	Can be destructive in areas up to 100 kilometers across where people live.
7.0 – 7.9	Major earthquake. Can cause serious damage over larger areas.
8.0 or greater	Great earthquake. Can cause serious damage in areas several hundred kilometers across.

Source: FEMA

Table 2.64 – Comparison of Richter Scale and Modified Mercalli Intensity (MMI) Scale

MMI	Richter Scale	Felt Intensity
I	0 – 1.9	Not felt. Marginal and long period effects of large earthquakes.
II	2.0 – 2.9	Felt by persons at rest, on upper floors, or favorably placed.
III	3.0 – 3.9	Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.
IV	4.0 – 4.3	Hanging objects swing. Vibration like passing of heavy trucks. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink the upper range of IV, wooden walls and frame creak.
V	4.4 – 4.8	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Pendulum clocks stop, start.
VI	4.9 – 5.4	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Books, etc., fall off shelves. Pictures fall off walls. Furniture moved. Weak plaster and masonry D cracked. Small bells ring. Trees, bushes shaken.
VII	5.5 – 6.1	Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices. Some cracks in masonry C. Waves on ponds. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.
VIII	6.2 – 6.5	Steering of motor cars is affected. Damage to masonry C; partial collapse. Some damage to masonry B. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory

MMI	Richter Scale	Felt Intensity
		stacks, monuments, towers, elevated tanks. Frame houses moved on foundations. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX	6.6 – 6.9	General panic. Masonry D destroyed; masonry C heavily damaged, sometimes with complete collapse; masonry B seriously damaged. (General damage to foundations.) Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas sand and mud ejected, earthquake fountains, sand craters.
X	7.0 – 7.3	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	7.4 – 8.1	Rails bent greatly. Underground pipelines completely out of service.
XII	> 8.1	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown in the air.

Masonry A: Good workmanship, mortar, and design; reinforced, especially laterally, and bound together by using steel, concrete, etc.; designed to resist lateral forces. Masonry B: Good workmanship and mortar; reinforced, but not designed in detail to resist lateral forces. Masonry C: Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners, but neither reinforced nor designed against horizontal forces. Masonry D: Weak materials, such as adobe; poor mortar; low standards of workmanship; weak horizontally.
Source: Oklahoma State Hazard Mitigation Plan.

The most severe earthquake to impact Florida measured a VIII on the Modified Mercalli Intensity Scale.

Impact: 2 – Limited

Spatial Extent: 3 – Moderate

Historical Occurrences

The USGS Earthquake Hazards Program maintains a database of historical earthquakes of a magnitude 2.5 and greater from 1973 to 2019. Collier County has no history of earthquakes or damage from earthquakes. No earthquakes have had epicenters in Florida and there are no documented faults in the State.

The National Geophysical Data Center maintains a database of all earthquakes from 1638 to 1985 including the maximum intensity for each locality that felt the earthquake. Since 1985, no major earthquake events have impacted the planning area. The largest earthquake to be felt in Florida was the Charleston earthquake of 1886, which registered an MMI of VIII in Savannah. Table 2.65 shows historic seismic events felt in Florida. No earthquake epicenters have occurred in Collier County.

Table 2.65 – Historical Seismic Events Felt in Florida, 1886-2016

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.

Date	Description
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.
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.

Source: USGS

Probability of Future Occurrence

Ground motion is the movement of the earth's surface due to earthquakes or explosions. It is produced by waves generated by a sudden slip on a fault or sudden pressure at the explosive source and travels through the earth and along its surface. Ground motion is amplified when surface waves of unconsolidated materials bounce off or are refracted by adjacent solid bedrock. The probability of ground motion is depicted in USGS earthquake hazard maps by showing, by contour values, the earthquake ground motions (of a frequency) that have a common given probability of being exceeded in 50 years.

Figure 2.38 reflects the seismic hazard for Collier County based on the national USGS map of peak acceleration with two percent probability of exceedance in 50 years. To produce these estimates, the ground motions being considered at a given location are those from all future possible earthquake magnitudes at all possible distances from that location. The ground motion coming from a particular magnitude and distance is assigned an annual probability equal to the annual probability of occurrence of the causative magnitude and distance. The method assumes a reasonable future catalog of earthquakes, based upon historical earthquake locations and geological information on the recurrence rate of fault ruptures. When all the possible earthquakes and magnitudes have been considered, a ground motion value is determined such that the annual rate of its being exceeded has a certain value.

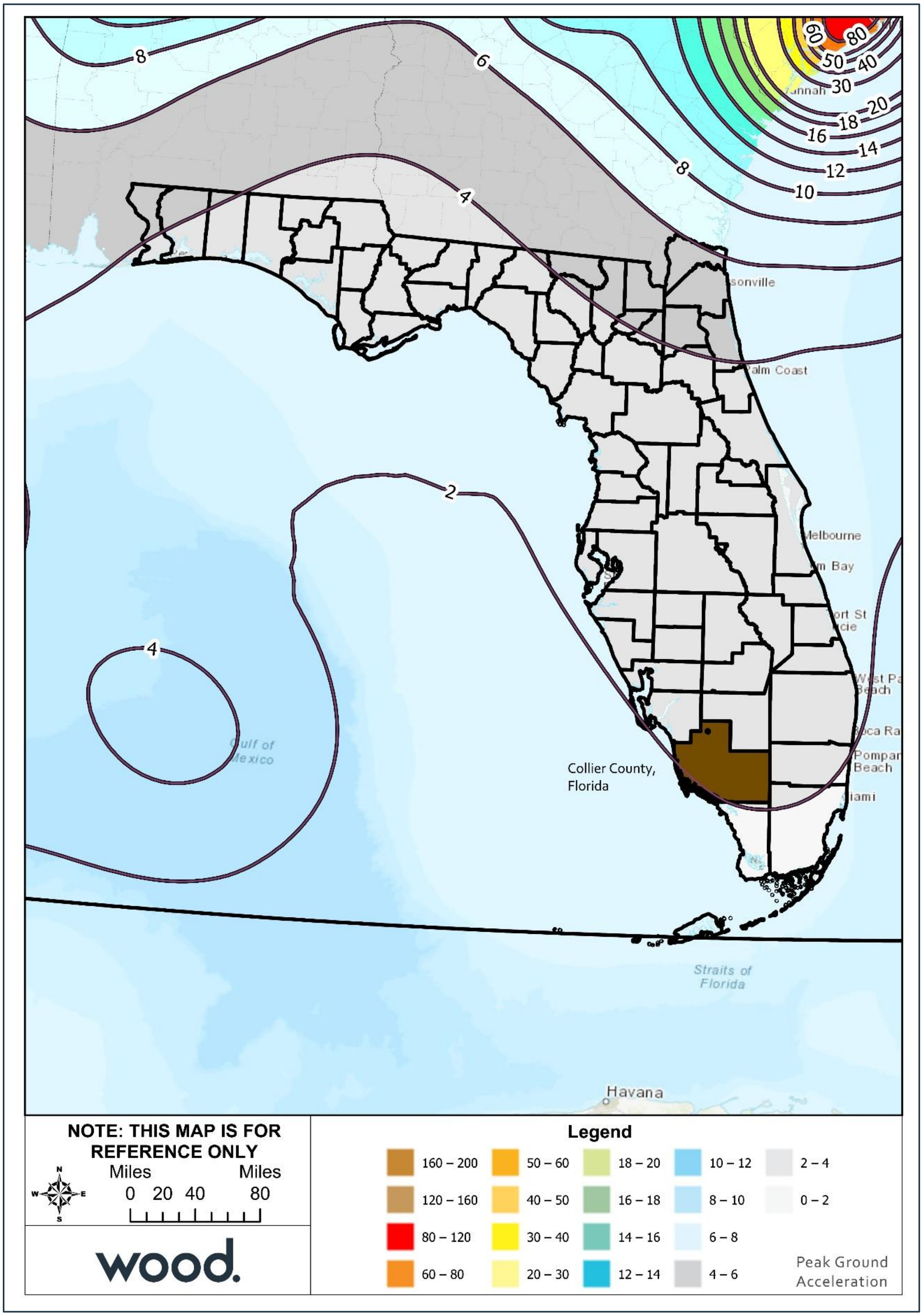
Therefore, for the given probability of exceedance, two percent, the locations shaken more frequently will have larger ground motions. All of Collier County is located within zones with peak acceleration of 0-2% g.

There have been no past occurrences of earthquakes in Collier County. Using past occurrence as an indicator of future probability, there is a low chance of an earthquake causing some building damage.

Based on this data, it can be reasonably assumed that an earthquake event affecting Collier County is possible but unlikely.

Probability: 1 – Unlikely

Figure 2.38 – Seismic Hazard Information for Collier County



Source: USGS Earthquake Hazards Program

Climate Change

Scientists are beginning to believe there may be a connection between climate change and earthquakes. Changing ice caps and sea-level redistribute weight over fault lines, which could potentially have an influence on earthquake occurrences. However, currently no studies quantify the relationship to a high level of detail, so recent earthquakes should not be linked with climate change. While not conclusive, early research suggest that more intense earthquakes and tsunamis may eventually be added to the adverse consequences that are caused by climate change.

Vulnerability Assessment

People

Earthquake events in Collier County are unlikely to produce more than moderate ground shaking; therefore, injury or death is unlikely. Objects falling from shelves generally pose the greatest threat to safety.

A 2,500-year event was estimated using Hazus because a 2,500-year event is the "maximum considered earthquake" and is used for building codes. It has a 2-percent probability of being exceeded in 50 years.

Hazus estimates that the 2,500-year earthquake would result in complete damage of 115,442 residential structures. With these estimates, potential population at risk was calculated using the American Community Survey 2018 5-Year Estimates for household factor, the average number of individuals per occupied household. The household factor for Collier County is 2.68, therefore there are an estimated 309,385 individuals are at severe risk to the 2,500-year earthquake event.

Property

In a severe earthquake event, buildings can be damaged by the shaking itself or by the ground beneath them settling to a different level than it was before the earthquake (subsidence). Buildings can even sink into the ground if soil liquefaction occurs. If a structure (a building, road, etc.) is built across a fault, the ground displacement during an earthquake could seriously damage that structure.

Earthquakes can also cause damages to infrastructure, resulting in secondary hazards. Damages to dams or levees could cause failures and subsequent flooding. Fires can be started by broken gas lines and power lines. Fires can be a serious problem, especially if the water lines that feed the fire hydrants have been damaged as well. Impacts of earthquakes also include debris clean-up and service disruption.

Collier County has not been impacted by an earthquake, so major damage to the built environment is unlikely. However, if an earthquake were to occur, there is potential for impacts to certain masonry buildings, as well as environmental damages with secondary impacts on structures.

Table 2.66 details the estimated buildings impacted by 2,500-year earthquake event based on a Hazus level 1 analysis. Note that building value estimates are inherent to Hazus and do not necessarily reflect damages to the asset inventory provided by the County's parcel and building data.

Table 2.66 – Estimated Buildings Impacted by 2,500-Year Earthquake Event

Occupancy Type	Estimated Building Damage	Estimated Content Loss	Estimated Total Damage
Residential	$35,361,570,000	$6,630,180,000	$41,991,750,000
Commercial	$5,628,150,000	$2,225,650,000	$7,853,800,000
Industrial	$951,070,000	$442,910,000	$1,393,980,000
Other	$963,070,000	$378,580,000	$1,341,650,000
Total	**$42,903,860,000**	**$9,677,320,000**	**$52,581,180,000**

Source: Hazus

Environment

An earthquake is unlikely to cause substantial impacts to the natural environment in Collier County. Impacts to the built environment (e.g. ruptured gas line) could damage the surrounding environment. However, this type damage is unlikely based on historical occurrences.

Consequence Analysis

Table 2.67 summarizes the potential negative consequences of earthquake.

Table 2.67 – Consequence Analysis - Earthquake

Category	Consequences
Public	Impact expected to be severe for people who are unprotected or unable to take shelter; moderate to light impacts are expected for those who are protected.
Responders	Responders may be required to enter unstable structures or compromised infrastructure. Adverse impacts are expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations (including Continued Delivery of Services)	Damage to facilities/personnel in the area of the incident may require relocation of operations and lines of succession execution. Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
Property, Facilities and Infrastructure	Damage to facilities and infrastructure in the area of the incident may be extensive for facilities, people, infrastructure, and HazMat.
Environment	May cause extensive damage, creating denial or delays in the use of some areas. Remediation may be needed.
Economic Condition of the Jurisdiction	Local economy and finances expected to be adversely affected, possibly for an extended period.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery are not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes earthquake hazard risk by jurisdiction. Despite minor differences in peak acceleration probabilities, earthquake risk is uniform across the planning area.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	1	2	3	4	1	2.0	M
Immokalee Reservation	1	2	3	4	1	2.0	M
Marco Island	1	2	3	4	1	2.0	M
Naples	1	2	3	4	1	2.0	M
Unincorporated Collier County	1	2	3	4	1	2.0	M

2.5.12 Tsunami

Hazard Description

A tsunami is a series of large ocean waves formed as a result of an underwater disturbance such as an earthquake, landslide, volcanic eruption, or meteorite. Earthquakes are the most common cause of tsunamis. Tsunami waves radiate in all directions from the site of the disturbance, traveling as fast as 450 mph and slowing as they reach shallow waters. As the waves slow, they draw together and grow in height. The resulting phenomenon appears as a constant wall of water and can resemble hurricane storm surge when it reaches the shore.

There can be as many as 60 miles between peaks of each wave series and be as far as one hour apart. 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. 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. Tsunami Warning Centers monitor which earthquakes are likely to generate tsunamis and can issue warning messages when a tsunami is possible. The National Tsunami Warning Center in Palmer, Alaska, serves the continental United States, Alaska, Puerto Rico, and Virgin Islands and Canada.

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 crest typically arrives seconds to minutes later.

Tsunamis are often referred to as tidal waves; however, oceanographers discourage this misnomer because tsunamis are not impacted by tides.

Warning Time: 3 – 6 to 12 hours

Duration: 3 – Less than 1 week

Location

Tsunamis can strike any coastal area but are most commonly associated with the Pacific Coast where there is a higher probability of them occurring due to the number of subduction zones and high probability of earthquakes. Tsunamis on the east coast are more likely to occur as a result of landslides or slumping associated with local earthquakes, though these events are rare. The most at-risk areas are those less than 25 feet above sea level and within 1 mile of the coastline. Per the 2018 Florida State Hazard Mitigation Plan, 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.

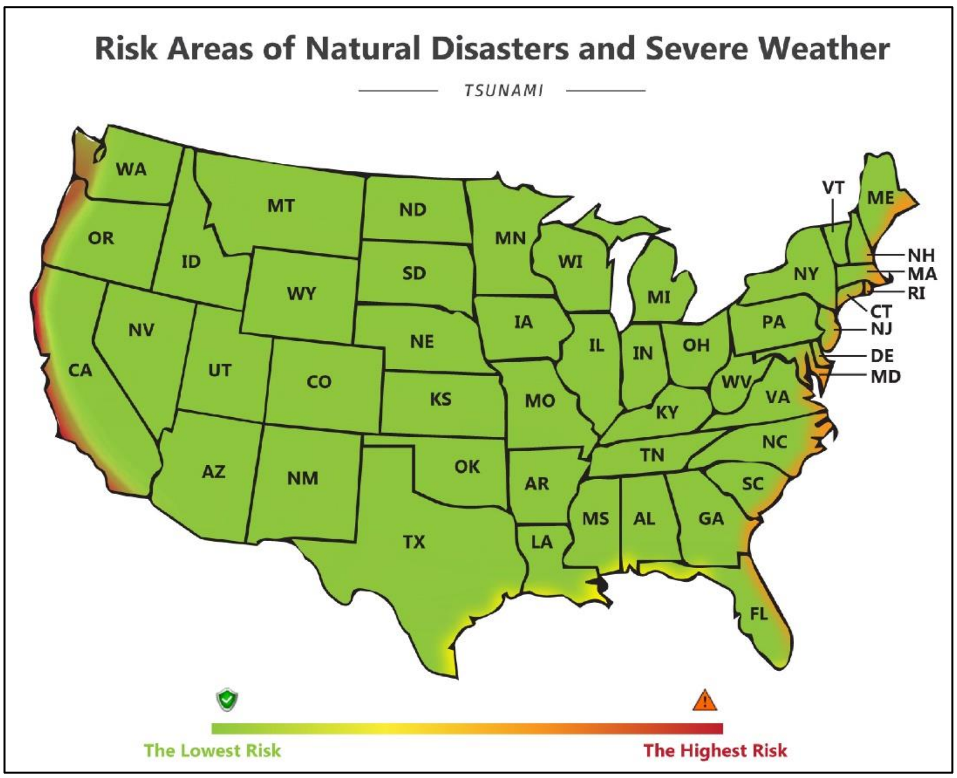
Earthquakes are frequently the cause for tsunami events, and because the location and timing of future earthquake events are unpredictable, the 2018 Florida State Hazard Mitigation Plan concludes that all geographic areas of Florida that border the Atlantic Ocean or Gulf of Mexico are at risk. Additionally, sediment deposits in the Gulf of Mexico may lead to underwater landslide activity.

A Report to the National Tsunami Hazard Mitigation Program titled "Regional Assessment of Tsunami Potential in the Gulf of Mexico" by Brink, et al. concludes that "there are no significant earthquake sources within the Gulf of Mexico that are likely to generate tsunamis…" and "Tsunami propagation from significant earthquake sources outside the Gulf of Mexico… shows that wave amplitude is greatly attenuated by the narrow and shallow passages into the gulf, and as a result, these tsunami sources do not constitute a tsunami hazard to the Gulf of Mexico coast" (2009). However, the report does confirm that submarine landslides pose a tsunami hazard to the Gulf of Mexico coast.

Per the County's previous LMS, the actual tsunami hazard in Collier County, potentially caused by an earthquake or a seafloor landslide on the northern side of the Caribbean plate, is likely low. An earthquake of record-breaking magnitude in the northwest Caribbean could potentially cause a rise of 1-2 feet in the Gulf, as reported by Robert Molleda of the Miami Weather Office. Still, seismic events are unpredictable and there is some possibility for a tsunami in Collier County. Particularly, low lying areas of Naples, Marco Island, Everglades City, and unincorporated coastal areas of Collier County might also be at risk due to the flat low-lying areas. The low slope to the Continental shelf makes Naples, Marco Island, Everglades City and unincorporated areas of coastal Collier County more susceptible to a potential Tsunami event.

Figure 2.39 shows the at-risk areas for tsunamis in the United States.

Figure 2.39 – Tsunami Risk Areas in the United States



Source: Envista Forensics, National Weather Service

Extent

The Regional Assessment of Tsunami Potential in the Gulf of Mexico report by Brink, et al. indicates that submarine landslides have occurred in the Gulf of Mexico that were of sufficient volume to cause destructive tsunamis. Sediment supply from the Mississippi River may cause further landslide activity; however, future landslides on the northern Gulf continental slope would not be large enough to pose a tsunami hazard (Brink, et al., 2009). Although future probability is uncertain, this research concludes that Gulf of Mexico landslide sources could realistically produce potential maximum tsunami runup of 4 meters above mean sea level. Thus, if a submarine landslide in the Gulf of Mexico were to produce a tsunami, the impacts could be catastrophic depending on the origination point and the size and force of the waves.

Impact: 4 – Catastrophic

Spatial Extent: 4 – Large

Historical Occurrences

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.

- 1 was caused by an Atlantic Coast earthquake
- 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 unlikely but not impossible.

Probability of Future Occurrence

Based on a historical analysis, the frequency of prior tsunami events from around the world, and current research on the geologic potential for Gulf of Mexico tsunamis, it has been concluded that future tsunami events affecting Collier County are unlikely.

Probability: 1 – Unlikely

Climate Change

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

Vulnerability Assessment

People

Many of the effects of tsunamis on people are the same as those for other types of coastal flooding, described in Sections 2.5.1 and 2.5.2. The greatest threat to people during a tsunami is drowning. There may be injury or death. Rescue missions may be life-threatening for rescuers if buildings are not structurally stable or if rescuing from waters of unknown depth. If a structure were severely damaged or flooded, operations would be disrupted.

Property

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.

Data on potential tsunami extent is not available; therefore, potential loss estimates for property and critical facilities could not be generated.

Environment

The coast could be altered, including intra-coastal areas, beaches, mangroves, etc. Vegetation would likely be damaged and severe erosion would occur.

Consequence Analysis

The consequence analysis for tsunami hazards is shown in Table 2.68.

Table 2.68 – Consequence Analysis – Tsunami

Category	Consequences
Public	There may be injury or death.
Responders	Responders face similar risks as the general public but a heightened potential for life-threatening rescue missions if buildings are not structurally sound or if water depth is unknown.
Continuity of Operations (including Continued Delivery of Services)	Operations would likely be disrupted as a result of damages to buildings, roads, transportation infrastructure, communications infrastructure, utilities, and other key lifelines.
Property, Facilities and Infrastructure	Many structures and critical infrastructure would be severely damaged from the force of the water and flooding effects.
Environment	The coast, beaches, mangroves, etc. could be altered.
Economic Condition of the Jurisdiction	Many businesses would be damaged and forced to close causing loss of revenue and loss of jobs.
Public Confidence in the Jurisdiction's Governance	As with other hazards, public confidence could be affected by the speed of response and recovery efforts.

Hazard Summary by Jurisdiction

The following table summarizes tsunami hazard risk by jurisdiction. Tsunami hazard is not expected to change much by jurisdiction.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	1	4	4	3	2	2.8	H
Immokalee Reservation	1	3	3	3	2	2.3	M
Marco Island	1	4	4	3	2	2.8	H
Naples	1	4	4	3	2	2.8	H
Unincorporated Collier County	1	4	4	3	2	2.8	H

2.5.13 Major Transportation Incidents

Hazard Background

Collier County depends on several key bridges, roads, and ferry crossings for access and services. This infrastructure is integral to the functioning of the communities in the planning area and would cause major disruptions should they become inaccessible. Damage to any of this infrastructure could result from most of the natural and human-caused hazards described in this plan. In addition to a secondary or cascading impact from another primary hazard, infrastructure can fail as a result of faulty equipment, lack of maintenance, degradation over time, or accidental damage such as a barge colliding with a bridge support.

Building and construction standards along with regular inspection and maintenance can provide a degree of certainty as to the capacity of infrastructure to withstand some damages. However, accidental damage is unpredictable. Moreover, any damages that take a road or bridge out of service will likely require significant repairs that could take weeks or months to complete.

Warning Time: 4 – Less than six hours

Duration: 4 – More than one week

Location

The primary transportation systems in the region are shown in Figure 2.40. The Florida Department of Transportation maintains a list of bridges in Florida. There are 211 bridges built in 1989 or prior, listed below in Table 2.69. Due to their age, these bridges may be deteriorating and in need of maintenance, repair, or replacement. Aging infrastructure may also be more vulnerable to impacts from other natural or technological hazards.

Table 2.69 – Bridges Built in 1989 or Prior

Bridge Number	Route	Crossing	Year Built	Age (years)
30102	US-41 (SR-90)	Canal 102	1940	80
30092	US-41 (SR-90)	Canal 092	1941	79
30136	CR 846	DRAINAGE CANAL	1948	72
30137	CR 846	DRAINAGE CANAL	1948	72
30138	CR 846	DRAINAGE CNL	1948	72
30139	CR-846	DRAINAGE CANAL	1948	72
30140	CR 846	DRAINAGE CANAL	1948	72
30141	CR 846	DRAINAGE CNL	1948	72
30079	US-41 (SR-90)	Canal 079	1949	71
30083	US-41 (SR-90)	Turner River	1949	71
30087	US-41 (SR-90)	Canal 087	1949	71
30088	US-41 (SR-90)	Canal 088	1949	71
30091	US-41 (SR-90)	Canal 091	1949	71
30093	US-41 (SR-90)	K.S. STROUD CANAL	1949	71
30094	US-41 (SR-90)	NEW RIVER STRAND CANAL	1949	71
30095	US-41 (SR-90)	BYPASS CANAL	1949	71
30097	US-41 (SR-90)	Canal 097	1949	71
30098	US-41 (SR-90)	Canal 098	1949	71
30099	US-41 (SR-90)	Canal 099	1949	71
30100	US-41 (SR-90)	Canal 100	1949	71
30101	US-41 (SR-90)	Canal 101	1949	71
30103	US-41 (SR-90)	Canal 103	1949	71

Bridge Number	Route	Crossing	Year Built	Age (years)
30104	US-41 (SR-90)	Canal 104	1949	71
30105	US-41 (SR-90)	Canal 105	1949	71
30106	US-41 (SR-90)	Canal 106	1949	71
30107	US-41 (SR-90)	Canal 107	1949	71
30108	US-41 (SR-90)	Canal 108	1949	71
30109	US-41 (SR-90)	Canal 109	1949	71
30110	US-41 (SR-90)	Canal 110	1949	71
30114	US-41 (SR-90)	Canal 114	1949	71
30115	US-41 (SR-90)	Canal 115	1949	71
30116	US-41 (SR-90)	Canal 116	1949	71
30117	US-41 (SR-90)	Canal 117	1949	71
30032	WAGON WHEEL RD.	DEEP LAKE STRAND	1950	70
30060	US-41 (SR-90)	Canal 060	1950	70
30078	US-41 (SR-90)	Canal 078	1950	70
30111	US-41 (SR-90)	Canal 111	1950	70
30142	SR-82	Canal 142	1950	70
30143	SR-82	Canal 143	1950	70
30112	US-41 (SR-90)	Canal 112	1951	69
30113	US-41 (SR-90)	Canal 113	1951	69
30153	CR 858	OKALOACOOCHEE SLOUGH	1951	69
30154	CR 858	OKALOACOOCHEE SLOUGH	1951	69
30155	CR 858	OKALOACOOCHEE SLOUGH	1951	69
30156	CR-858	OKALOACOOCHEE SLOUGH	1951	69
30061	US-41 (SR-90)	Canal 061	1952	68
30065	US-41 (SR-90)	Canal 065	1952	68
30066	US-41 (SR-90)	Canal 066	1952	68
30067	US-41 (SR-90)	Canal 067	1952	68
30068	US-41 (SR-90)	Canal 068	1952	68
30069	US-41 (SR-90)	Canal 069	1952	68
30070	US-41 (SR-90)	Canal 070	1952	68
30072	US-41 (SR-90)	Canal 072	1952	68
30073	US-41 (SR-90)	Canal 073	1952	68
30074	US-41 (SR-90)	Canal 074	1952	68
30075	US 41 (SR 90)	Canal 075	1952	68
30077	US-41 (SR-90)	Canal 077	1952	68
30071	US-41 (SR-90)	Canal 071	1953	67
30081	US-41 (SR-90)	Canal 081	1953	67
30158	CR 858	OBIE CANAL	1953	67
30047	US-41	DRAINAGE CANAL 047	1954	66
30049	US-41	DRAINAGE CANAL 049	1954	66
30059	US-41 (SR-90)	Canal 059	1954	66
30076	US-41 (SR-90)	Canal 076	1954	66
30082	US-41 (SR-90)	Canal 082	1954	66
30085	US-41 (SR-90)	Canal 085	1954	66
30089	US-41 (SR-90)	Canal 089	1954	66
30951	US-41	Canal 951	1954	66
30039	US-41 (SR-45)	DRAINAGE CANAL 039	1955	65
30042	US-41 (SR-45)	DRAINAGE CANAL 042	1955	65
30043	US-41 (SR-45)	DRAINAGE CANAL 043	1955	65

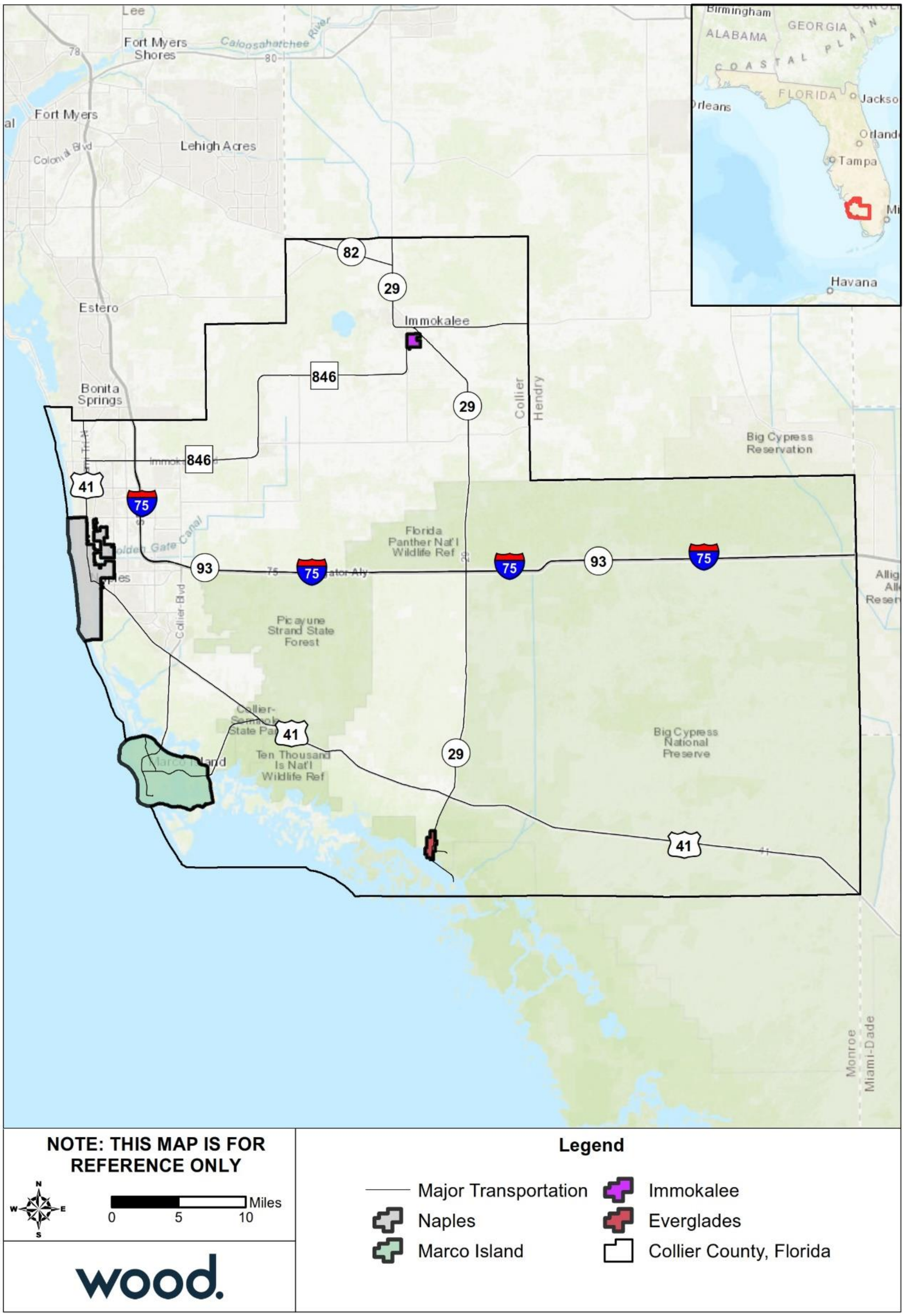
Bridge Number	Route	Crossing	Year Built	Age (years)
30044	US-41 (SR-45)	DRAINAGE CANAL 044	1955	65
30045	US-41 (SR-45)	DRAINAGE CANAL 045	1955	65
30046	US-41 (SR-45)	DRAINAGE CANAL 046	1955	65
30048	US-41	DRAINAGE CANAL 048	1955	65
30050	US-41	DRAINAGE CANAL 041	1955	65
30052	US-41	DRAINAGE CANAL 052	1955	65
30054	US-41	DRAINAGE CANAL 054	1955	65
30055	US-41	DRAINAGE CANAL 055	1955	65
30057	US-41	Canal 057	1955	65
30058	US-41	Canal 058	1955	65
30080	US-41 (SR 90)	Canal 080	1955	65
30086	US-41 (SR-90)	Canal 086	1955	65
30157	CR-837	FAKAHATCHEE STRAND	1955	65
30160	CR-846	GATOR CANAL	1955	65
30940	US-41 (SR-90)	Canal 940	1955	65
30941	US-41(SR-45/SR-90)	Canal 941	1955	65
30090	US-41 (SR-90)	Canal 090	1956	64
34101	PARK SHORE DR	MOORING BAY	1957	63
30165	CR837 WAGON WHL RD	DEEP LAKE STRAND	1959	61
30166	TURNER RIVER ROAD	COPELAND PRAIRIE	1960	60
34014	GREEN BLVD.	GOLDEN GATE CANAL	1960	60
34032	WILSON BLVD.	CYPRESS CANAL	1960	60
34046	PALM RIVER BLVD	PALM RIVER CANAL	1960	60
30084	US-41 (SR-90)	Park Canal	1961	59
30168	CR 839	EAST HINSON MARSH	1962	58
30169	CR839 TURNER RIVRD	EAST HINSON MARSH	1962	58
34111	PALM DRIVE	CANAL	1962	58
30172	GOLDEN GATE PKWY	GORDON RIVER	1963	57
30122	CR-29	BARRON RIVER	1964	56
34037	CR 846	DRAINAGE CANAL	1964	56
30006	I-75 SB/SR-93	NUNYA CREEK	1965	55
30007	I-75 SB (SR-93)	FIREBIRD CANAL	1965	55
30019	SR-29	Canal 019	1965	55
30062	US-41 (SR-90)	Canal 062	1965	55
34012	SW 25TH AVE.	CR-951 CANAL	1965	55
34019	32ND AVE. SW	SHELL CANAL	1965	55
34030	GOLDEN GATE BLVD	FAKA UNION CANAL	1965	55
34042	18th AVENUE NE	GOLDEN GATE CANAL	1965	55
34044	18TH AVE. NE	GOLDEN GATE DRAIN CANAL	1965	55
34048	RANDALL BLVD.	GOLDEN GATE MAIN CANAL	1965	55
34050	RANDALL BLVD.	FAKA UNION CANAL	1965	55
34052	43RD AVE. NE	FAKA UNION CANAL	1965	55
34054	56TH AVE NE	CIA DRAIN CANAL	1965	55
35250	HARBOUR DRIVE	MOORING BAY	1965	55
30001	I-75 (SR-93) SB	GOLDEN GATE CANAL	1966	54
30002	I-75 (SR-93) SB	FAKA UNION CANAL	1966	54
30003	I-75 SB (SR-93)	Canal 003	1966	54
30011	I-75 SB (SR-93)	Canal 011	1966	54
30033	CR 846	DRAINAGE CANAL	1966	54

Bridge Number	Route	Crossing	Year Built	Age (years)
30038	CR-846	DRAINAGE CANAL	1966	54
30063	US-41 (SR-90)	Canal 063	1966	54
30064	US-41 (SR-90)	Canal 064	1966	54
30150	CR-858	FAKA UNION CANAL	1966	54
30251	I-75 SB (SR-93)	EAST HINSON SLOUGH	1966	54
34036	CYPRESS WAY	COCOHATCHEE CANAL	1966	54
30012	I-75 SB (SR-93)	Canal 012	1967	53
30027	I-75 SB (SR-93)	Canal 027	1967	53
30028	I-75 SB (SR-93)	Canal 028	1967	53
30029	I-75 SB (SR-93)	Canal 029	1967	53
30030	I-75 SB (SR-93)	Canal 030	1967	53
34006	STEWART BLVD.	PICAYUNE STRAND	1967	53
34008	STEWART BLVD.	DRAINAGE CANAL	1967	53
34103	CORONADO PKWY WB	CORONADO CANAL	1967	53
34105	SUNSHINE BLVD.	GREEN CANAL	1967	53
34106	20TH PLACE SW	HUNTER CANAL	1967	53
34113	WINTERBERRY DRIVE	SMOKEHOUSE CREEK	1967	53
34122	TED CURCIE ROAD	DRAINAGE CANAL	1967	53
30021	I-75 SB (SR-93)	REST AREA CANAL	1968	52
30022	CR 850	PRIVATE CANAL	1968	52
30119	IMMOKALEE RD	COCOHATCHEE RIVER	1968	52
34108	18TH AVENUE SW	GREEN CANAL	1968	52
34123	CR-890	RELIEF CANAL	1968	52
30145	US-41 NB	FAKA UNION CANAL	1969	51
30146	US-41 SB	FAHKA UNION CANAL	1969	51
30148	SR-951 NB(COLLIER)	BIG MARCO PASS	1969	51
30149	BLUEBILL AVE CR846	NAPLES PARK CANAL	1969	51
30017	US 41 SB (SR 45)	COCOHATCHEE RIVER	1970	50
30037	US-41 (SR-90)	DRAINAGE CANAL 037	1970	50
30123	GLDN GT PKWY CR886	SANTA BARBARA CNL	1971	49
30147	BIRDON RD - CR-841	HALFWAY CREEK	1971	49
30920	US-41 (SR-90)	Canal 920	1971	49
34102	CORONADO PKWY EB	CORONADO CANAL	1972	48
34116	GOLDENROD AVE.	SMOKEHOUSE BAY	1972	48
34117	KENDALL DR	CLAM BAY	1972	48
34118	HERNANDO DRIVE	CLAM BAY	1972	48
34119	BLACKMORE COURT	CLAM BAY	1972	48
34120	KENDALL DR	COLLIER BAY	1972	48
30174	CR951/COLLIER BLVD	BIG CYPRESS BASIN CANAL	1973	47
34112	CAXAMBAS COURT	ROBERTS BAY	1973	47
30181	US-41 (SR-45)	DUNRUSS CREEK	1974	46
30125	MOORINGLINE DRIVE	DOCTOR PASS INLET	1975	45
30184	CR-92 SAN MARCO RD	MARCO CHANNEL	1975	45
30183	US 41NB TAMIAMI TR	HALDEMAN RIVER	1976	44
30193	US-41SB TAMIAMI TR	TAYLOR GLEAM CANAL	1976	44
30194	US 41 (SR 90)	GATOR HOLE	1976	44
30185	AIRPORT PULLING RD	BIG CYPRESS BASIN CANAL	1978	42
34011	TROPICANA BLVD. NB	TROPICANA CANAL	1978	42
34017	TROPICANA BLVD. SB	TROPICANA CANAL	1978	42

Bridge Number	Route	Crossing	Year Built	Age (years)
30186	AIRPORT RD.(CR-31)	ROCK CREEK	1979	41
30207	N COLLIER BLVD	CLAM BAY	1979	41
30189	I-75 SB (SR93)	ROCK CANAL	1980	40
30190	I-75 NB (SR93)	ROCK CANAL	1980	40
34107	SUNSET ROAD	SUNSHINE CANAL	1980	40
30200	I-75 SB (SR 93)	CR 896/PINE RIDGE RD	1983	37
30201	I-75 NB (SR 93)	CR 896/PINE RIDGE RD	1983	37
30202	I-75 SB (SR 93)	CR862(VANDERBILT BCH RD)	1983	37
30203	I-75 NB (SR 93)	CR862(VANDERBILT BCH RD)	1983	37
34132	SANTA BARBARA BLVD	GOLDEN GATE CANAL	1983	37
34133	CR-896(PINE RIDGE)	GORDON CANAL	1983	37
34135	TOWER RD	EAGLE CREEK	1983	37
30195	I-75 NB (SR-93)	SR-951	1984	36
30196	I-75 SB (SR-93)	SR-951	1984	36
30197	I-75 SB (SR-93)	GOLDEN GATE CANAL	1984	36
30198	I-75 NB (SR-93)	GOLDEN GATE CANAL	1984	36
30199	CR886(GLDN GT PKY)	I-75 AND CANAL C-1	1984	36
30205	SANTA BARBARA BLVD	I-75 (SR 93)	1984	36
30210	W PLANTATION PKWY	EVERGLADES DRAIN CANAL	1985	35
34124	CR-31(BAYSHORE DR)	HALDERMAN CREEK	1985	35
30211	SR-29	Canal 211	1986	34
30212	SR-29	Canal 212	1986	34
30213	SR-29	Canal 213	1986	34
34126	SANDHILL ST.	TIDAL CANAL	1986	34
34127	SOUTH SEAS COURT	TIDAL CANAL	1986	34
30290	SR-84 (Davis Blvd)	Canal	1988	32
34823	OAKES BLVD	DRAINAGE CANAL	1988	32
30221	I-75/SR-93 SB	PENNINGTON CAMP WC X 4	1989	31
30222	I-75/SR-93 NB	PENNINGTON CAMP WC X 4	1989	31
30223	I-75/SR-93 NB	KOJAK CREEK	1989	31
30224	I-75/SR-93 SB	WILDLIFE CROSSING NO-6	1989	31
30225	I-75 NB	WILDLIFE CROSSING NO-6	1989	31
30226	I-75 SB (SR-93)	WILDLIFE CROSSING NO-7	1989	31
30227	I-75 NB (SR-93)	WILDLIFE CROSSING NO-7	1989	31
30228	I-75 SB (SR-93)	WILDLIFE CROSSING NO-8	1989	31
30229	I-75 NB (SR-93)	WILDLIFE CROSSING NO-8	1989	31
30230	I-75 NB (SR-93)	NUNYA CREEK	1989	31
30231	I-75 SB (SR-93)	SLOANS CROSSING WC-10	1989	31
30232	I-75 NB (SR-93)	SLOANS CROSSING WC-10	1989	31
30233	I-75 NB (SR-93)	FIREBIRD CANAL	1989	31
30234	I-75 SB (SR-93)	SHANNAS CROSSING WC 12	1989	31
30235	I-75 NB (SR-93)	SHANNAS CROSSING WC 12	1989	31
30102	US-41 (SR-90)	Canal 102	1940	80

Source: Florida Department of Transportation, updated January 2020

Figure 2.40 – Key Transportation Routes in the Planning Area



Source: Collier County

Extent

The significance of any transportation infrastructure failure will vary depending on the location and nature of the infrastructure itself. The loss of a local road may have only minor impacts limited to the immediate area. However, the loss of a major highway or key bridge could cause significant disruption across the Region. Depending on time of day and the onset of the failure, significant casualties are also possible: the 1967 Silver Bridge collapse between Point Pleasant, West Virginia and Gallipolis, Ohio and the 1980 Sunshine Skyway Bridge collapse outside St. Petersburg, Florida killed 46 and 35 people respectively. If a bridge or key route were closed or failed during a hurricane evacuation, it could put thousands of residents and visitors at risk.

Impact: 3 – Critical

Spatial Extent: 2 – Small

Historical Occurrences

A 2014 analysis of bridge failure rates by Dr. Wesley Cook of Utah State University found that an average of 128 bridges collapse every year in the U.S.; 53% of bridges that collapsed had been rated as structurally deficient prior to their collapse. Only 4% of bridge collapses resulted in loss of life.

Probability of Future Occurrence

The likelihood of a major transportation infrastructure failure occurring in Collier County is difficult to quantify. The continuing age and deterioration of America's transportation infrastructure, coupled with increasing traffic and declining public investment in maintaining our infrastructure, indicate that road and bridge failures are likely to be more common in future decades than they have in the past. The American Society of Civil Engineers (ASCE) has estimated that $2.2 trillion would be needed to bring the nation's infrastructure up to a condition that meets the needs of the current population (note that this total includes non-transportation infrastructure). The potential for accidents and failures from infrastructure operating beyond its intended lifespan or with insufficient maintenance thus continues to increase.

According to the Federal Highway Administration (FHA), Florida ranks 50th among the 50 states in having the most roads in poor condition (1.3 percent) and 44th in terms of number of bridges rated as structurally deficient (2.6 percent), making Florida rank 49th overall for worst roads (or 2nd out of 50 for best road infrastructure).

Probability: 2 – Possible

Climate Change

Climate change could cause more major infrastructure incidents in some cases. As sea level rises, bridges may be more vulnerable to flooding or scour, roads could be flooded as well, and other types of transportation could be hindered.

Vulnerability Assessment

The impacts of transportation failures vary widely by the type of system, as well as the time of day and season of the failure.

Methodologies and Assumptions

Vulnerability to transportation infrastructure failures was assessed based on past occurrences nationally and internationally as well as publicly available information on infrastructure vulnerability.

People

People can be injured or killed during transportation infrastructure failures. As noted above, the U.S. averages five fatality-causing bridge collapses per year, although data on the number of fatalities involved was not available. Numbers of non-fatal injuries was also not available.

Aside from direct injuries and fatalities, transportation failures can result in significant losses of time and money as individuals and commercial shipments are detoured or blocked. Disruption of transportation systems can limit the ability of emergency services and utility work crews to reach affected areas and can put some members of the public at severe risk if they are unable to reach needed medical services, such as dialysis patients.

In extreme cases, a transportation failure could leave residents stranded without power, food, or other emergency supplies. Residents at a public meeting in Buxton expressed concern that a road or bridge washout following a major storm will leave them stranded for an extended period without emergency supplies or an alternative route off the island.

Property

The primary property damage from transportation infrastructure failures is to the infrastructure itself, as well as to privately-owned automobiles.

Environment

Transportation infrastructure failures can result in oil spills or other hazardous materials releases that can severely impact the environment in the surrounding area.

Consequence Analysis

Table 2.70 summarizes the potential consequences of a transportation infrastructure failure.

Table 2.70 – Consequence Analysis – Transportation Infrastructure Failure

Category	Consequences
Public	Potential injuries and fatalities.
Responders	Potential injuries and fatalities, as well as potentially significant delays to response times.
Continuity of Operations (including Continued Delivery of Services)	Loss of key roads or bridges can affect delivery of services.
Property, Facilities and Infrastructure	In addition to the loss of transportation infrastructure itself, sustained road closure can impact supply chain deliveries to other critical facilities.
Environment	Potential for oil spills or other hazardous materials releases.
Economic Condition of the Jurisdiction	Delays in movement of commuters, as well as good and services
Public Confidence in the Jurisdiction's Governance	Can cause loss of confidence in government's ability to maintain other critical infrastructure

Hazard Summary by Jurisdiction

The following table summarizes major transportation incident risk by jurisdiction. Risk is not expected to change substantially between jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	2	3	1	4	4	2.5	H

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Immokalee Reservation	2	3	1	4	4	2.5	H
Marco Island	2	3	1	4	4	2.5	H
Naples	2	3	1	4	4	2.5	H
Unincorporated Collier County	2	3	1	4	4	2.5	H

2.5.14 Pandemic Outbreak

Hazard Description

Public health emergencies can take many forms—disease epidemics, large-scale incidents of food or water contamination, or extended periods without adequate water and sewer services. There can also be harmful exposure to chemical, radiological, or biological agents, and largescale infestations of disease-carrying insects or rodents. The first part of this section focuses on emerging public health concerns and potential pandemics, while the second part addresses natural and human-caused air and water pollution.

Public health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident. For more information on those particular incidents, see Sections 2.5.2 (Tornado), 2.5.1 (Flood), and 2.5.15 (Hazardous Materials). The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, many people. Public health emergencies can be worldwide or localized in scope and magnitude.

The Florida Department of Health in Collier County has partnered with Collier Emergency Management and the local Red Cross chapter to plan and prepare for public health emergencies. The Department of Health provides resources and guidance in support of business, community, faith-based organization, health care provider, and individual preparedness.

The primary communicable, or infectious, disease addressed within this plan is influenza:

Influenza - Whether natural or manmade, health officials say the threat of a dangerous new strain of influenza (flu) virus in pandemic proportions is a very real possibility in the years ahead. Unlike most illnesses, the flu is especially dangerous because it is spread through the air. A classic definition of influenza is a respiratory infection with fever. Each year, flu infects humans and spreads around the globe. There are three types of influenza virus: Types A, B, and C. Type A is the most common, most severe, and the primary cause of flu epidemics. Type B cases occur sporadically and sometimes as regional or widespread epidemics. Type C cases are quite rare and hence sporadic, but localized outbreaks have occurred. Seasonal influenza usually is treatable, and the mortality rate remains low. Each year, scientists estimate which strain of flu is likely to spread, and they create a vaccine to combat it. A flu pandemic occurs when the virus suddenly changes or mutates and undergoes an —antigenic shift, permitting it to attach to a person’s respiratory system and leave the body’s immune system defenseless against the invader.

Additional diseases of public health concern include tuberculosis, Smallpox, St. Louis Encephalitis, Meningitis, Lyme disease, West Nile, SARS, Zika, and Ebola. These communicable diseases are introduced within this plan, but full vulnerability analyses are not included at this time.

Tuberculosis - Tuberculosis, or TB, is the leading cause of infectious disease worldwide. It is caused by a bacteria called Mycobacterium tuberculosis that most often affects the lungs. TB is an airborne disease spread by coughing or sneezing from one person to another. The World Health Organization (WHO) estimates that one-third of the world's population, approximately two billion people, has latent TB, which means people have been infected by TB bacteria but are not yet ill with the disease and cannot transmit the disease. In 2015, 10.4 million people fell ill with TB and 1.8 million died from the disease (including 0.4 million among people with HIV). Over 95% of TB deaths occur in low- and middle- income countries.

Smallpox - Smallpox is a contagious, sometimes fatal, infectious disease. There is no specific treatment for smallpox disease, and the only prevention is vaccination. Smallpox is caused by the variola virus that emerged in human populations thousands of years ago. It is generally spread by face- to-face contact or by direct contact with infected bodily fluids or contaminated objects (such as bedding or clothing). A person with smallpox is sometimes contagious with onset of fever, but the person becomes most contagious with the onset of rash. The rash typically develops into sores that spread over all parts of the body. The infected person remains contagious until the last smallpox scab is gone. Smallpox outbreaks have occurred periodically for thousands of years, but the disease is now largely eradicated after a worldwide vaccination program was implemented. After the disease was eliminated, routine vaccination among the general public was stopped. The last case of smallpox in the United States was in 1949.

St. Louis Encephalitis - In the United States, the leading type of epidemic flaviviral Encephalitis is St. Louis encephalitis (SLE), which is transmitted by mosquitoes that become infected by feeding on birds infected with the virus. SLE is the most common mosquito-transmitted pathogen in the United States. There is no evidence to suggest that the virus can be spread from person to person.

Meningitis - Meningitis is an infection of fluid that surrounds a person's spinal cord and brain. High fever, headache, and stiff neck are common symptoms of meningitis, which can develop between several hours to one to two days after exposure. Meningitis can be caused by either a viral or bacterial infection; however, a correct diagnosis is critically important, because treatments for the two varieties differ. Meningitis is transmitted through direct contact with respiratory secretions from an infected carrier. Primary risk groups include infants and young children, household contact with patients, and refugees. In the United States, periodic outbreaks continue to occur, particularly among adolescents and young adults. About 2,600 people in the United States get the disease each year. Generally, 10 to 14 percent of cases are fatal, and 11 to 19 percent of those who recover suffer from permanent hearing loss, mental retardation, loss of limbs, or other serious effects. Two vaccines are available in the United States.

Lyme Disease - Lyme disease was named after the town of Lyme, Connecticut, where an unusually large frequency of arthritis-like symptoms was observed in children in 1977. It was later found that the problem was caused by bacteria transmitted to humans by infected deer ticks, causing an average of more than 16,000 reported infections in the United States each year (however, the disease is greatly under-reported). Lyme disease bacteria are not transmitted from person to person. Following a tick bite, 80 percent of patients develop a red ―bulls-eye‖ rash accompanied by tiredness, fever, headache, stiff neck, muscle aches, and joint pain. If untreated, some patients may develop arthritis, neurological abnormalities, and cardiac problems, weeks to months later. Environmental issues addressed in this profile focus on air and water pollution, because contamination of those media can have widespread impacts on public health and devastating consequences. Issues of primary concern associated with sources of air and water pollution change over time depending on recent industrial activity, economic development, enforcement of environmental regulations, new scientific information on adverse health effects of particular contaminants or concentrations, and other factors. Lyme disease is rarely fatal. During early stages of the disease, oral antibiotic treatment is generally effective, while intravenous treatment may be required in more severe cases.

West Nile Virus - West Nile virus is a flavivirus spread by infected mosquitoes and is commonly found in Africa, West Asia, and the Middle East. It was first documented in the United States in 1999. Although it is not known where the U.S. virus originated, it most closely resembles strains found in the Middle East. It is closely related to St. Louis encephalitis and can infect humans, birds, mosquitoes, horses, and other mammals.

Most people who become infected with West Nile virus will have either no symptoms or only mild effects. However, on rare occasions, the infection can result in severe and sometimes fatal illness. There is no evidence to suggest that the virus can be spread from person to person.

An abundance of dead birds in an area may indicate that West Nile virus is circulating between the birds and mosquitoes in that area. Although birds are particularly susceptible to the virus, most infected birds survive. The continued expansion of West Nile virus in the United States indicates that it is permanently established in the Western Hemisphere.

Severe Acute Respiratory Syndrome - Severe acute respiratory syndrome (SARS) is a respiratory illness that has recently been reported in Asia, North America, and Europe. Although the cause of SARS is currently unknown, scientists have detected in SARS patients a previously unrecognized coronavirus that appears to be a likely source of the illness. In general, humans infected with SARS exhibit fevers greater than 100.4 F, headaches, an overall feeling of discomfort, and body aches. Some people also experience mild respiratory symptoms. After two to seven days, SARS patients may develop a dry cough and have trouble breathing. The primary way that SARS appears to spread is by close person-to-person contact; particularly by an infected person coughing or sneezing contaminated droplets onto another person, with a transfer of those droplets to the victim's eyes, nose, or mouth.

Zika Virus - Discovered in the Zika forest of Uganda in 1947, the Zika virus is a member of the flavivirus family. It is transmitted to humans through the bite of an infected Aedes species mosquito (Ae. aegypti and Ae. albopictus). Zika virus can also be transmitted from an infected pregnant woman to her baby during pregnancy and can result in serious birth defects, including microcephaly. Less commonly, the virus can be spread through intercourse or blood transfusion. However, most people infected with the Zika virus do not become sick.

Ebola - previously known as Ebola hemorrhagic fever, is a rare and deadly disease caused by infection with one of the Ebola virus species. It was first discovered in 1976 near the Ebola River in what is now the Democratic Republic of the Congo. Since then, outbreaks have appeared sporadically in Africa.

Additional environmental concerns addressed in this hazard profile focus on air and water pollution, because contamination of those media can have widespread impacts on public health and devastating consequences. Issues of primary concern associated with sources of air and water pollution change over time depending on recent industrial activity, economic development, enforcement of environmental regulations, new scientific information on adverse health effects of contaminants or concentrations, and other factors.

Warning Time: 1 – More than 24 hours

Duration: 4 – More than one week

Location

Infectious disease outbreaks can occur anywhere in the planning area, especially where there are groups of people in close quarters.

Extent

When on an epidemic scale, diseases can lead to high infection rates in the population causing isolation, quarantine, and potential mass fatalities. An especially severe influenza pandemic or other major disease outbreak could lead to high levels of illness, death, social disruption, and economic loss. Impacts could range from school and business closings to the interruption of basic services such as public transportation, health care, and the delivery of food and essential medicines.

Table 2.71 describes the World Health Organization's six main phases to a pandemic flu as part of their planning guidance.

Table 2.71 – World Health Organization's Pandemic Flu Phases

Phase	Description
1	No animal influenza virus circulating among animals have been reported to cause infection in humans.
2	An animal influenza virus circulating in domesticated or wild animals is known to have caused infection in humans and is therefore considered a specific potential pandemic threat.
3	An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people but has not resulted in human-to-human transmission sufficient enough to sustain community-level breakouts.
4	Human-to-human transmission of an animal or human-animal influenza reassortant virus able to sustain community-level breakouts has been verified.
5	The same identified virus has caused sustained community-level outbreaks in two or more countries in one WHO region.
6	In addition to the criteria defined in Phase 5, the same virus has caused sustained community-level outbreaks in at least one other country in another WHO region.
Post-Peak Period	Levels of pandemic influenza in most countries with adequate surveillance have dropped below peak levels.
Post-Pandemic Period	Levels of influenza activity have returned to levels seen for seasonal influenza in most countries with adequate surveillance.

Source: World Health Organization

Impact: 3 – Critical

Spatial Extent: 3 – Moderate

Historical Occurrences

Public Health Emergencies – Influenza Pandemics

Since the early 1900s, four lethal pandemics have swept the globe: Spanish Flu of 1918-1919; Asian Flu of 1957-1958; Hong Kong Flu of 1968-1969; and Swine Flu of 2009-2010. The Spanish Flu was the most severe pandemic in recent history. The number of deaths was estimated to be 50-100 million worldwide and 675,000 in the United States. Its primary victims were mostly young, healthy adults. The 1957 Asian Flu pandemic killed about 70,000 people in the United States, mostly the elderly and chronically ill. The 1968 Hong Kong Flu pandemic killed 34,000 Americans. The 2009 Swine Flu caused 12,469 deaths in the United States. These historic pandemics are further defined in the following paragraphs along with several "pandemic scares".

Spanish Flu (H1N1 virus) of 1918-1919

In 1918, when World War I was in its fourth year, another threat began that rivaled the war itself as the greatest killer in human history. The Spanish Flu swept the world in three waves during a two-year period, beginning in March 1918 with a relatively mild assault.

The first reported case occurred at Camp Funston (Fort Riley), Kansas, where 60,000 soldiers trained to be deployed overseas. Within four months, the virus traversed the globe, as American soldiers brought the virus to Europe. The first wave sickened thousands of people and caused many deaths (46 died at Camp Funston), but it was considered mild compared to what was to come. The second and deadliest wave struck in the autumn of 1918 and killed millions. At Camp Funston alone, there were 14,000 cases and 861 deaths reported during the first three weeks of October 1918.

Outbreaks caused by a new variant exploded almost simultaneously in many locations including France, Sierra Leone, Boston, and New York City, where more than 20,000 people died that fall. The flu gained its name from Spain, which was one of the hardest hit countries. From there, the flu went through the Middle East and around the world, eventually returning to the United States along with the troops.

Of the 57,000 Americans who died in World War I, 43,000 died as a result of the Spanish Flu. At one point, more than 10 percent of the American workforce was bedridden. By a conservative estimate, a fifth of humans suffered the fever and aches of influenza between 1918 and 1919 and 20 million people died. At the height of the flu outbreak during the winter of 1918-1919, at least 20% of North Carolinians were infected by the disease. Ultimately, 10,000 citizens of the state succumbed to this disease.

Asian Flu (H2N2 virus) of 1957-1958

This influenza pandemic was first identified in February 1957 in the Far East. Unlike the Spanish Flu, the 1957 virus was quickly identified, and vaccine production began in May 1957. A number of small outbreaks occurred in the United States during the summer of 1957, with infection rates highest among school children, young adults, and pregnant women; however, the elderly had the highest rates of death. A second wave of infections occurred early the following year, which is typical of many pandemics.

Hong Kong Flu (H3N2 virus) of 1968-1969

This influenza pandemic was first detected in early 1968 in Hong Kong. The first cases in the United States were detected in September 1968, although widespread illness did not occur until December. This became the mildest pandemic of the twentieth century, with those over the age of 65 the most likely to die. People infected earlier by the Asian Flu virus may have developed some immunity against the Hong Kong Flu virus. Also, this pandemic peaked during school holidays in December, limiting student-related infections.

Pandemic Flu Threats: Swine Flu of 1976, Russian Flu of 1977, and Avian Flu of 1997 and 1999

Three notable flu scares occurred in the twentieth century. In 1976, a swine-type influenza virus appeared in a U.S. military barracks (Fort Dix, New Jersey). Scientists determined it was an antigenically drifted variant of the feared 1918 virus. Fortunately, a pandemic never materialized, although the news media made a significant argument about the need for a Swine Flu vaccine.

In May 1977, influenza viruses in northern China spread rapidly and caused epidemic disease in children and young adults. By January 1978, the virus, subsequently known as the Russian Flu, had spread around the world, including the United States. A vaccine was developed for the virus for the 1978–1979 flu season. Because illness occurred primarily in children, this was not considered a true pandemic.

In March 1997, scores of chickens in Hong Kong's rural New Territories began to die—6,800 on three farms alone. The Avian Flu virus was especially virulent and made an unusual jump from chickens to humans. At least 18 people were infected, and six died in the outbreak. Chinese authorities acted quickly to exterminate over one million chickens and successfully prevented further spread of the disease. In 1999, a new avian flu virus appeared. The new virus caused illness in two children in Hong Kong. Neither of these avian flu viruses started pandemics.

Swine Flu (H1N1 virus) of 2009–2010

This influenza pandemic emerged from Mexico in 2009. The first U.S. case of H1N1, or Swine Flu, was diagnosed on April 15, 2009. The U.S. government declared H1N1 a public health emergency on April 26. By June, approximately 18,000 cases of H1N1 had been reported in the United States. A total of 74 countries were affected by the pandemic.

The CDC estimates that 43 million to 89 million people were infected with H1N1 between April 2009 and April 2010. There were an estimated 8,870 to 18,300 H1N1 related deaths. On August 10, 2010, the World Health Organization (WHO) declared an end to the global H1N1 flu pandemic.

Public Health Emergencies – Other Pandemics

St. Louis Encephalitis, 1964-2005

Between 1964 and 2005, there were 4,651 confirmed cases of SLE in the United States. In 1990 alone, there were 223 cases in Florida. It should be noted, however, that less than 1 percent of SLE infections are clinically apparent, so most infections remain undiagnosed. Illnesses range from mild headaches and fever to convulsions, coma, and paralysis. The last major outbreak of SLE occurred in the Midwest from 1974 to 1977, when over 2,500 cases were reported in 35 states. The most recent outbreak of St. Louis encephalitis was in 1999 in New Orleans, Louisiana, with 20 reported cases. The disease is generally milder in children than in adults, with the elderly at highest risk for severe illness and death. Approximately 3 to 30 percent of cases are fatal; no vaccine against SLE exists. In 2014, two U.S. cases were reported and were the first human cases since 2002.

Meningitis, 1996-1997, 2005

During 1996 and 1997, 213,658 cases of meningitis were reported, along with 21,830 deaths, in Africa. Between 2005 and 2014, Florida reported 354 cases of meningitis.

Lyme Disease, 2015

In the United States, Lyme disease is mostly found in the northeastern, mid-Atlantic, and upper north-central regions, and in several counties in northwestern California. In 2015, 95-percent of confirmed Lyme Disease cases were reported from 14 states: Connecticut, Delaware, Maine, Maryland, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and Wisconsin. Lyme disease is the most commonly reported vector-borne illness in the United States. In 2015, it was the sixth most common nationally notifiable disease. even though it does not occur nationwide.

Severe Acute Respiratory Syndrome, 2003

During November 2002-July 2003, a total of 8,098 probable SARS cases were reported to the World Health Organization (WHO) from 29 countries. In the United States, only 8 cases had laboratory evidence of infection. There were no confirmed cases in Florida. Since July 2003, when SARS transmission was declared contained, active global surveillance for SARS disease has detected no person-to-person transmission. CDC has therefore archived the case report summaries for the 2003 outbreak.

Zika Virus, 2015

In May 2015, the Pan American Health Organization issued an alert noting the first confirmed case of a Zika virus infection in Brazil. Since that time, Brazil and other Central and South America countries and territories, as well as the Caribbean, Puerto Rico, and the U.S. Virgin Islands have experienced ongoing Zika virus transmission. In August 2016, the Centers for Disease Control and Prevention (CDC) issued guidance for people living in or traveling to a 1-square-mile area in Miami, Florida, identified by the Florida Department of Health as having mosquito-borne spread of Zika. In October 2016, the transmission area was expanded to include a 4.5-square-mile area of Miami Beach and a 1-squre mile area of Miami-Dade County. In addition, all Miami-Dade County was identified as a cautionary area with an unspecified level of risk. As of the end of 2018, the CDC reported 74 cases of Zika across the United States.

Ebola, 2014-2016

Most recently, in March 2014, West Africa experienced the largest outbreak of Ebola in history. Wide spread transmission was found in Liberia, Sierra Leone, and Guinea with the number of cases totaling 28,616 and the number of deaths totaling 11,310. In the United States, four cases of Ebola were confirmed in 2014 including a medical aid worker returning to New York from Guinea, two healthcare workers at Texas Presbyterian Hospital who provided care for a diagnosed patient, and the diagnosed patient who traveled to Dallas, Texas from Liberia. All three healthcare workers recovered. The diagnosed patient passed away in October 2014.

In March 2016, the WHO terminated the public health emergency for the Ebola outbreak in West Africa.

Probability of Future Occurrence

It is impossible to predict when the next pandemic will occur or its impact. The CDC continually monitors and assesses pandemic threats and prepares for an influenza pandemic. Novel influenza A viruses with pandemic potential include Asian lineage avian influenza A (H5N1) and (H7N9) viruses. These viruses have all been evaluated using the Influenza Risk Assessment Tool (IRAT) to assess their potential pandemic risk. Because the CDC cannot predict how severe a future pandemic will be, advance planning is needed at the national, state and local level; this planning is done through public health partnerships at the national, state and local level.

Today, a much larger percentage of the world's population is clustered in cities, making them ideal breeding grounds for epidemics. Additionally, the explosive growth in air travel means the virus could literally be spread around the globe within hours. Under such conditions, there may be very little warning time. Most experts believe we will have just one to six months between the time that a dangerous new influenza strain is identified and the time that outbreaks begin to occur in the United States. Outbreaks are expected to occur simultaneously throughout much of the nation, preventing shifts in human and material resources that normally occur with other natural disasters. These and many other aspects make influenza pandemic unlike any other public health emergency or community disaster.

Probability: 2 – Possible

Climate Change

According to the U.S. Global Change Research Program, the influences of climate change on public health are significant and varied. The influences range from the clear threats of temperature extremes and severe storms to less obvious connections related to insects. Climate and weather can also affect water and food quality in particular areas, with implications for public health.

Hot days can be unhealthy—even dangerous. High air temperatures can cause heat stroke and dehydration and affect people's cardiovascular and nervous systems. Florida is heavily influenced by tropical moisture since the state is surrounded by the Atlantic Ocean and the Gulf of Mexico. The heat index can get dangerously high, especially in the summer. In recent decades, severe heat waves have killed hundreds of people across the Southeast. Heat stress is expected to increase as climate change brings hotter summer temperatures and more humidity. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

Higher temperatures and wetter conditions tend to increase mosquito and tick activity, leading to an increased risk of zoonotic diseases. Mosquitos are known to carry diseases such as West Nile virus (WNV), La Crosse/California encephalitis, Jamestown Canyon virus, St. Louis encephalitis, and Eastern equine encephalitis. The two major concerns associated with warmer and wetter conditions are that the mosquito species already found in Florida and the diseases that they carry will become more prevalent, and that new species carrying unfamiliar diseases will start to appear for the first time.

Warmer winters with fewer hard freezes in areas that already see WNV-carrying mosquitos are likely to observe both a higher incidence of WNV and a longer WNV season, ultimately leading to an increase in human cases. Non-native mosquito species may move into Florida if the climate becomes more suitable for them, bringing with them diseases such as Jamestown Canyon virus, Chikungunya, and Dengue Fever.

Ticks are also well-known disease vectors in Florida, carrying pathogens such as Lyme disease, anaplasmosis, Ehrlichiosis, Powassan virus, and Babesiosis. Warmer, wetter weather can lead to an increase in algal blooms and declining beach health. An increase in flood events may also be associated with an increased incidence of mold problems in homes and businesses, as well as contamination of wells and surface waters due to sewer overflows and private septic system failures.

If these predictions come true, communities must contend with the human health impacts related to the increased prevalence of infectious diseases, heat waves, and changes in air and water quality. Public health officials will need to focus on spreading information and enacting pest and disease reduction. Flood prone communities will need to focus on continuously improving flood controls and mitigation strategies, including restricting building and chemical storage in floodplains, upgrading well and septic requirements, and providing water testing kits to residents.

Vulnerability Assessment

People

Disease spread and mortality is affected by a variety of factors, including virulence, ease of spread, aggressiveness of the virus and its symptoms, resistance to known antibiotics and environmental factors. While every pathogen is different, diseases normally have the highest mortality rate among the very young, the elderly or those with compromised immune systems. As an example, the unusually deadly 1918 H1N1 influenza pandemic had a mortality rate of 20%. If an influenza pandemic does occur, it is likely that many age groups would be seriously affected. The greatest risks of hospitalization and death—as seen during the last two pandemics in 1957 and 1968 as well as during annual outbreaks of influenza—will be to infants, the elderly, and those with underlying health conditions. However, in the 1918 pandemic, most deaths occurred in young adults. Few people, if any, would have immunity to a new virus.

Approximately twenty percent of people exposed to West Nile Virus through a mosquito bite develop symptoms related to the virus; it is not transmissible from one person to another. Preventive steps can be taken to reduce exposure to mosquitos carrying the virus; these include insect repellent, covering exposed skin with clothing and avoiding the outdoors during twilight periods of dawn and dusk, or in the evening when the mosquitos are most active.

Property

For the most part, property itself would not be impacted by a human disease epidemic or pandemic. However, as concerns about contamination increase, property may be quarantined or destroyed as a precaution against spreading illness. Furthermore, staffing shortages could affect the function of critical facilities.

Environment

A widespread pandemic would not have an impact on the natural environment unless the disease was transmissible between humans and animals. However, affected areas could result in denial or delays in the use of some areas, and may require remediation.

Consequence Analysis

Table 2.72 summarizes the potential consequences of infectious disease.

Table 2.72 – Consequence Analysis – Infectious Disease

Category	Consequences
Public	Adverse impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Adverse impact expected to be severe for unprotected personnel and uncertain for trained and protected personnel, depending on the nature of the incident.
Continuity of Operations (including Continued Delivery of Services)	Danger to personnel in the area of the incident may require relocation of operations and lines of succession execution. Disruption of lines of communication and destruction of facilities may extensively postpone delivery of services.
Property, Facilities and Infrastructure	Access to facilities and infrastructure in the area of the incident may be denied until decontamination completed.
Environment	Incident may cause denial or delays in the use of some areas. Remediation needed.
Economic Condition of the Jurisdiction	Local economy and finances adversely affected, possibly for an extended period.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes pandemic outbreak risk by jurisdiction. This risk is not expected to change substantially between jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	2	3	3	1	4	2.6	H
Immokalee Reservation	2	3	3	1	4	2.6	H
Marco Island	2	3	3	1	4	2.6	H
Naples	2	3	3	1	4	2.6	H
Unincorporated Collier County	2	3	3	1	4	2.6	H

2.5.15 Hazardous Materials

Hazard Description

A hazardous substance is any substance that may cause harm to persons, property, or the environment when released to soil, water, or air. Chemicals are manufactured and used in increasing types and quantities. Each year over 1,000 new synthetic chemicals are introduced and as many as 500,000 products pose physical or health hazards and can be defined as “hazardous chemicals”. Hazardous substances are categorized as toxic, corrosive, flammable, irritant, or explosive. Hazardous material incidents generally affect a localized area.

Fixed Hazardous Materials Incident

A fixed hazardous materials incident is the accidental release of chemical substances or mixtures during production or handling at a fixed facility.

Transportation Hazardous Materials Incident

A transportation hazardous materials incident is the accidental release of chemical substances or mixtures during transport. Transportation Hazardous Materials Incidents in the Eno-Haw Region can occur during highway or air transport. Highway accidents involving hazardous materials pose a great potential for public exposures. Both nearby populations and motorists can be impacted and become exposed by accidents and releases. If airplanes carrying hazardous cargo crash, or otherwise leak contaminated cargo, populations and the environment in the impacted area can become exposed.

Pipeline Incident

A pipeline transportation incident occurs when a break in a pipeline creates the potential for an explosion or leak of a dangerous substance (oil, gas, etc.) possibly requiring evacuation. An underground pipeline incident can be caused by environmental disruption, accidental damage, or sabotage. Incidents can range from a small, slow leak to a large rupture where an explosion is possible. Inspection and maintenance of the pipeline system along with marked gas line locations and an early warning and response procedure can lessen the risk to those near the pipelines.

Warning Time: 4 – Less than six hours

Duration: 2 – Less than 24 hours

Location

The Toxics Release Inventory (TRI) Program run by the U.S. Environmental Protection Agency (EPA) maintains a database of industrial facilities across the country and the type and quantity of toxic chemicals they release. The program also tracks pollution prevention activities and which facilities are reducing toxic releases. The Toxic Release Inventory reports 13 sites reporting hazardous materials in Collier County. These sites are shown in Figure 2.41 and detailed in Table 2.73.

Table 2.73 – Toxic Release Inventory Facilities

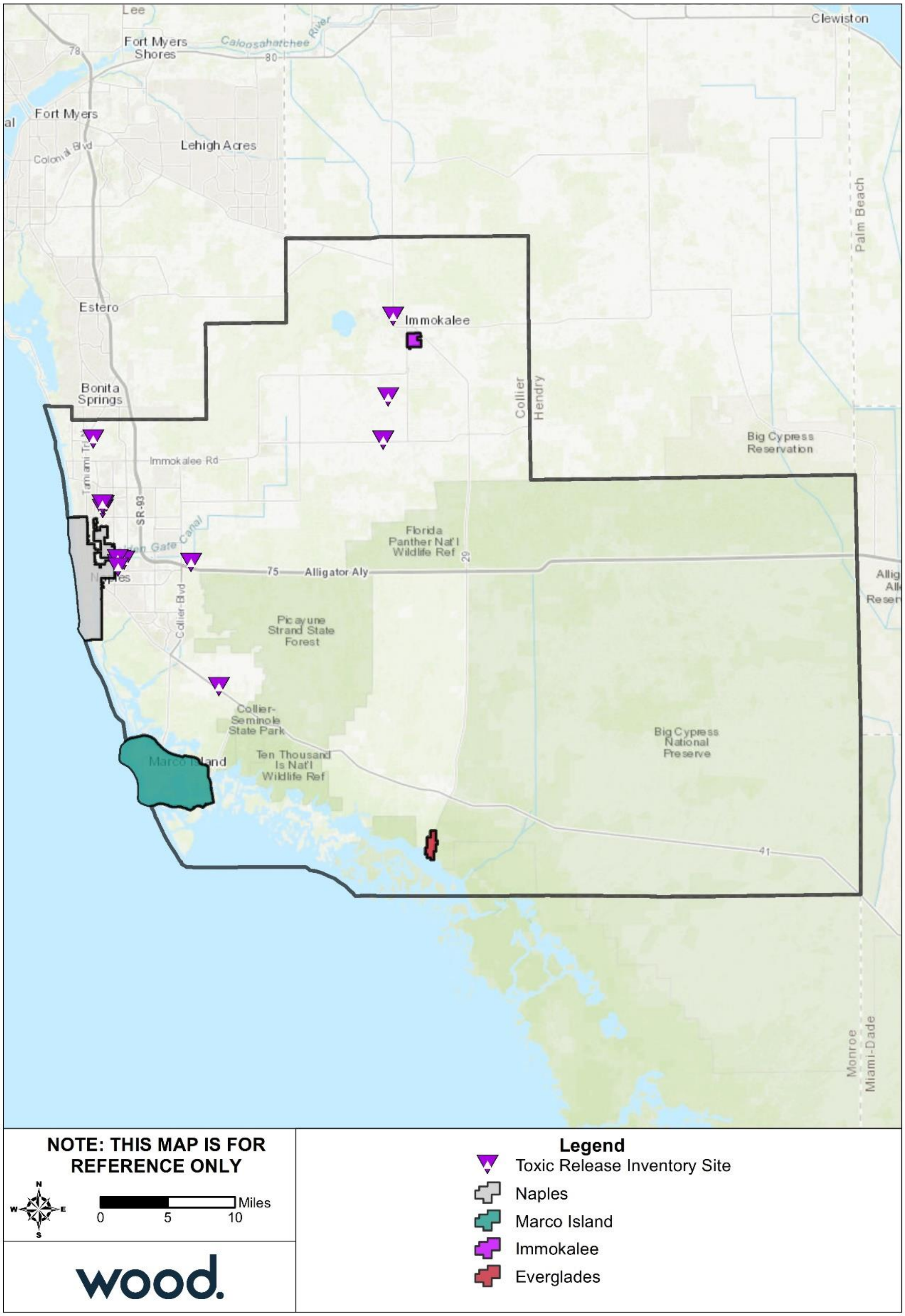
Facility Name	Facility Location
Arthrex Manufacturing, Inc.[1]	6875 Arthrex Commerce Drive, Ave Maria, FL 34142
Cemex Ave Maria	4811 Ave Maria Boulevard, Ave Maria, FL 34142
Cemex East Trail	15555 East Tamiami Trail, Naples, FL 34114
Cemex Prospect	3728 Prospect Avenue, Naples, FL 34103
Cemex Wiggins Pass	1425 Wiggins Pass Road East, Naples, FL 34110
Cemex Shirley Street	6100 Shirley Street, Naples, FL 34109

Facility Name	Facility Location
Commercial Refrigeration, Inc.	1901 J and C Boulevard, Naples, FL 34109
Florida Rock Industries, Inc. Naples Ready Mix Plant	4406 Progress Avenue, Naples, FL 34104
Interiors Cultured Marble, Inc.	1734 Trade Center Way, Naples, FL 34109
Naples Marble Co.	3963 Progress Avenue, Naples, FL 34104
Parker Hannifin Corporation	3580 Shaw Boulevard, Naples, FL 34117
Progress Rail Services	3581 Mercantile Avenue, Naples, FL 34104
SMI Florida Fabricators Naples	3684 Enterprise Avenue, Naples, FL 34104

Source: U.S. EPA Toxics Release Inventory, 2018
[1]This facility is listed in the TRI for three types of chemicals.

The U.S. Department of Transportation (USDOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) maintains an inventory of the location of all gas transmission and hazardous liquid pipelines as well as liquid natural gas plants and hazardous liquid breakout tanks. Collier County has no gas transmission pipelines or hazardous liquid pipelines as of January 2020 according to the public viewer of the National Pipeline Mapping System.

Figure 2.41 – Toxic Release Inventory Sites in Collier County



Source: EPA Toxic Release Inventory

Extent

The magnitude of a hazardous materials incident can be defined by the material type, the amount released, and the location of the release. The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA), which records hazardous material incidents across the country, defines a "serious incident" as a hazardous materials incident that involves:

- a fatality or major injury caused by the release of a hazardous material,
- the evacuation of 25 or more persons as a result of the release of a hazardous material or exposure to fire,
- a release or exposure to fire which results in the closure of a major transportation artery,
- the alteration of an aircraft flight plan or operation,
- the release of radioactive materials from Type B packaging,
- the release of over 11.9 galls or 88.2 pounds of a severe marine pollutant, or
- the release of a bulk quantity (over 199 gallons or 882 pounds) of a hazardous material.

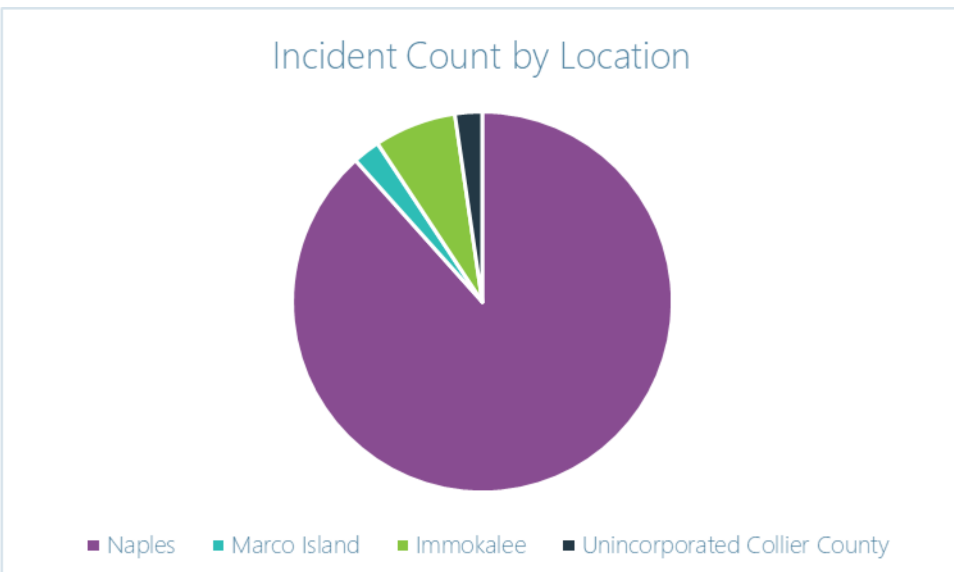
Impact: 1 – Minor

Spatial Extent: 1 – Negligible

Historical Occurrences

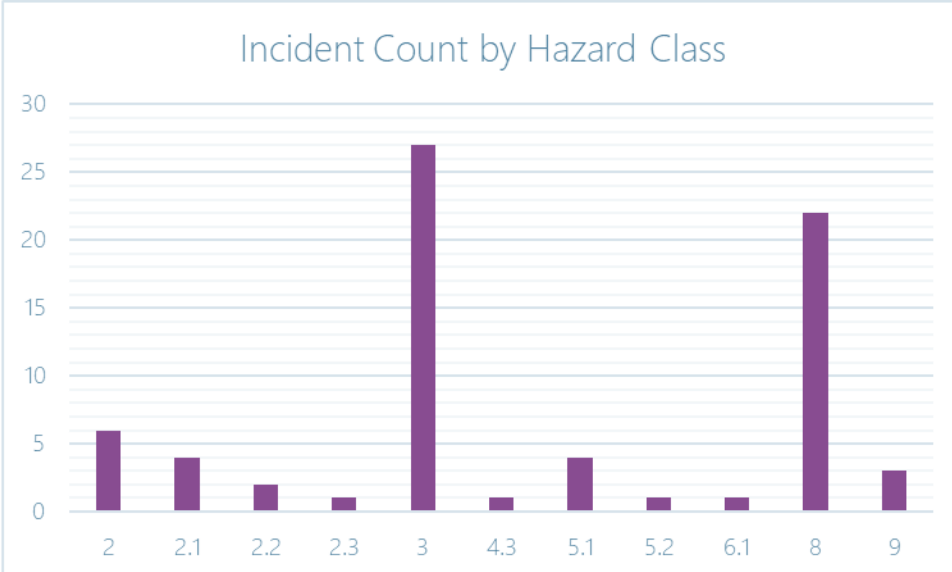
The USDOT's PHMSA maintains a database of reported hazardous materials incidents, which are summarized below in Figure 2.42 by location and in Figure 2.43 hazardous material class. According to PHMSA records, there were 43 recorded releases in Collier County in the 20-year period from 2000 through 2019. None of these events were considered serious incidents; however, 12 events had serious impacts, including nine serious bulk releases; one event flagged for serious evacuation, two minor injuries, and five events resulting in the closure of major transportation arteries.

Figure 2.42 – Count of Hazardous Materials Release Incidents by Location, 2000-2019



Source: PHMSA Incident Reports, Office of Hazardous Materials Safety, Incident Reports Database Search, data as of Feb. 13, 2020.

Figure 2.43 – Count of Hazardous Materials Release Incidents by Hazard Class, 2000-2019



Source: PHMSA Incident Reports, Office of Hazardous Materials Safety, Incident Reports Database Search, data as of Feb. 13, 2020.

The most common materials spilled in the planning area are Class 3 (Flammable and Combustible Liquids) and Class 8 (Corrosives). Figure 2.44 describes all nine hazard classes.

Figure 2.44 – Hazardous Materials Classes

Source: U.S. Department of Transportation

Probability of Future Occurrence

Based on historical occurrences recorded by PHMSA, there have been 43 hazardous materials releases in the 20-year period from 2000 through 2019, 12 of which had serious impacts. Using historical occurrences as an indication of future probability, there is a 60 percent annual probability of a serious hazardous materials incident occurring.

Probability: 3 – Likely

Climate Change

Climate change is not expected to impact hazardous materials incidents.

Vulnerability Assessment

People

Hazardous materials incidents can cause injuries, hospitalizations, and even fatalities to people nearby. People living near hazardous facilities and along transportation routes may be at a higher risk of exposure, particularly those living or working downstream and downwind from such facilities. For example, a toxic spill or a release of an airborne chemical near a populated area can lead to significant evacuations and have a high potential for loss of life. Individuals working with or transporting hazardous materials are also at heightened risk.

In addition to the immediate health impacts of releases, a handful of studies have found long term health impacts such as increased incidence of certain cancers and birth defects among people living near certain chemical facilities. However there has not been enough research done on the subject to allow detailed analysis.

The primary economic impact of hazardous material incidents results from lost business, delayed deliveries, property damage, and potential contamination. Large and publicized hazardous material-related events can deter tourists and could potentially discourage residents and businesses. Economic effects from major transportation corridor closures can be significant.

Property

The impact of a fixed hazardous facility, such as a chemical processing facility is typically localized to the property where the incident occurs. The impact of a small spill (i.e. liquid spill) may also be limited to the extent of the spill and remediated if needed. While cleanup costs from major spills can be significant, they do not typically cause significant long-term impacts to property.

Impacts of hazardous material incidents on critical facilities are most often limited to the area or facility where they occurred, such as at a transit station, airport, fire station, hospital, or railroad. However, they can cause long-term traffic delays and road closures resulting in major delays in the movement of goods and services. These impacts can spread beyond the planning area to affect neighboring counties, or vice-versa. While cleanup costs from major spills can be significant, they do not typically cause significant long-term impacts to critical facilities.

Environment

Hazardous material incidents may affect a small area at a regulated facility or cover a large area outside such a facility. Widespread effects occur when hazards contaminate the groundwater and eventually the municipal water supply, or they migrate to a major waterway or aquifer. Impacts on wildlife and natural resources can also be significant.

Consequence Analysis

Table 2.74 summarizes the potential detrimental consequences of hazardous materials incident.

Table 2.74 – Consequence Analysis – Hazardous Materials Incident

Category	Consequences
Public	Contact with hazardous materials could cause serious illness or death. Those living and working closest to hazardous materials sites face the greatest risk of exposure. Exposure may also occur through contamination of food or water supplies.
Responders	Responders face similar risks as the general public but a heightened potential for exposure to hazardous materials.
Continuity of Operations (including Continued Delivery of Services)	A hazardous materials incident may cause temporary road closures or other localized impacts but is unlikely to affect continuity of operations.
Property, Facilities and Infrastructure	Some hazardous materials are flammable, explosive, and/or corrosive, which could result in structural damages to property. Impacts would be highly localized.
Environment	Consequences depend on the type of material released. Possible ecological impacts include loss of wildlife, loss of habitat, and degradation of air and/or water quality.
Economic Condition of the Jurisdiction	Clean up, remediation, and/or litigation costs may apply. Long-term economic damage is unlikely.
Public Confidence in the Jurisdiction's Governance	A hazardous materials incident may affect public confidence if the environmental or health impacts are enduring.

Hazard Summary by Jurisdiction

The following table summarizes hazardous materials hazard risk by jurisdiction. With the exception of probability, based on past occurrences, this risk is not expected to vary substantially between jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	2	2	1	4	2	2.0	M
Immokalee Reservation	2	2	1	4	2	2.0	M
Marco Island	2	2	1	4	2	2.0	M
Naples	3	2	1	4	2	2.3	M
Unincorporated Collier County	2	2	1	4	2	2.0	M

2.5.16 Coastal Oil Spills

Hazard Description

As defined in the 2018 Florida State Hazard Mitigation Plan, an oil spill is the release of crude oil, or liquid petroleum, into the environment. Usually associated with marine spills, they 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 major effects including continual damage to the environment and a financial loss to communities affected.

As of January 2020, there are 22 operating rigs in the Gulf of Mexico, 21 drilling for crude oil and 1 drilling for natural gas. While there are currently no drilling rigs on the east coast of Florida, the U.S. 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. As of January 2020, Florida produced about 5 thousand barrels of crude oil a day, or about 1.83 million barrels a year.

An oil spill could have severe detrimental impacts on the natural environment, primarily impacting shorelines and beaches. Given Collier County's dependence on tourism, which relies heavily on beach access, an oil spill could have a catastrophic impact on the county's economy. In Collier County, tourism is the leading employer and the primary economic engine. The tourism industry provides over 38,500 jobs in Collier County. In 2018, Collier County had over 2 million tourists visit the state, spending an estimated $1.5 billion, resulting in a total economic impact of over $2.1 billion to Collier County.

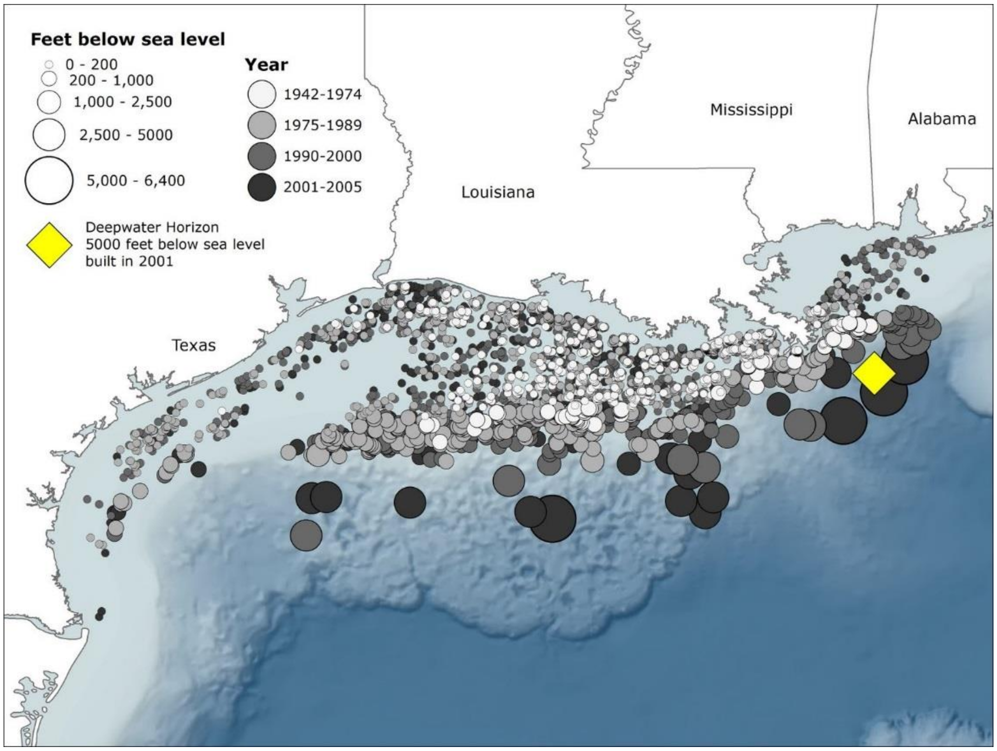
Warning Time: 3 – 6 to 12 hours

Duration: 4 – More than 1 week

Location

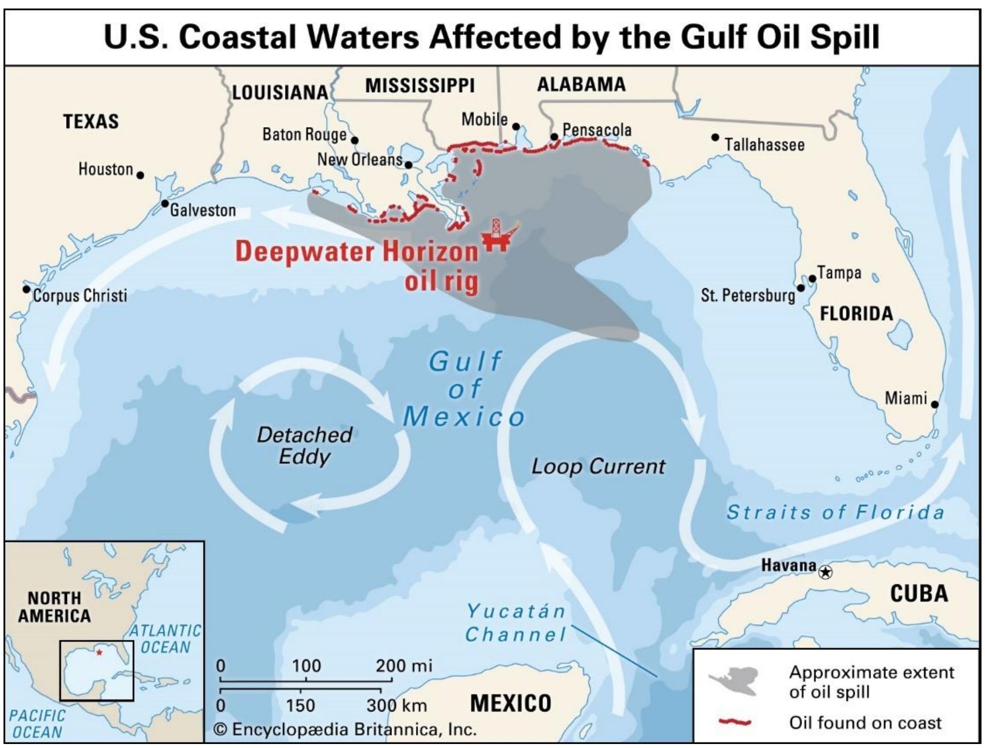
While there are no drilling rigs off the coast of Collier County, Figure 2.45 shows the location of oil drilling rigs in the Gulf of Mexico by feet below sea level and year. It also shows the location of the Deepwater Horizon accident. Figure 2.46 shows the extent of the most devastating oil spill in the Gulf of Mexico to date, Deepwater Horizon, detailed in the historical occurrences section below.

Figure 2.45 – Location of Oil Drilling Rigs in the Gulf of Mexico



Source: DeepSeaNews.com

Figure 2.46 – Extent of the Deepwater Oil Spill



Source: Encyclopedia Britannica

Extent

The extent of coastal oil spills can vary greatly. On average, 1.3 million gallons of petroleum are spilled in U.S. waters every year. The Deepwater Horizon spill released 210 million gallons. The consequential extent, or the extent of organisms, mammals, and the environment that are negatively affected can be huge. However, given the lack of oil rigs off the coast of Collier County, current extent is limited. Oil spills could still result from tankers while oil is being transported.

Impact: 2 – Limited

Spatial Extent: 2 – Small

Historical Occurrences

The following information on the Deepwater Horizon spill was reported in the 2018 State Hazard Mitigation Plan:

In April 2010, an explosion occurred on BP's Macondo Prospect drilling rig in the Gulf of Mexico causing the largest marine oil spill in history. This was named the Deepwater Horizon oil spill. The Florida impacts of the 2010 Deepwater Horizon incident were 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. The spill lasted for five months though some reports say that it had been leaking for so long, that it could have been a 14-year long oil spill. Eleven people were killed and another seventeen were injured from the wellhead blowout that caused the leak.

As a result of the Deepwater Horizon spill, Florida began funding remediation projects with settlements from the spill, including with non-operating investors. There are 131 projects which include stormwater management, habitat restoration, unpaved roads and wetland initiatives, water quality improvements. Three of these projects are just north of Collier in Lee and Charlotte Counties. The website floridadep.gov/wra/deepwater-horizon details the Deepwater Horizon Program and links to a story map highlighting all the projects.

Probability of Future Occurrence

Since the U.S. is reliant on fossil fuels such as oil, and accidents happen, it is highly likely that another oil spill in the Gulf of Mexico will occur again. However, the probability of an oil spill impacting the Collier County coast is lower.

Probability: 2 – Possible

Climate Change

Climate change is not expected to impact coastal oil spills. Though climate change in addition to a coastal oil spill could be detrimental for environmental, animal, and human health.

Vulnerability Assessment

Oil spill damage is directly related to the amount of oil spilled in which locations and the movement of the currents.

People

Some injuries but no human deaths have been recorded from an oil spill. However, there were a total of eleven deaths and seventeen injuries from the explosion that caused the Deepwater Horizon oil spill.

Property

Oil spills can cause severe property damage to oil rigs, pipeline infrastructure, and beaches and cost lots of money for clean-up.

Environment

Oil spills can be one of the most harmful hazards for the environment. Many aquatic ecosystems can be destroyed and take hundreds of years to replenish. There are often huge numbers of dead or sick aquatic life after oil spills. It is estimated that only 2% of the marine life carcasses from the Deepwater Horizon spill were found or washed up.

Consequence Analysis

Table 2.75 details the consequences of a coastal oil spill.

Table 2.75 – Consequence Analysis – Coastal Oil Spills

Category	Consequences
Public	Localized impact expected to be severe for affected areas and moderate to light for other less affected areas.
Responders	Adverse impact expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations (including Continued Delivery of Services)	Localized disruption of trade or ferry routes and higher demand of petroleum, therefore creating a price increase) caused by incident may postpone delivery or use of some services.
Property, Facilities and Infrastructure	Localized impact to facilities and infrastructure in the areas of the incident. Beaches most adversely affected.
Environment	Environmental damage to beaches, marine life, aquatic ecosystems, and other life forms who get sustenance from the water.
Economic Condition of the Jurisdiction	Local economy and finances may be adversely affected, depending on damage. The tourism industry could take a large hit.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery is not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes coastal oil spill hazard risk by jurisdiction. Jurisdictions with shoreline at risk were assigned a probability of 2 (possible), an impact of 2 (limited), and a spatial extent of 2 (small). Jurisdictions with little to no shoreline at risk were assigned a probability score of 1 (unlikely), an impact of 1 (minor), and a spatial extent of 1 (negligible). Warning time and duration are inherent to the hazard and remain constant across jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	2	2	2	3	4	2.3	M

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Immokalee Reservation	1	1	1	3	4	1.5	L
Marco Island	2	2	2	3	4	2.3	M
Naples	2	2	2	3	4	2.3	M
Unincorporated Collier County	2	2	2	3	4	2.3	M

2.5.17 Nuclear Power Plant

Hazard Background

A radiological incident is an occurrence resulting in the release of radiological material at a fixed facility (such as power plants, hospitals, laboratories, etc.) or in transit.

Radiological incidents related to transportation are described as an incident resulting in a release of radioactive material during transportation. Transportation of radioactive materials through Florida over the interstate highway system is considered a radiological hazard. The transportation of radioactive material by any means of transport is licensed and regulated by the federal government. As a rule, there are two categories of radioactive materials that are shipped over the interstate highways:

- Low level waste consists primarily of materials that have been contaminated by low level radioactive substances but pose no serious threat except through long-term exposure. These materials are shipped in sealed drums within placarded trailers. The danger to the public is no more than a wide array of other hazardous materials.
- High level waste, usually in the form of spent fuel from nuclear power plants, is transported in specially constructed casks that are built to withstand a direct hit from a locomotive.

Radiological emergencies at nuclear power plants are divided into classifications. Table 2.76 shows these classifications, as well as descriptions of each.

Table 2.76 – Radiological Emergency Classifications

Emergency Classification	Description
Notification of Unusual Event (NOUE)	Events are in progress or have occurred which indicate a potential degradation of the level of safety of the plant or indicate a security threat to facility protection has been initiated. No releases of radioactive material requiring offsite response or monitoring are expected unless further degradation of safety systems occurs.
Alert	Events are in progress or have occurred which involve an actual or potential substantial degradation of the level of safety of the plant or a security event that involves probable life-threatening risk to site personnel or damage to site equipment because of hostile action. Any releases are expected to be limited to small fractions of the Environmental Protection Agency (EPA) Protective Action Guides (PAGs)
Site Area Emergency (SAE)	Events are in progress or have occurred which involve actual or likely major failures of plant functions needed for protection of the public or hostile action that results in intentional damage or malicious acts; 1) toward site personnel or equipment that could lead to the likely failure of or; 2) that prevent effective access to, equipment needed for the protection of the public. Any releases are not expected to result in exposure levels which exceed EPA PAG exposure levels beyond the site boundary.
General Emergency	Events are in progress or have occurred which involve actual or imminent substantial core degradation or melting with potential for loss of containment integrity or hostile action that results in an actual loss of physical control of the facility. Releases can be reasonably expected to exceed EPA PAG exposure levels offsite for more than the immediate site area.

Warning Time: 4 – Less than 6 hours

Duration: 4 – More than one week

Location

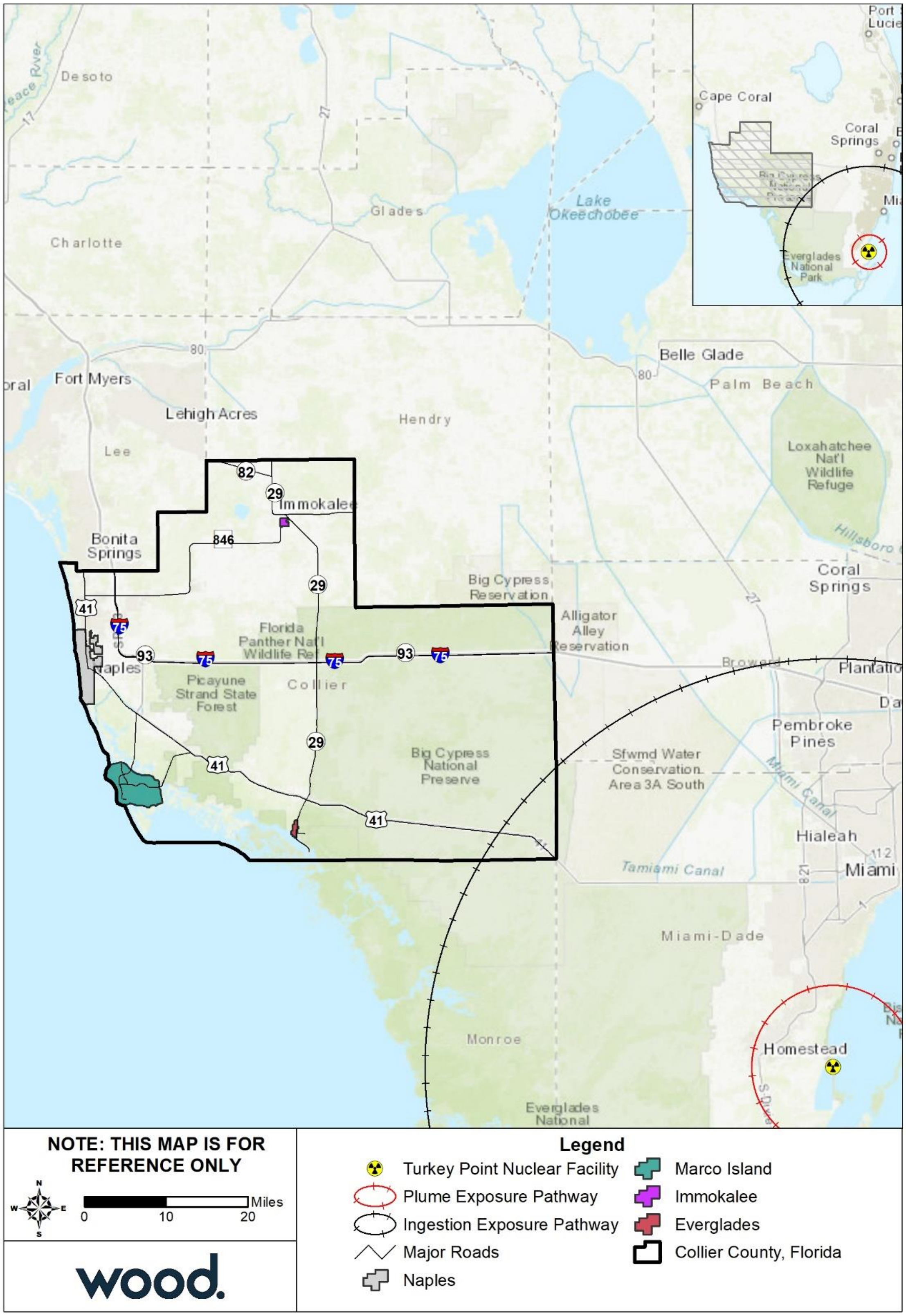
Turkey Point Nuclear Generating Station, located in the south of Miami-Dade County and southeast of the planning area, is a twin reactor nuclear power station. It has three currently operating units including two 802-megawatt units (units 3 and 4) and one 1,150-megawatt unit (unit 5). There are two retired 404-megawatt units (units 1 and 2) still on-site. Commercial operation began in 1967 and the most recent unit was completed in 2007. Units 3 and 4 are pressurized water reactors and unit 5 is a combined-cycle gas-fired unit. As the sixth largest power plant in the United States and third largest in Florida, it serves all of southern Florida. The plant is operated with a very high level of security. This is the location from which the most catastrophic nuclear accident might occur and will be the focal point of the nuclear analysis in this plan.

The Nuclear Regulatory Commission defines two emergency planning zones around nuclear plants:

- **Emergency Planning Zone (EPZ)** – The EPZ is a 10-mile radius around nuclear facilities. It is also known as the Plume Exposure Pathway. Areas located within this zone are at highest risk of exposure to radioactive materials. Within this zone, the primary concern is exposure to and inhalation of radioactive contamination. Predetermined action plans within the EPZ are designed to avoid or reduce dose from such exposure. Residents within this zone would be expected to evacuate in the event of an emergency. Other actions such as sheltering, evacuation, and the use of potassium-iodide must be taken to avoid or reduce exposure in the event of a nuclear incident.
- **Ingestion Pathway Zone (IPZ)** – The IPZ is delineated by a 50-mile radius around nuclear facilities as defined by the federal government. Also known as the Ingestion Exposure Pathway, the IPZ has been designated to mitigate contamination in the human food change resulting from a radiological accident at a nuclear power facility. Contamination to fresh produce, water supplies, and other food produce may occur when radionuclides are deposited on surfaces.

Figure 2.47 shows the location of Turkey Point Nuclear Generating Station and the approximate 10-mile Emergency Planning Zone (EPZ) buffer and 50-mile Ingestion Pathway Zone (IPZ) around the plant. While none of the counties or communities in the planning area fall into the 10-mile EPZ, the southeast corner of Collier County is included in the 50-mile IPZ.

Figure 2.47 – Turkey Point Nuclear Generating Station Location in Relation to Planning Area

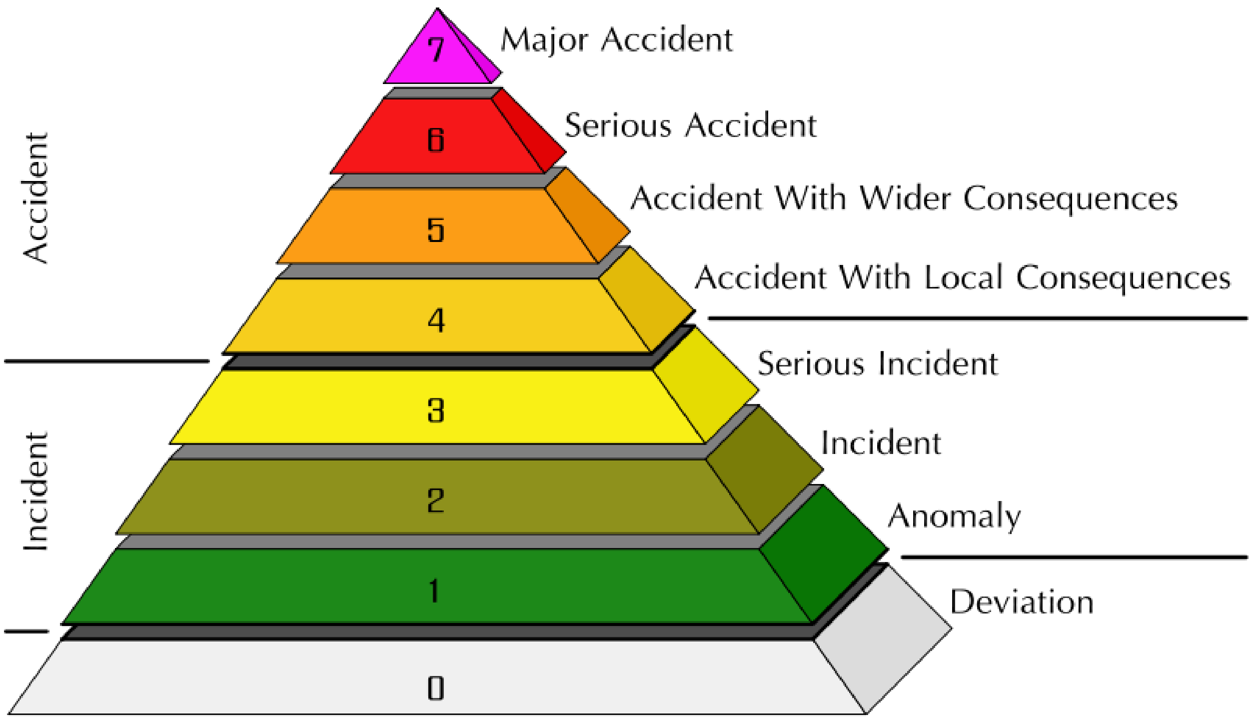


Source: U.S. Energy Information Administration

The Nuclear Regulatory Commission defines two emergency planning zones around nuclear plants. Areas located within 10 miles of the station are within the zone of highest risk to a nuclear incident and this radius is the designated evacuation radius recommended by the Nuclear Regulatory Commission. Within the 10-mile zone, the primary concern is exposure to and inhalation of radioactive contamination. The most concerning effects in the secondary 50-mile zone are related to ingestion of food and liquids that may have been contaminated. All areas of the county that are located within this 50-mile radius that are still considered to be at risk from a nuclear incident.

Extent

The International Atomic Energy Association (IAEA) developed the International Nuclear and Radiological Event Scale to quantify the magnitude of radiological events. This scale is logarithmic, meaning each increasing level represents a 10-fold increase in severity compared to the previous level.



Source: International Atomic Energy Association

Impact: 4 – Catastrophic

Spatial Extent: 2 – Small

Historical Occurrences

May 8, 1974 – During a routine test, it was discovered that two of the three Emergency Feedwater pumps which served unit 3 failed due to overtightened packing. The third pump also failed but was caused by a malfunction in the turbine. These failures, had they not been found and corrected, could have led to a nuclear disaster if other failures had occurred simultaneously.

August 24, 1992 – Category 5 Hurricane Andrew hit Turkey Point causing damage to many systems. The fire protection systems were partly disabled, two raw water tanks were destroyed, a third was drained, and the smokestack on unit 1 cracked. Offsite power was lost so onsite generators had to be operated for numerous days.

February 26, 2008 – The loss of offsite power prompted both reactors to shut down which lead to a widespread power outage affecting 700,000 customers and a total of 2.5 million people. The originating event was an overheated voltage switch that caught fire in a substation 23 miles away from Turkey Point. Power was restored within 5 hours of the blackout. Large commercial locations such as Walt Disney World, Orlando International Airport, and Miami International Airport were affected.

March 18, 2017 – An electrical fault happened in unit 3 causing the loss of a safety system and a reactor trip. This fault caused an arc flash which minorly burned one plant worker. All other safety systems were operational so there was no threat to the community or environment.

Probability of Future Occurrence

Radiological hazards are highly unpredictable. Nuclear reactors present the possibility of catastrophic damages, yet the industry is highly regulated and historical precedence suggests an incident is unlikely.

Probability: 1 – Unlikely

Climate Change

Climate change is not projected to have any impact on a potential nuclear power plant incident.

Vulnerability Assessment

People

People within the 50-mile EPZ are at risk of exposure through ingestion of contaminated food and water. Low levels of radiation are not considered harmful, but a high exposure to radiation can cause serious illness or death.

Property

A radiological incident could cause severe damage to the power station itself but would not cause direct property damage outside the station, especially with the distance between the reactor and the planning area. However, property values could drop substantially if a radiological incident resulted in contamination of nearby areas.

Environment

A radiological incident could result in the spread of radioactive material into the environment, which could contaminate water and food sources and harm animal and plant life. These impacts are lessened the further an area is to the plant site.

Consequence Analysis

Table 2.77 summarizes the potential detrimental consequences of radiological incident.

Table 2.77 – Consequence Analysis – Radiological Incident

Category	Consequences
Public	High levels of radiation could cause serious illness or death. Those living and working closest to the nuclear plant would face the greatest risk of exposure.
Responders	Responders face potential for heightened exposure to radiation, which could cause severe chronic illness and death.
Continuity of Operations (including Continued Delivery of Services)	An incident at the nuclear plant could interrupt power generation and cause power shortages. Regular operations would likely be affected by the response effort an event would require.

Category	Consequences
Property, Facilities and Infrastructure	The plant itself could be damaged by a radiological incident. Nearby property and facilities could be affected by contamination.
Environment	Water supplies, food crops, and livestock within 50 miles of the nuclear plant could be contaminated by radioactive material in the event of a major incident.
Economic Condition of the Jurisdiction	The local economy could be affected if a radiological incident caused contamination of nearby areas. Property values and economic activity could decline as a result.
Public Confidence in the Jurisdiction's Governance	A radiological incident would likely cause severe loss of public confidence given that the hazard is human-caused and highly regulated. Public confidence can also be affected by false alarms.

Hazard Summary by Jurisdiction

The following table summarizes nuclear power plant risk by jurisdiction. Jurisdictions overlapping the Ingestion Pathway Zone of the closest nuclear power plant were given an impact of 4 (catastrophic) and a spatial extent of 2 (small). Jurisdictions further away from the IPZ were given an impact of 3 (critical) and a spatial extent of 1 (negligible). Probability, warning time, and duration are uniform across jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	1	3	1	4	4	2.2	M
Immokalee Reservation	1	3	1	4	4	2.2	M
Marco Island	1	3	1	4	4	2.2	M
Naples	1	3	1	4	4	2.2	M
Unincorporated Collier County	1	4	2	4	4	2.7	H

2.5.18 Terrorism

Hazard Description

There is no universal globally agreed-upon definition of terrorism. In a broad sense, terrorism is the use of violence and threats to intimidate or coerce, especially against civilians, in the pursuit of political aims. Terrorism is defined in the United States by the Code of Federal Regulations as “the unlawful use of force or violence against persons or property to intimidate or coerce a government, civilian population, or any segment thereof, in furtherance of political or social objectives.”

For this analysis, this hazard encompasses the following sub-hazards: enemy attack, biological terrorism, chemical terrorism, conventional terrorism, and radiological terrorism. These hazards can occur anywhere and demonstrate unlawful force, violence, and/or threat against persons or property causing intentional harm for purposes of intimidation, coercion or ransom in violation of the criminal laws of the United States. These actions may cause massive destruction and/or extensive casualties. The threat of terrorism, both international and domestic, is ever present, and an attack can occur when least expected.

Enemy attack is an incident that could cause massive destruction and extensive casualties throughout the world. Some areas could experience direct weapons’ effects: blast and heat; others could experience indirect weapons’ effect. International political and military activities of other nations are closely monitored by the federal government and the State of Florida would be notified of any escalating military threats.

The use of biological agents against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion or ransom can be described as biological terrorism. Liquid or solid contaminants can be dispersed using sprayers/aerosol generators or by point of line sources such as munitions, covert deposits and moving sprayers. Biological agents vary in the amount of time they pose a threat. They can be a threat for hours to years depending upon the agent and the conditions in which it exists.

Chemical terrorism involves the use or threat of chemical agents against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion or ransom. Effects of chemical contaminants are like those of biological agents.

Use of conventional weapons and explosives against persons or property in violation of the criminal laws of the United States for purposes of intimidations, coercion, or ransom is conventional terrorism. Hazard effects are instantaneous; additional secondary devices may be used, lengthening the time duration of the hazard until the attack site is determined to be clear. The extent of damage is determined by the type and quantity of explosive. Effects are generally static other than cascading consequences and incremental structural failures. Conventional terrorism can also include tactical assault or sniping from remote locations.

Radiological terrorism is the use of radiological materials against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion or ransom. Radioactive contaminants can be dispersed using sprayers/aerosol generators, or by point of line sources such as munitions, covert deposits and moving sprayers or by the detonation of a nuclear device underground, at the surface, in the air or at high altitude.

Electronic attack using one computer system against another in order to intimidate people or disrupt other systems is a cyber-attack. All governments, businesses and citizens that conduct business utilizing computers face these threats. Cyber-security and critical infrastructure protection are among the most important national security issues facing our country today. The Florida Department of Law Enforcement

Computer Crime Center helps law enforcement across the State solve sophisticated crimes involving digital evidence. Cyber attack is discussed in greater detail in Section 2.5.21.

Mass demonstrations, or direct conflict by large groups of citizens, as in riots and non-peaceful strikes, are examples of public disorder. These are assembling of people together in a manner to substantially interfere with public peace to constitute a threat, and with use of unlawful force or violence against another person, or causing property damage or attempting to interfere with, disrupting, or destroying the government, political subdivision, or group of people. Labor strikes and work stoppages are not considered in this hazard unless they escalate into a threat to the community. Vandalism is usually initiated by a small number of individuals and limited to a small target or institution. Most events are within the capacity of local law enforcement. Civil disturbance is discussed in greater detail in Section 2.5.20.

The Southern Poverty Law Center (SPLC) reports 75 active hate groups in Florida, shown in Table 2.78. The SPLC defines a hate group as any group with “beliefs or practices that attack or malign an entire class of people – particularly when the characteristics being maligned are immutable.” It is important to note that inclusion on the SPLC list is not meant to imply that a group advocates or engages in violence or other criminal activity.

Table 2.78 – Hate Groups Active in Florida

Group	Type	Location
Legal Immigrants for America	Anti-Immigrant	Winter Springs
American College of Pediatricians	Anti-LGBT	Gainesville
D. James Kennedy Ministries	Anti-LGBT	Fort Lauderdale
Liberty Counsel	Anti-LGBT	Orlando
Stedfast Baptist Church	Anti-LGBT	Jacksonville
ACT for America	Anti-Muslim	Heathrow
ACT for America	Anti-Muslim	Jacksonville
Citizens for National Security	Anti-Muslim	Boca Raton
Citizens' Action Group of South Florida	Anti-Muslim	Hollywood
Cultures In Context Incorporated/Turning Point Project	Anti-Muslim	Immokalee
Florida Family Association	Anti-Muslim	Tampa
Soldiers of Odin	Anti-Muslim	N/A
Straight Way and More, The	Anti-Muslim	Venice
United West, The	Anti-Muslim	Lake Worth
Army of Israel	Black Nationalist	Orlando
Great Millstone	Black Nationalist	Miami
Great Millstone	Black Nationalist	Tampa
Israel United In Christ	Black Nationalist	Orlando
Israel United In Christ	Black Nationalist	Tallahassee
Israel United In Christ	Black Nationalist	Miami
Israel United In Christ	Black Nationalist	Jacksonville
Israelite Church of God in Jesus Christ, The	Black Nationalist	West Palm Beach
Israelite School of Universal Practical Knowledge	Black Nationalist	Jacksonville
Israelite School of Universal Practical Knowledge	Black Nationalist	Tampa
Nation of Islam	Black Nationalist	Tampa
Nation of Islam	Black Nationalist	Saint Petersburg
Nation of Islam	Black Nationalist	Pensacola
Nation of Islam	Black Nationalist	Miami
Nation of Islam	Black Nationalist	Jacksonville
Nation of Islam	Black Nationalist	Fort Lauderdale

Group	Type	Location
Nation of Islam	Black Nationalist	Orlando
Nation of Kings and Priests	Black Nationalist	Orlando
New Black Panther Party for Self Defense	Black Nationalist	Tampa Bay
New Black Panther Party for Self Defense	Black Nationalist	Jacksonville
New Black Panther Party for Self Defense	Black Nationalist	Tallahassee
Sicarii 1715	Black Nationalist	Orlando
Christogenea	Christian Identity	Panama City
Gallows Tree Wotansvolk Alliance	General Hate	N/A
American Guard	General Hate	N/A
Bill Keller Ministries	General Hate	St. Petersburg
Insight USA	General Hate	Longwood
Proud Boys	General Hate	Jacksonville
Proud Boys	General Hate	Tampa
Proud Boys	General Hate	DeLand
Proud Boys	General Hate	Miami
Sharkhunters International	General Hate	Hernando
American Christian Dixie Knights of the Ku Klux Klan	Ku Klux Klan	N/A
International Keystone Knights of the Ku Klux Klan	Ku Klux Klan	N/A
Loyal White Knights of the Ku Klux Klan	Ku Klux Klan	N/A
Traditionalist American Knights of the Ku Klux Klan	Ku Klux Klan	N/A
Identity Dixie	Neo-Confederate	N/A
League of the South	Neo-Confederate	Lake City
League of the South	Neo-Confederate	Hialeah
League of the South	Neo-Confederate	Panama City
League of the South	Neo-Confederate	Ocala
League of the South	Neo-Confederate	Jacksonville
League of the South	Neo-Confederate	N/A
Atomwaffen Division	Neo-Nazi	N/A
Creativity Alliance, The	Neo-Nazi	N/A
Endangered Souls RC/Crew 519	Neo-Nazi	N/A
National Socialist Movement	Neo-Nazi	N/A
Traditionalist Worker Party	Neo-Nazi	N/A
Confederate Hammerskins	Racist Skinhead	N/A
Crew 38	Racist Skinhead	N/A
Firm 22	Racist Skinhead	N/A
United Southern Skins	Racist Skinhead	N/A
Vinlanders Social Club	Racist Skinhead	N/A
American Freedom Party	White Nationalist	Lakewood Ranch
American Freedom Party	White Nationalist	Bradenton
Identity Evropa	White Nationalist	Gainesville
Identity Evropa	White Nationalist	Lakeland
Patriot Front	White Nationalist	N/A
Real Republic of Florida	White Nationalist	Tallahassee
Stormfront	White Nationalist	West Palm Beach
The Right Stuff	White Nationalist	N/A

Source: Southern Poverty Law Center, 2018, https://www.splcenter.org/hate-map

One hate group identified by the SPLC has a known footprint in Collier County: Cultures in Context Incorporated/ Turning Point Project in Immokalee.

Warning Time: 4 – Less than 6 hours

Duration: 1 – *Less than 6 hours*

Generally, no warning is given for specific acts of terrorism. Duration is dependent on the vehicle used during the terrorist attack. This score considers a prolonged scenario with continuous impacts.

Location

A terror threat could occur at any location in the County, but are more likely to target highly populated areas, critical infrastructure, or symbolic locations. Any of the critical facilities identified by the LMS working group could be targeted. Per the 2015 Local Mitigation Strategy, the LMS working group chose not to analyze the risks associated with terrorist attacks given the low probability of occurrence.

Extent

The extent of a terrorist incident is tied to many factors, including the attack vector, location, time of day, and other circumstances; for this reason, it is difficult to put assess a single definition or conclusion of the extent of "terrorism." As a general rule, terrorism incidents are targeted to where they can do the most damage and have the maximum impact possible, though this impact is tempered by the weapon used in the attack itself.

Impact: 4 – Catastrophic

Spatial Extent: 1 – Negligible

Historical Occurrences

As noted in the previous Collier County Local Mitigation Strategy, there have been no major terror events in the County, thus the hazard risk had not previously been analyzed. There is still, however, some possibility that one could occur in the future given the incidents that have occurred in the United States in the past and the facilities and locations in the county that could be potential targets.

Probability of Future Occurrence

While difficult to estimate when a deliberate act like terrorism may occur, it can be inferred that the probability of a terrorist attack in any one area in the County is very low at any given time. When identified, credible threats may increase the probability of an incident; these threats are generally tracked by law enforcement.

Probability: 1 – Unlikely

Climate Change

Climate change is not expected to influence terrorism. However, climate change could cause more protests, gatherings, or votes which could be targets for terrorism.

Vulnerability Assessment

Methodologies and Assumptions

Vulnerability to terrorism was assessed through hypothetical scenarios. These scenarios were modeled using the Electronic Mass Casualty Assessment and Planning Scenarios (EMCAPS) tool developed by the Johns Hopkins Office of Critical Event Preparedness and Response, Johns Hopkins Applied Physics Laboratory, the U.S. Department of Homeland Security, and the National Center for the Study of Preparedness and Catastrophic Event Response.

People

People can suffer death or illness as a result of a terrorist attack. Symptoms of illness from a biological or chemical attack may go undetected for days or even weeks. Local healthcare workers may observe a pattern of unusual illness or early warning monitoring systems may detect airborne pathogens. People will face increased risk if a biological or chemical agent is released indoors, as this may result in exposure to a higher concentration of pathogens, whereas agents that are released outdoors would disperse in the direction of the wind. Physical harm from a weapons attack or explosive device is not dependent on location, but risk is greater in areas where higher numbers of people may gather. People could also be affected by an attack on food and water supply. In addition to impacts on physical health, any terrorist attack could cause significant stress and anxiety.

Property

The potential for damage to property is highly dependent on the type of attack. Buildings and infrastructure may be damaged by an explosive device or by contamination from a biological or chemical attack. Impacts are generally highly localized to the target of the attack.

Environment

Environmental impacts are also dependent on the type of attack. Impacts could be negligible or could require major clean-up and remediation.

Consequence Analysis

Table 2.79 summarizes the potential detrimental consequences of a terror threat.

Table 2.79 – Consequence Analysis – Terrorism

Category	Consequences
Public	Illness, injury, or fatality are possible; these impacts would be highly localized to the attack. Widespread stress and psychological suffering may occur.
Responders	Responders face increased risks during an effort to stop an attack or rescue others while an attack is underway.
Continuity of Operations (including Continued Delivery of Services)	Critical infrastructure may be targeted by an attack; therefore, continuity of operations may be affected. Long-term issues may arise if transportation or utility infrastructure is severely damaged.
Property, Facilities and Infrastructure	Impacts depend of the type of attack. Buildings and infrastructure could be unaffected or completely destroyed.
Environment	Water and food supply could be contaminated by a biological or chemical attack. Remediation could be required.
Economic Condition of the Jurisdiction	The local economy could be disrupted, depending on the location and scale of an attack.
Public Confidence in the Jurisdiction's Governance	Loss of public confidence likely should an attack be carried out; additional loss of confidence and trust may result if response and recovery are not swift and effective

Hazard Summary by Jurisdiction

The following table summarizes terrorism hazard risk by jurisdiction. This risk is not expected to change substantially between jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	1	4	1	4	1	2.2	M

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Immokalee Reservation	1	4	1	4	1	2.2	M
Marco Island	1	4	1	4	1	2.2	M
Naples	1	4	1	4	1	2.2	M
Unincorporated Collier County	1	4	1	4	1	2.2	M

2.5.19 Mass Migration Incident

Hazard Description

Florida is the closest State to the Caribbean Basin, and Collier County's location on the Gulf Coast and the southern-most tip of the peninsula makes it a possible point of entry for a massive influx of immigrants and refugees wishing to enter the United States. Immigrants and refugees in Florida typically come from the Caribbean, Mexico, and South America. Their arrival can threaten the health, safety, and welfare of citizens as well as of their own if they are detained for a long period. The state of Florida has developed a federal Mass Immigration Annex with the federal government which covers the gap between the federal Mass Immigration Plan and the National Response Framework. Enforcement of immigration laws remains the responsibility of the federal government; however, Collier County officials may need to coordinate with state and federal agencies in response to a mass migration event.

Mass Migration

Mass migration, according to U.S. Code, is defined as "a migration of undocumented aliens that is of such magnitude and duration that it poses a threat to the national security of the United States, as determined by the President." This is most often an event or multiple events which can happen over several years. It can be driven by an event that is economic, social, or political, causing the desire of people to leave one country for another. A continuous and high-volume flow of migrants over a period of time could exceed the normal capabilities of the local offices of the United States Coast Guard and Customs and Border Protection. Undocumented individuals may find it difficult to assimilate without affecting local economies and infrastructure that are already strained. The Pew Research Center estimates that in fiscal year 2014, Florida had an influx of 850,000 (+/- 40,000) undocumented migrants and that the state experienced growth in undocumented population at the national average of 250%.

Unaccompanied Minors

Unaccompanied minors are children who arrive in the United States alone or who are required to appear in immigration court on their own. An unaccompanied alien child (UAC) is a technical term for a child who doesn't have immigration status in the U.S., is not yet 18 years of age, and who has no parent or legal guardian in the U.S., or whose parent or legal guardian in the U.S. is unable to provide care and physical custody. These children often leave their home countries and join some of their family already in the U.S. They move for any number of reasons which could include to escape abuse, persecution or exploitation in their home country or to seek employment or educational opportunities in the United States. Unaccompanied children are especially vulnerable to human trafficking, exploitation, and abuse since they are young and often traveling alone. When an unaccompanied child is picked up by immigration authorities, the child is transferred to the care and protection of the Office of Refugee Resettlement (ORR). Federal law requires that ORR feed, shelter, and provide medical care for unaccompanied children until they can release them to safe settings with sponsors (usually family members), while they await immigration proceedings. According to the U.S. Department of Health & Human Services, Collier County had a total of 186 unaccompanied minors released to sponsors in 2017.

Mass Immigration

Immigration is defined as the movement of people to another country, where they are not natives or citizens, in order to live there. The U.S. Code defines an immigrant or alien as an applicant for admission into the United States at a port-of-entry or a person apprehended in international or U.S. waters and brought into the U.S. by any means in any location. Migration or immigration was the primary source of Florida's population growth in 2015 with 86% of the growth due to net migration and immigration. Miami-

Dade County, which borders Collier, saw one quarter of Florida's foreign immigrants between 2005 and 2009. An influx of immigrants to Collier County could overwhelm the local economy and infrastructure.

Warning Time: 3 – 6 to 12 hours

Duration: 4 – More than 1 week

Location

A mass migration incident could affect the entire County though the likely point of entry is along the coast line. Collier County is in proximity to islands such as Cuba, Puerto Rico, Dominican Republic and Haiti, and the Gulf Coast is within proximity of Mexico. Mass migration can also occur domestically due to an impending hazard causing large groups of people to evacuate.

Extent

A mass migration event could affect the entirety of Collier County though migrants are likely to settle in areas of the County with existing populations of their same origin.

Impact: 3 – Critical

Spatial Extent: 3 – Moderate

Historical Occurrences

While there are no documented historical occurrences of mass migration to or within Collier County, the County does have a documented immigrant population. According to the U.S. Census Bureau's 2013-2017 American Community Survey, Collier County is home to 19,300 immigrants from Mexico and 29,000 immigrants from the Caribbean. These immigration statistics could be the result of previous migration events.

Probability of Future Occurrence

There's no real way to predict mass migration events since most occur without warning. However, we can assume there is a high likelihood of future occurrence due to Collier County's geographic location on the coast. Political unrest in the Caribbean region or Mexico could be an early indicator. As stated above, Collier County already has an immigrant population from the Caribbean and Mexico and it will likely be the destination during future migrations.

Probability: 2 – Possible

Climate Change

Climate change will most likely affect mass migration indirectly by causing more severe storms, sea level rise, drought and increased earthquakes that may cause specific areas around the world to become uninhabitable. Climate change refugees may be forced to leave uninhabitable locations.

Vulnerability Assessment

People

A mass migration incident could result in loss of life or, injury to those involved in the migration. Also, fear of going to law enforcement can lead to undocumented individuals not seeking help or evacuating in the event of a hazard. If undocumented individuals do evacuate, the additional population numbers may result in congestion and overpopulation of shelters. Migrant people may also have limited resources available to them such as food, school, water, work, translators, and housing.

Public safety resources could be strained or depleted causing community wide problems. Local law enforcement is affected with added population and confrontation with undocumented individuals.

Property

A mass migration may cause strain on detention facilities if there is an intervention. Undocumented families can place a strain on local schools and facilities within a community, and Social services may be strained to accommodate incoming immigrants/migrants and unaccompanied children.

Environment

According to the Center for Immigration Studies, immigration-driven population growth impacts the environment in the following ways:

- Loss of biodiversity and species extinction: overpopulation threatens animal species through consumption of resources, loss of habitat and environmental pollution.
- Water shortages: immigration places an increased demand on water supply which may already be limited due to drought conditions.
- Urban sprawl: the expansion of cities leads to reduced farmlands and grassland which results in reduced habitat for animal species. Furthermore, increased development likely results in flooding and water pollution due to an increase in runoff.
- Overcrowding and carbon emissions: overcrowding places a strain on public utilities and mass transit. Furthermore, immigration transfers carbon emissions from likely more rural areas to more populated areas which already sustain higher levels of carbon emissions per person.

Consequence Analysis

Table 2.80 shows the consequences of a mass migration incident.

Table 2.80 – Consequence Analysis – Mass Migration Incident

Category	Consequences
Public	Loss of life, injury, and limited food, water, or shelter available.
Responders	Impacts expected to be severe for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations (including Continued Delivery of Services)	Localized disruption of public safety resources and public services because of overwhelming numbers of migrants and lack of resources.
Property, Facilities and Infrastructure	Localized impact to facilities and infrastructure in the areas of migration. Lack of housing available.
Environment	Environmental damage to locations seeing large impacts from migration.
Economic Condition of the Jurisdiction	Local economy and finances may be affected, depending on number of migrants.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes mass migration incident hazard risk by jurisdiction. This risk is not expected to change substantially between jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	2	3	3	3	4	2.8	H

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Immokalee Reservation	2	3	3	3	4	2.8	H
Marco Island	2	3	3	3	4	2.8	H
Naples	2	3	3	3	4	2.8	H
Unincorporated Collier County	2	3	3	3	4	2.8	H

2.5.20 Civil Disturbance

Hazard Background

Civil disorder is a term that generally refers to groups of people purposely choosing not to observe a law, regulation, or rule, usually in order to bring attention to a cause, concern, or agenda. Civil disorder can take the form of small gatherings or large groups blocking or impeding access to a building or disrupting normal activities by generating noise and intimidating people. They can range from a peaceful sit-in to a full-scale riot in which a mob burns or otherwise destroys property and terrorizes individuals. Even in its more passive forms, a group that blocks roadways, sidewalks, or buildings interferes with public order. In the 1990s abortion clinics, for example, were targets for these disruptive-type activities.

Throughout this country's history, incidents that disrupted the public peace have figured prominently. The constitutional guarantees allow for ample expression of protest and dissent, and in many cases collide with the preamble's requirement of the government "to ensure domestic tranquility." Typical examples of such conflicting ideology include the protest movements for civil rights in the late 1960s and the Vietnam War protest demonstrations in the early 1970s. The balance between an individual's and group's legitimate expression of dissent and the right of the populace to live in domestic tranquility requires the diligent efforts of everyone to avoid such confrontations in the future.

In modern society, laws have evolved that govern the interaction of its members to peacefully resolve conflict. In the United States, a crowd itself is constitutionally protected under "the right of the people to peacefully assemble." However, assemblies that are not peaceable are not protected, and this is generally the dividing line between crowds and mobs. The laws that deal with disruptive conduct are generally grouped into offenses that disturb the public peace. They range from misdemeanors, such as blocking sidewalks or challenging another to fight, to felonies, such as looting and rioting.

It is important to note that civil unrest is not synonymous with peaceful assembly or peaceful protest; Americans are guaranteed a right to assemble peacefully under the First Amendment to the Constitution.

Types of Crowds

A crowd may be defined as a casual, temporary collection of people without a strong, cohesive relationship. Crowds can be classified into four general categories:

Casual Crowd — A casual crowd is merely a group of people who happen to be in the same place at the same time. Examples of this type include shoppers and sightseers. The likelihood of violent conduct is all but nonexistent.

Cohesive Crowd — A cohesive crowd consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common activity, such as worshiping, dancing, or watching a sporting event. Although they may have intense internal discipline (e.g., rooting for a team), they require substantial provocation to arouse to action.

Expressive Crowd — An expressive crowd is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of common sentiment or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest something.

Aggressive Crowd — An aggressive crowd is made up of individuals who have assembled for a specific purpose. This crowd often has leaders who attempt to arouse the members or motivate them to action. Members are noisy and threatening and will taunt authorities. They tend to be impulsive and highly emotional and require only minimal stimulation to arouse them to violence. Examples of this type of crowd include demonstrations and strikers.

Types of Mobs

A mob can be defined as a large disorderly crowd or throng. Mobs are usually emotional, loud, tumultuous, violent, and lawless. Like crowds, mobs have different levels of commitment and can be classified into four categories:

Aggressive Mob—An aggressive mob is one that attacks, riots, and terrorizes. The object of violence may be a person, property, or both. An aggressive mob is distinguished from an aggressive crowd only by lawless activity. Examples of aggressive mobs are the inmate mobs in prisons and jails, mobs that act out their frustrations after political defeat, or violent mobs at political protests or rallies.

Escape Mob—An escape mob is attempting to flee from something such as a fire, bomb, flood, or other catastrophe. Members of escape mobs have lost their capacity to reason and are generally impossible to control. They are characterized by unreasonable terror.

Acquisitive Mob—An acquisitive mob is one motivated by a desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits a lack of control by authorities in safeguarding property. Examples of acquisitive mobs would include the looting in South Central Los Angeles in 1992, or food riots in other countries.

Expressive Mob—An expressive mob is one that expresses fervor or revelry following some sporting event, religious activity, or celebration. Members experience a release of pent up emotions in highly charged situations. Examples of this type of mob include the June 1994 riots in Canada following the Stanley Cup professional hockey championship, European soccer riots, and those occurring after other sporting events in many countries, including the United States.

Although members of mobs have differing levels of commitment, as a group they are far more committed than members of a crowd. As such, a "mob mentality" sets in, which creates a cohesiveness and sense of purpose that is lacking in crowds. Thus, any strategy that causes individual members to contemplate their personal actions will tend to be more effective than treating an entire mob as a single entity.

Warning Time: 4 – Less than six hours

Duration: 3 – Less than one week

Location

Civil disorder can arise from several causes for a variety of reasons. Circumstances may be spontaneous or may result from escalating tensions. Civil disorder can erupt anywhere, but the most likely locations are those areas with large population groupings or gatherings. Sites that are attractive for political or other rallies should be considered as probable locations for the epicenter of civil disorder events; arenas and stadiums are another type of venue where civil disorder can occur. Civil disorder can also occur in proximity to locations where a "trigger event" occurred.

Extent

The ultimate extent of any civil disorder incident will depend on the magnitude of that event and its location. The more widespread an incident is, the greater the likelihood of excessive injury, loss of life and property damage; additional factors, such as the ability of law enforcement to contain the event, are also critical in minimizing damages.

Impact: 2 – Limited

Spatial Extent: 2 – Small

Historical Occurrences

There are documented events that indicate that Florida and the southern peninsula region in particular are not immune to riots, protests, and social upheaval. Some brief examples of civil unrest near Collier County are provided below.

The Miami Riot of 1968 occurred at the Vote Power building in the Liberty City neighborhood in August. A group of black organizations called for this rally in order to make known the unfair systems at play throughout the nation. This date overlapped with the Republican National Convention in Miami Beach. Things got aggressive once a white reported was forcibly kicked out and the police showed up. One passer-by had his car stoned and multiple bottles thrown at him for having a republican political sticker on his car. He fled his car which was then overturned and set on fire. The following day, the police responded to what they thought was sniper fire as the rioters were terrorizing shops. The police killed three residents and left a bullet wound in a fourth only to find no weapons close by. The riot ended when the Florida National Guard responded, imposed a curfew, and heavy rains kept people inside.

The 1980 Miami riots were race riots that began on May 18, 1980. The event that triggered the riots was the clearing of four Dade County Public Safety Department officers. They had been previously been tried for the manslaughter of Arthur McDuffie, a black salesman who passed away from wounds suffered during a high-speed chase in which these four white officers were involved. The riot broke out in the Liberty City and Overtown neighborhoods. After filing a civil lawsuit against County officials, McDuffie's family received a settlement of $1.1 million from Dade County. These were the deadliest riots between the 1960s and the 1992 Los Angeles riots.

The 1990 Wynwood riot began in the Wynwood neighborhood in Miami after six officers had been acquitted for the death of Leonardo Mercado. Mercado was a Puerto Rican and suspected drug dealer. Puerto Ricans were unhappy during this time since they felt they had no representation in any positions of authority. Six undercover officers in the Street Narcotics Unit of the Miami Police Department met with Mercado outside of his apartment in 1988. After forcing him back inside, they beat him to death. They were charged with conspiracy and three counts of civil rights violations. After their acquittal, a mob became violent for about three hours causing $3 million in property damage before order was restored by 200 patrolmen.

The 1996 St. Petersburg riots began after the death of an unarmed black, male teenage driver which occurred during a police traffic stop. There were two other people at the scene, one was the shooting policeman's partner, and the other was the passenger in the teenage male's car. Additionally, there were multiple witnesses, and everyone had a slightly different story of what happened. Immediately following the shooting, a crowd gathered and became frustrated when police didn't release any information. The crowd began throwing rocks and bottles at police officers. The riot continued through other areas of the city resulting in 20 people arrested, 28 arson fires, 11 injured, and multiple stores were looted. After the two original responding police officers were cleared of any charges a few week later, more rioting occurred.

Since 2010, civil unrest has again trended toward race relations as a cause. From controversial shootings of African American men by white police officers to the resulting Black Lives Matter movement, these trends may continue as the country finds ways to improve race relations. Florida has experienced specific incidents of racial unrest and violence as part of this trend and may continue to see these types of incidents in the future.

Specific incidents occurring in a single jurisdiction can cause civil unrest nationally; the Michael Brown shooting incident in Ferguson, MO is an example of this. On November 25, 2014, CNN reported that thousands of people in more than 170 U.S. cities rallied to protest the grand jury decision not to indict the officer involved.

Another recent trend is the destruction, defacement, and/or removal of statues and other memorials dedicated to the Confederacy during the Civil War. Areas near Collier County have experienced incidents of this nature, including the vandalization and subsequent removal of a confederate monument in West Palm Beach in August 2017, the removal and renaming of streets in Hollywood in April 2018, and the removal of the Robert E. Lee's bust in Fort Meyers in March 2019. As the country continues to debate whether monuments to the Confederacy are appropriate, these types of incidents may continue to occur.

Probability of Future Occurrence

In their article on "Understanding Riots" published in the *Cato Journal* (Vol. 14, No 1), David D. Haddock and Daniel D. Polsby note that a large crowd itself is not an incipient riot merely because it assembles a great many people. Haddock and Polsby explain that "starting signals" must occur for civil disorder to erupt; these starting signals include certain kinds of high-profile events. With any conventional triggering event, such as news of an assassination or unpopular jury verdict, crowds form spontaneously in various places as word of the incident spreads, without any one person having to recruit them. But since not every crowd threatens to evolve into a riot, the authors reason that a significant number of people must expect and desire that the crowd will become riotous. In addition, "someone has to serve as a catalyst" The authors conclude that once someone has taken a risk to get things started, the rioting will begin and spread until civil authorities muster enough force to make rioters believe they face a realistic prospect of arrest.

Collier County will likely experience future episodes of marches, protests, demonstrations, and gatherings that could lead to some type of disruptive civil disorder. However, based on the general history of civil disturbance and the various human factors noted above, the probability that such incidents will develop into full-scale, widespread riots is considered low.

Should the planning area experience future incidents of disruptive civil disorder or rioting, the severity of a given event could range from low to high, depending on many factors. Civil disturbances may result in arrests, damage to property (police vehicles with broken windows, etc.), injuries, fatalities and manpower/overtime costs for police, fire, and other response services.

Probability: 2 – Possible

Climate Change

As a human-caused hazard, any changes in climate would not have a direct impact on civil disorder. Far more relevant, though, could be the implications of future climate change as a cause for civil disorder. Climate change impact forecasts include increasingly extreme weather patterns that exacerbate issues of drought, flooding, severe weather and other weather hazards globally that could affect whole ecosystems. Incidents of civil disobedience could be a secondary result related to societal unrest as a result of other climate-impacted hazards.

Vulnerability Assessment

As discussed above, the impacts from civil disorder vary greatly depending on the nature, severity, and success of the attack.

When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. The rules of constitutional law set stringent limits on how police officers can behave toward the people they try to arrest. Restraint also plays a crucial part in avoiding any action that "fans the flames." Initial police presence is often undermined because forces may be staffed below the peak loads needed to bring things back under control. At a result, the riot may continue until enough state police or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to life and property may already be extensive.

People

Injuries and fatalities can occur during civil unrest.

Property

Should a large gathering of people turn violent, damage to property and infrastructure can result, as well as looting of property.

Environment

Environmental impacts could occur if the civil unrest occurs in an outdoor or environmentally sensitive area. These impacts would be tied to the parameters of the incident.

Consequence Analysis

Table 2.81 summarizes the potential consequences of civil unrest.

Table 2.81 – Consequence Analysis – Civil Unrest

Category	Consequences
Public	Possible injuries and fatalities can occur during civil unrest. The location of the unrest will be inaccessible to those who live or work in that area.
Responders	Localized impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations (including Continued Delivery of Services)	Damage to facilities/personnel in the area of the incident may require temporary relocation of operations; localized disruption of lines of communication and destruction of facilities may postpone delivery of some services.
Property, Facilities and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	May cause extensive damage in isolated cases and some denial or delays in the use of some areas. Remediation needed.
Economic Condition of the Jurisdiction	Local economy and finances adversely affected, possibly for an extended period, depending on damage.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes civil disturbance risk by jurisdiction. Risk is not expected to change substantially between jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	2	2	2	4	3	2.3	M
Immokalee Reservation	2	2	2	4	3	2.3	M
Marco Island	2	2	2	4	3	2.3	M
Naples	2	2	2	4	3	2.3	M

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Unincorporated Collier County	2	2	2	4	3	2.3	M

2.5.21 Critical Infrastructure Disruption

Hazard Background

Critical infrastructure disruptions include threats such as cyber-attacks. Cyber-attacks are commonly defined as “deliberate attacks on information technology systems in an attempt to gain illegal access to a computer, or purposely cause damage.” Cyber-attacks use malicious code to alter computer operations or data. The vulnerability of computer systems to attacks is a growing concern as people and institutions become more dependent upon networked technologies. The Federal Bureau of Investigation (FBI) reports that “cyber intrusions are becoming more commonplace, more dangerous, and more sophisticated,” with implications for private- and public-sector networks.

There are many types of cyber-attacks. Among the most common is a direct denial of service, or DDoS attack. This is when a server or website will be queried or pinged rapidly with information requests, overloading the system and causing it to crash.

Malware, or malicious software, can cause numerous problems once on a computer or network, from taking control of users’ machines to discreetly sending out confidential information. Ransomware is a specific type of malware that blocks access to digital files and demands a payment to release them. Hospitals, school districts, state and local governments, law enforcement agencies, businesses, and even individuals can be targeted by ransomware.

Cyber spying or espionage is the act of illicitly obtaining intellectual property, government secrets, or other confidential digital information, and often is associated with attacks carried out by professional agents working on behalf of a foreign government or corporation. According to cybersecurity firm Symantec, in 2016 “…the world of cyber espionage experienced a notable shift towards more overt activity, designed to destabilize and disrupt targeted organizations and countries.”

Major data breaches - when hackers gain access to large amounts of personal, sensitive, or confidential information - have become increasingly common. The Symantec report says more than seven billion identities have been exposed in data breaches over the last eight years. In addition to networked systems, data breaches can occur due to the mishandling of external drives, as has been the case with losses of some state employee data.

Cybercrime can refer to any of the above incidents when motivated primarily by financial gain or other criminal intent.

The most severe type of attack is cyber terrorism, which aims to disrupt or damage systems in order to cause fear, injury, and loss to advance a political agenda.

Warning Time: 4 – Less than six hours

Duration: 3 – Less than one week

Location

Our society is highly networked and interconnected. Cyber disruption events can occur and/or impact virtually any location in the county where computing devices are used. Incidents may involve a single location or multiple geographic areas. A disruption can have far-reaching effects beyond the location of the targeted system; disruptions that occur far outside the region can still impact people, businesses, and institutions within the region. Depending on the attack vector and parameters, a cyber-attack could impact all of Collier County and its associated municipal jurisdictions.

Extent

The extent or magnitude/severity of a cyber disruption event is variable depending on the nature of the event. A disruption affecting a small, isolated system could impact only a few functions/processes. Disruptions of large, integrated systems and especially systems related to the functionality of critical facilities could impact many functions/processes, as well as many individuals that rely on those systems.

There is no universally accepted scale to quantify the severity of cyber-attacks. The strength of a DDoS attack is sometimes explained in terms of a data transmission rate. One of the largest DDoS disruptions ever, which brought down some of the internet's most popular sites on October 21, 2016, peaked at 1.2 terabytes per second. Data breaches are often described in terms of the number of records or identities exposed.

Impact: 3 – Critical

Spatial Extent: 4 – Large

Historical Occurrences

The cyber security company Symantec reports there were a total of 1,209 data breaches worldwide in 2016, 15 of which involved the theft of more than 10 million identities. While the number of breaches has remained relatively steady, the average number of identities stolen has increased to almost one million per incident. The report also found that one in every 131 emails contains malware, and the company's software blocked an average of 229,000 web attacks every day.

The Privacy Rights Clearinghouse, a nonprofit organization based in San Diego, maintains a timeline of 9,361 data breaches, of which at least 2,792 were acts of computer hacking, in the United States from 2005-2019. The database lists 465 total data breaches, including 108 hacking events in Florida, totaling over 400 million impacted records. One attack was recorded in Naples, and others almost certainly included information on individuals who live in the region. Similarly, some residents in the region were likely affected by national and international data breaches. Media reports indicate an uptick in cyber-attacks across the state.

In 2018, Collier County was scammed out of $184,000 according to local news reports. Money from County offices was wire transferred to a fraudulent contractor unknowingly. The fraud originated abroad. Money was recovered from insurance carriers and the correct contractor was paid in full.

Probability of Future Occurrence

Cyber-attacks occur daily, but most have negligible impacts at the local or regional level. The possibility of a larger disruption affecting systems within the area is a constant threat, but it is difficult to quantify the exact probability due to such highly variable factors as the type of attack and intent of the attacker. Minor attacks against business and government systems have become a commonplace occurrence but are usually stopped with minimal impact. Similarly, data breaches impacting the information of residents of the Collier County area are almost certain to happen in coming years. Major attacks or breaches specifically targeting systems in the area are less likely but cannot be ruled out.

Probability: 2 – Possible

Climate Change

Climate change is not expected to affect critical infrastructure disruption.

Vulnerability Assessment

As discussed above, the impacts from a cyber-attack vary greatly depending on the nature, severity, and success of the attack.

People

Cyber-attacks can have a significant cumulative economic impact. Symantec reports that in the last three years, businesses have lost $3 billion due to spear-phishing email scams alone though phishing rates have declined from 1 in 2,995 emails in 2017 to 1 in 3,207 emails in 2018. A major cyber-attack has the potential to undermine public confidence and build doubt in their government's ability to protect them from harm.

Injuries or fatalities from cyber-attacks would generally only be possible from a major cyber terrorist attack against critical infrastructure.

Property

Short of a major cyber terrorist attacks against critical infrastructure, property damage from cyber-attacks is typically limited to computer systems.

Environment

Short of a major cyber terrorist attacks against critical infrastructure, property damage from cyber-attacks is typically limited to computer systems. A major cyber terrorism attack could potentially impact the environment by triggering a release of a hazardous materials, or by causing an accident involving hazardous materials by disrupting traffic-control devices.

Consequence Analysis

Table 2.82 summarizes the potential consequences of a cyber threat.

Table 2.82 – Consequence Analysis – Cyber Threat

Category	Consequences
Public	Cyber-attacks can impact personal data and accounts. Injuries or fatalities could potentially result from a major cyber terrorist attack against critical infrastructure.
Responders	Injuries or fatalities could potentially result from a major cyber terrorist attack against critical infrastructure.
Continuity of Operations (including Continued Delivery of Services)	Agencies that rely on electronic backup of critical files are vulnerable. The delivery of services can be impacted since governments rely, to a great extent, upon electronic delivery of services.
Property, Facilities and Infrastructure	Rare. Most attacks affect only data and computer systems. Sabotage of utilities and infrastructure from a major cyber terrorist attacks could potentially result in system failures that damage property on a scale equal with natural disasters. Facilities and infrastructure may become unusable as a result of a cyber-attack.
Environment	Rare. A major attack could theoretically result in a hazardous materials release.
Economic Condition of the Jurisdiction	Could greatly affect the economy. In an electronic-based commerce society, any disruption to daily activities can have disastrous impacts to the economy. It is difficult to measure the true extent of the impact.
Public Confidence in the Jurisdiction's Governance	The government's inability to protect critical systems or confidential personal data could impact public confidence. An attack could raise questions regarding the security of using electronic systems for government services.

Hazard Summary by Jurisdiction

The following table summarizes critical infrastructure disruption risk by jurisdiction. Risk is not expected to change substantially between jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	2	3	4	4	3	3.3	H
Immokalee Reservation	2	3	4	4	3	3.3	H
Marco Island	2	3	4	4	3	3.3	H
Naples	2	3	4	4	3	3.3	H
Unincorporated Collier County	2	3	4	4	3	3.3	H

2.5.22 Special Events

Hazard Description

Special events are defined as events of national significance or important visitors. Important visitors can include dignitaries among others. Many issues can arise because of these events including civil disturbance, terrorism, and criminal activity.

The U.S. Department of Homeland Security deem events that could be potential targets for terrorism or other criminal activity National Special Security Events (NSSE). These events can include but are not limited to summits of world leaders, meetings of international organizations, presidential nominating conversations, and presidential nominations. These events mostly occur in a specific location for a specific amount of time.

In order to determine what qualifies as a special event or an NSSE, there are several factors to consider. Table 2.83 below shows some common factors that would cause an event to be a special or NSSE event.

Table 2.83 – Special Event Factors to Consider

Factor	Description
Dignitary Attendance	Events attended by U.S. officials or foreign dignitaries may cause federal interest to guarantee the event occurs without incident, or at least that resources are available in the case that an incident occurs.
Size	More attendees and participants in an event cause more security measures to be needed. Larger events typically attract more attention of terrorists or criminals and may see weapons of mass destruction.
Significance	An event that has historical, political, cultural, or symbolic significance may attract criminal or terrorist activity.
Duration	If an even lasts several days or weeks, it is unlikely local and state law enforcement alone will be able to control the security of said event. Federal assistance may be required.
Availability of State and Local Resources	If state and local jurisdictions don't have the expertise, experience, or manpower to ensure protection of those at an event, federal assistance may be required.
Number of Jurisdictions	Multiple jurisdictions are sometimes required to coordinate law enforcement and public safety agencies. It could be helpful to include an agency to oversee the coordination.
Threat Assessments	When there is anticipated terrorism or criminal activity.

Source: U.S. Department of Homeland Security, National Special Security Event (NSSE)

Though these events are typically planned, issues could pop up at any moment giving little forewarning. Mobs or other types of civil disturbance can easily occur at or in response to special events.

Warning Time: 4 – Less than 6 Hours

Duration: 2 – Less than 24 Hours

Location

While special events could happen anywhere, they are most likely to occur at convention centers, political buildings, concert halls, and other locations of state, national, or international importance. Some locations in Collier County that would be ideal for special events include but are not limited to the following:

- Golf and Country Clubs
    - Naples Lakes Country Club

- Tiburón Golf Club
- Golf Club of the Everglades
- Cypress Woods Golf and Country Club
- Heritage Bay Golf and Country Club

- Hotels and Resorts
  - Inn of Naples
  - Lely Resort
  - Hyatt House
  - Hilton Marco Island Beach Resort
  - The Ritz-Carlton Golf Resort
  - Bayfront Inn
  - Hilton Naples
  - Edgewater Beach Hotel and Club
  - Naples Beach Hotel and Golf Club
  - LaPlaya Beach and Golf Resort
  - JW Marriott Marco Island
- Restaurants
  - Seasons 52
  - Shula's Steak House
- Other
  - Naples Zoo
  - Venue Naples
  - Marco Island Yacht Club
  - Marco Island Princess
  - Seminole Casino

Extent

Special events tend to be in a small area which will be most impacted. In some cases, road closures may be expected for high volume traffic purposes.

Impact: 1 – Minor

Spatial Extent: 1 – Negligible

Historical Occurrences

As detailed in the Civil Disturbance hazard in Section 2.5.20, the Miami Riot of 1968 occurred as a result of the Republican National Convention, a special event being held in Miami. While not in Collier County, it was nearby in Miami-Dade County.

Probability of Future Occurrence

Collier County's beaches and proximity to Big Cypress National Preserve and Everglades National Park make it a popular destination for several special events. Therefore, it is likely that more special events will occur in the County in the future.

Probability: 3 – Likely

Climate Change

Climate change is not expected to impact special event hazards. However, there could be more climate change summits or perhaps politically charged protests in the future which would require special security and preparation.

Vulnerability Assessment

People

Special events by nature will congregate a group of people together, however large. Having a group of people in the same space can cause logistical problems. This leads to the possibility of injury or death, though death is unlikely unless there is a concurrent hazard such as terrorism, civil disturbance, or a natural disaster.

Property

Any damages to property are likely to be localized to the event space. Anytime people gather in the same space, there is a possibility of property damage.

Environment

Any damages to the environment are likely to be localized around an event. There is a low possibility of environmental damage without a simultaneous natural or human caused disaster.

Consequence Analysis

Table 2.84 shows the consequences for special events.

Table 2.84 – Consequence Analysis – Special Events

Category	Consequences
Public	Localized impact expected to be moderate for affected areas and moderate to light for other less affected areas without a concurrent hazard or disaster.
Responders	Adverse impact expected to be moderate for unprotected personnel and moderate to light for trained, equipped, and protected personnel.
Continuity of Operations (including Continued Delivery of Services)	Localized disruption of roads caused by incidents may postpone delivery of some services.
Property, Facilities and Infrastructure	Localized impact to facilities and infrastructure in the areas of the incident. Roads most adversely affected.
Environment	Environmental damage to trees, bushes, beaches, etc. possible but unlikely.
Economic Condition of the Jurisdiction	Local economy and finances may be adversely affected, depending on damage.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes special event hazard risk by jurisdiction. This hazard is not expected to change substantially between jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	3	1	1	4	2	2.0	M
Immokalee Reservation	3	1	1	4	2	2.0	M
Marco Island	3	1	1	4	2	2.0	M
Naples	3	1	1	4	2	2.0	M
Unincorporated Collier County	3	1	1	4	2	2.0	M

2.5.23 Red Tide / Algae Bloom

Hazard Description

Red tide is a harmful type of algal bloom which are caused by colonies of algae growing out of control in aquatic environments. The name can be misleading since the blooms can be red, brown, blue, green, or yellow. Algae colonies themselves are not harmful until they are in excess. When they're out of control, they produce toxins that can harm humans, fish, shellfish, marine mammals, and birds. Algae have a seasonal growth cycle causing them to grow more in the spring and summer months, and they can often disappear in the winter months. Temperature, day length, and rainfall also affect their growth. The red tide organism, which is most commonly causing issues in Florida, *Karenia brevis*, is monitored by the Florida Fish and Wildlife Conservation Commission (FWC). They take daily samples in multiple locations to determine the level of red tide at any time.

The FWC measures the number of *Karenia brevis* cells in sample locations to determine the level of red tide present in a given area. Table 2.85 below shows the measurement categories and possible effects of *K. brevis*.

Table 2.85 – Measurement and Effects of *Karenia Brevis*

Description	*K. brevis* abundance	Possible effects
Not present-background	Background levels of 1,000 cells or less	No effects anticipated
Very low	Greater than 1,000 to 10,000 cells per liter	Possible respiratory irritation Shellfish harvesting closures when cell abundance equals or exceeds 5,000 cells per liter
Low	Greater than 10,000 to 100,000 cells per liter	Respiratory irritation Shellfish harvesting closures Possible fish kills Probable detection of chlorophyll by satellites at upper range of cell abundance
Medium	Greater than 100,000 to 1,000,000 cells per liter	Respiratory irritation Shellfish harvesting closures Probable fish kills Detection of surface chlorophyll by satellites
High	Greater than 1,000,000 cells per liter	Respiratory irritation Shellfish harvesting closures Probable fish kills Detection of surface chlorophyll by satellites Water discoloration

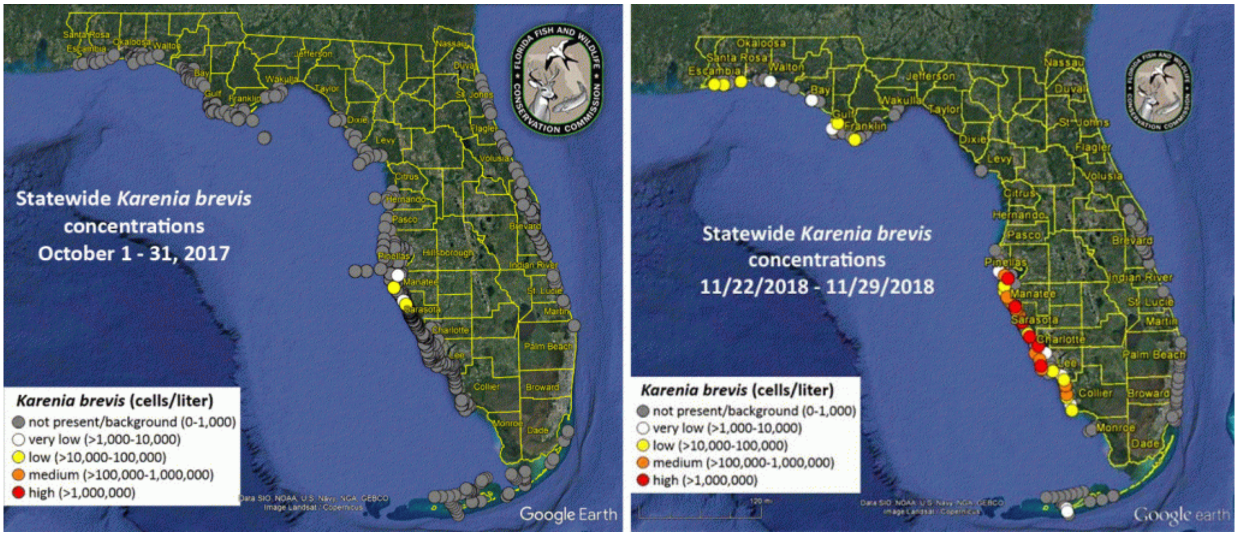
Source: Florida Fish and Wildlife Conservation Commission

The measurement system above is the legend key for Figure 2.48 and Figure 2.49 which show Florida *K. brevis* concentrations in October 2017 and November 2018, and December 2019 respectively. Watch as the concentration of the organism increases and then decreases on the coast of Florida.

Warning Time: 1 – More than 24 hours

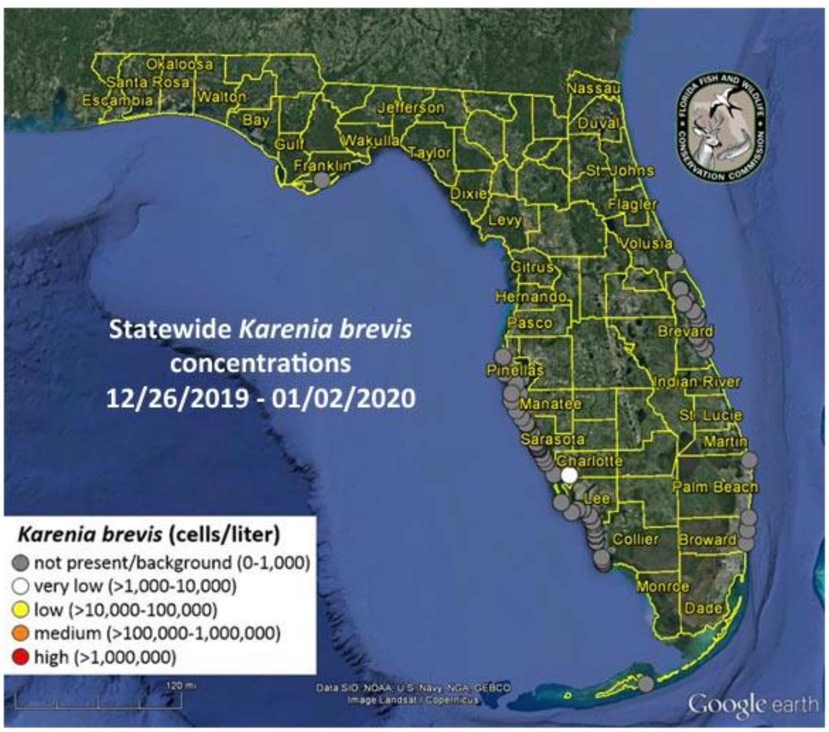
Duration: 4 – More than 1 week

Figure 2.48 – Red Tide Status Map, 2017-2018



Source: Florida Fish and Wildlife Conservation Commission

Figure 2.49 – Red Tide Status Map, 2019-2020



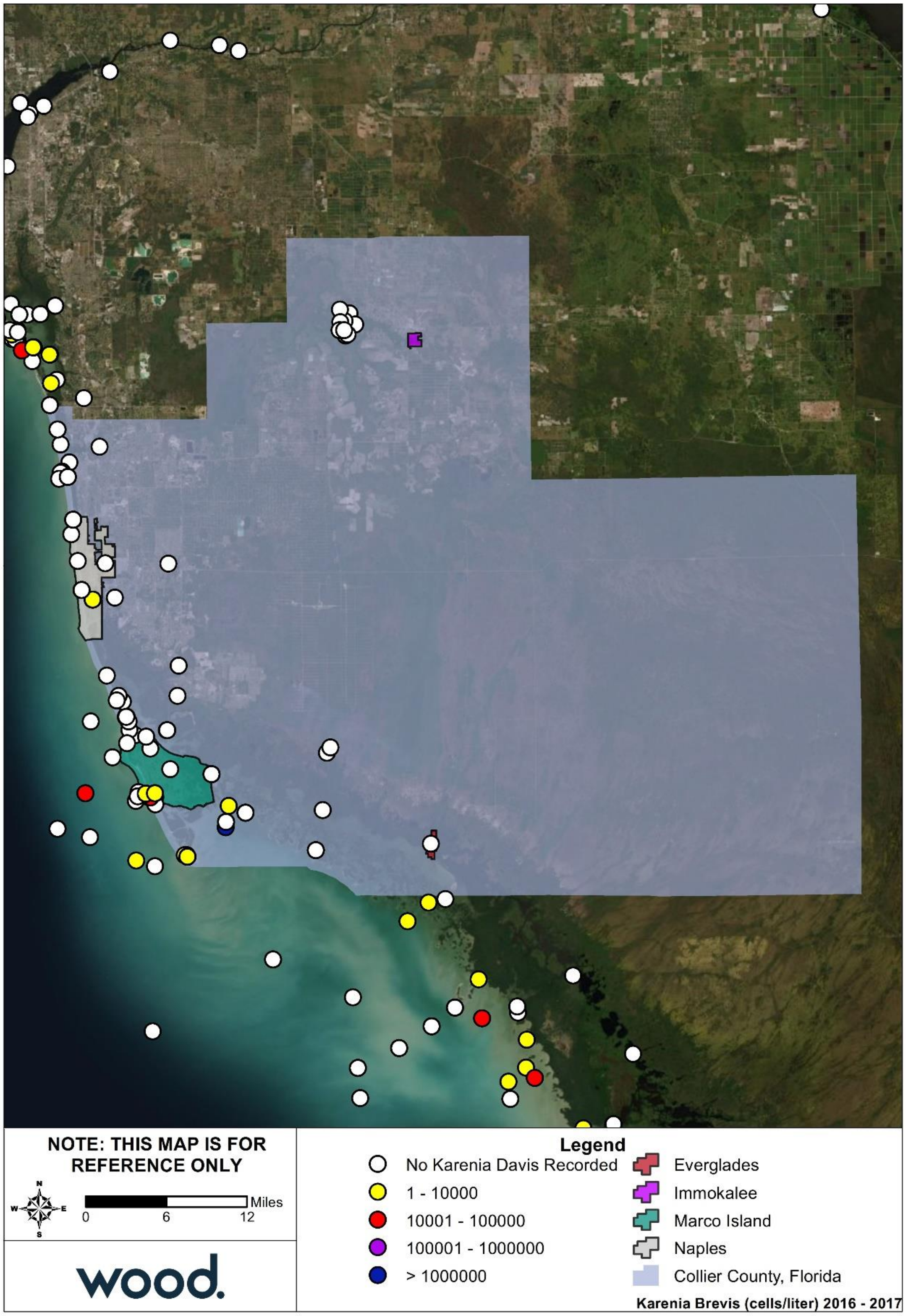
Source: Florida Fish and Wildlife Conservation Commission

Location

In late 2019 and early 2020, scientists and researchers have discovered little to no red tide around Florida. However, since *Karenia brevis* occurs naturally in the Gulf of Mexico, it's unlikely that red tide is gone for good.

Figure 2.50 shows where red tide was found close to Collier County between 2016 and 2017.

Figure 2.50 – Karenia Brevis Cells per Liter, 2016-2017



Source: Florida Fish and Wildlife Conservation Commission

Most of the sampling locations in early January 2020 showed little to no (less than 1,000) *K. brevis* cells in southern Florida. The highest concentration was located just off the coast of Collier County and was rated as "low," between 10,000 and 100,000 cells.

Extent

Karenia brevis is native to the Gulf of Mexico and is therefore found in the Gulf, often close to shorelines. Most of the red tide found in or off the coast of Florida occur on the western coast. However, red tide is also found on the eastern coast. This is due to the Florida Current which carries organisms from the Gulf of Mexico around the southern edge of Florida to the Atlantic Ocean. The Florida Current then joins with the Antilles Current to become the Gulf Stream.

Red tide can get as large as 10,000 square miles anywhere throughout the water column. This makes it very impractical to irradiate. Additionally, any current method of removing the toxins from the blooms or water could cause irreversible damage to ecosystems.

Impact: 2 – Limited

Spatial Extent: 3 – Moderate

Historical Occurrences

The first accounts of red tide in Florida came from the Spanish explorers thousands of years ago and the first sufficiently documented account came from 1844. It has only become well-known and studied in the past 60 years. A grant program called the Red Tide Control and Mitigation Program began in 2007 with the goal of finding new ways to control or mitigate the effects of red tide. It funded 12 projects that included outreach and public information.

The current Florida red tide began in October 2017. Even though blooms have only been monitored since 1954, few blooms have lasted longer than the current one. It has devastated the Gulf Coast from October 2017 to early 2019, killing millions of pounds of marine life and shutting down tourism, real estate, and recreational fishing in much of Lee, Collier, and Charlotte Counties.

Probability of Future Occurrence

Considering that the bloom from 2017 is still present in early 2020, and based on historical occurrences, it is safe to say that red tide will likely occur in the future. Scientists and researchers are working on ways to control and mitigate it. It is expected that there will be another great bloom in the future.

Probability: 3 – Likely

Climate Change

Climate change is expected to severely affect our ability to control blooms. Algal blooms thrive in higher air and ocean temperatures. In combination with fertilizer runoff which is nitrogen-rich, red tide has gotten harder to control even in recent years. It could become impossible to control in the future. K. brevis tends to thrive in water temperatures of 83 degrees Fahrenheit but can grow faster in hotter temperatures if there is more carbon dioxide. Atmospheric carbon dioxide has been on the rise for a long time and that trend will continue if society continues to burn fossil fuel.

Vulnerability Assessment

People

K. brevis puts off brevetoxins which can cause respiratory issues and irritation of the throat or skin in humans. Exposure can also occur through contamination of food or water supply. Seafood from a contaminated area may be unsafe to eat.

Property

Toxins could seep into land close to the ocean or other affected areas. Damages to property are highly unlikely.

Environment

The environment is likely to be affected because red tide is so toxic. There could be loss of life including birds, fish, shellfish, and aquatic animals. Additionally, water quality could be negatively affected.

Consequence Analysis

Table 2.86 summarizes the potential consequences of red tide.

Table 2.86 – Consequence Analysis – Red Tide / Algae Bloom

Category	Consequences
Public	Exposure to brevetoxins can cause respiratory issues and irritation. Those who encounter water with high *K. brevis* concentrations may have skin and eye irritation or rashes. Those living and working closest to sites with *K. brevis* face the greatest risk of exposure. Exposure may also occur through contamination of food or water supplies.
Responders	Responders face similar risks as the general public but a heightened potential for exposure to toxins.
Continuity of Operations (including Continued Delivery of Services)	A red tide incident may cause temporary localized impacts but is unlikely to affect continuity of operations.
Property, Facilities and Infrastructure	Damages to property are highly unlikely other than for ocean-side beaches. Impacts would be highly localized.
Environment	Possible ecological impacts include loss of wild and aquatic life, loss of habitat, and degradation of water quality.
Economic Condition of the Jurisdiction	Annual tourist, sales, health, and clean-up costs. Red tides are estimated to cost $20 million in tourist-related losses in Florida each year. Clean-up costs are around $163,000 annually.
Public Confidence in the Jurisdiction's Governance	A red tide incident may affect public confidence if the environmental or health impacts are enduring.

Hazard Summary by Jurisdiction

The following table summarizes red tide algae bloom hazard risk by jurisdiction. Risk is not expected to change substantially between jurisdictions. Jurisdictions with shoreline at risk were assigned a probability of 3 (likely), an impact of 2 (limited), and a spatial extent of 2 (small). Jurisdictions with little to no shoreline at risk were assigned a probability score of 1 (unlikely), an impact of 1 (minor), and a spatial extent of 1 (negligible). Warning time and duration are inherent to the hazard and remain constant across jurisdictions.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Everglades City	3	2	2	1	4	2.4	H
Immokalee Reservation	1	1	1	1	4	1.3	L
Marco Island	3	2	2	1	4	2.4	H
Naples	3	2	2	1	4	2.4	H
Unincorporated Collier County	3	2	2	1	4	2.4	H

2.6 CONCLUSIONS ON HAZARD RISK

Priority Risk Index

As discussed in Section 2.2 Hazard Identification, the Priority Risk Index was used to rate each hazard on a set of risk criteria and determine an overall standardized score for each hazard. The conclusions drawn from this process are summarized below.

Table 2.87 summarizes the degree of risk assigned to each identified hazard using the PRI method.

Table 2.87 – Summary of PRI Results

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Natural Hazards						
Flood	Highly Likely	Critical	Large	6 to 12 hours	Less than 1 week	3.5
Tropical Cyclones	Likely	Catastrophic	Large	More than 24 hrs	Less than 1 week	3.3
Severe Storms[1, 2] (Thunderstorm)	Highly Likely	Limited	Large	Less than 6 hrs	Less than 6 hrs	3.1
Severe Storms[1] (Lightning)	Highly Likely	Minor	Negligible	Less than 6 hrs	Less than 6 hrs	2.2
Severe Storms[1] (Hail)	Highly Likely	Minor	Small	Less than 6 hrs	Less than 6 hrs	2.4
Severe Storms[1, 2] (Tornado)	Highly Likely	Critical	Small	Less than 6 hrs	Less than 6 hrs	3.0
Wildfire[2]	Likely	Critical	Moderate	Less than 6 hrs	Less than 1 week	3.1
Coastal Erosion[2]	Likely	Limited	Small	More than 24 hrs	Less than 1 week	2.3
Drought	Likely	Minor	Large	More than 24 hrs	More than 1 week	2.5
Extreme Heat	Highly Likely	Limited	Large	More than 24 hrs	Less than 1 week	3.0
Sea Level Rise and other Climate Change Characteristics[2]	Likely	Critical	Moderate	More than 24 hrs	More than 1 week	2.9
Sink holes	Unlikely	Limited	Negligible	Less than 6 hrs	More than 1 week	1.9
Winter Storms and Freeze	Likely	Limited	Large	More than 24 hrs	Less than 1 week	2.7
Earthquake	Unlikely	Limited	Moderate	Less than 6 hrs	Less than 6 hrs	2.0
Tsunami[2]	Unlikely	Catastrophic	Large	6 to 12 hrs	Less than 24 hrs	2.8
Technological and Human-Caused Hazards & Threats						
Major Transportation Incidents	Possible	Critical	Negligible	Less than 6 hrs	More than 1 week	2.5
Pandemic Outbreak	Possible	Critical	Moderate	More than 24 hrs	More than 1 week	2.6
Hazardous Materials	Likely	Minor	Negligible	Less than 6 hrs	Less than 24 hrs	2.0
Coastal Oil Spills[2]	Possible	Limited	Small	6 to 12 hrs	More than 1 week	2.3
Nuclear Power Plant[2]	Unlikely	Catastrophic	Small	Less than 6 hours	More than 1 week	2.3
Terrorism	Unlikely	Catastrophic	Negligible	Less than 6 hrs	Less than 6 hrs	2.2
Mass Migration Incident	Possible	Critical	Moderate	6 to 12 hrs	More than 1 week	2.8
Civil Disturbance	Possible	Limited	Small	Less than 6 hrs	Less than 1 week	2.3
Critical Infrastructure Disruption	Possible	Critical	Large	Less than 6 hrs	Less than 1 week	3.3
Special Events	Likely	Minor	Negligible	Less than 6 hrs	Less than 24 hrs	2.0
Red Tide/Algae Bloom[2]	Likely	Limited	Small	More than 24 hrs	More than 1 week	2.2

[1]Severe Storms and Tornadoes hazards average to a score of 2.76 and are therefore considered together as a high-risk hazard.
[2]Note: These risks varied by jurisdiction, so the most severe score is shown.

The results from the PRI have been classified into three categories based on the assigned risk value which are summarized in Table 2.88:

- **High Risk** – Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread.
- **Medium Risk** – Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
- **Low Risk** – Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal. This is not a priority hazard.

Table 2.88 – Summary of Hazard Risk Classification

High Risk (> 2.4)	Flood Tropical Cyclones Severe Storms (Thunderstorm, Lightning, Hail, Tornado) Wildfire Drought Extreme Heat Sea Level Rise Winter Storms and Freeze Tsunami Major Transportation Incidents Pandemic Outbreak Mass Migration Incident Civil Infrastructure Disruption
Moderate Risk (2.0 – 2.4)	Coastal Erosion Earthquake Hazardous Materials Coastal Oil Spills Nuclear Power Plant Terrorism Civil Disturbance Red Tide/Algae Bloom Special Events
Low Risk (< 2.0)	Sink Holes

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