4 RISK ASSESSMENT

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.

4.1 OVERVIEW

This section describes the Hazard Identification and Risk Assessment process for the development of the Outer Banks Regional Hazard Mitigation Plan. It describes how the region 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 Currituck and Dare Counties, including unincorporated areas 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 planning area 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 4.2**: **Hazard Identification** identifies the natural and human-caused hazards that threaten the planning area.
- **Section 4.3: Risk Assessment Methodology and Assumptions** describes how the risk and vulnerability assessment was conducted and presented.
- **Section 4.4: Asset Inventory** details the population, buildings, and critical facilities at risk within the planning area.
- **Section 4.5**: **Hazard Profiles, Analysis, and Vulnerability** discusses the threats 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 conditions.
- **Section 4.6: Conclusions on Hazard Risk** summarizes the results of the Priority Risk Index and defines each hazard as a Low, Medium, or High-Risk hazard.

4.2 HAZARD IDENTIFICATION

To identify the full range of hazards relevant to the planning area, the HMPC began with a review of the lists of hazards identified in the 2020 Outer Banks Regional Hazard Mitigation Plan and the 2023 State Hazard Mitigation Plan. This review of hazards is summarized in Table 4.1. The HMPC used this process to ensure consistency across hazard mitigation planning efforts. All hazards listed below were evaluated for inclusion in this plan update, and, where appropriate, the hazard list in this plan was updated to be consistent with the State Hazard Mitigation Plan.

Table 4.1 – Full Range of Hazards Evaluated

Hazard	Included in 2023 State HMP?	Included in 2020 Outer Banks Regional HMP?
Coastal Hazards (Erosion, Rip Current, and Sea Level Rise)	Yes, with Hurricanes and Coastal Hazards and Flooding	Yes
Drought	Yes	Yes
Earthquake	Yes	Yes
Extreme Heat	Yes	Yes
Flood	Yes (including sea level rise)	Yes
Hurricane and Tropical Storm	Yes (including coastal hazards and nor'easters)	Yes
Severe Weather (Thunderstorm Winds, Lightning, and Hail)	Yes	Yes
Severe Winter Storm	Yes	Yes
Tornado	Yes, with Tornadoes/Thunderstorms	Yes
Wildfire	Yes	Yes
Dam Failures	Yes	No
Geological Hazards (Landslide and Sinkholes)	Yes	No
Infectious Disease	Yes	No
Hazardous Materials Incident	Yes	Yes

Hazard	Included in 2023 State HMP?	Included in 2020 Outer Banks Regional HMP?
Radiological Emergency	Yes	Yes
Cyber Threat	Yes	Yes
Terrorism	Yes	Yes
Transportation Infrastructure Failure	No	Yes
Civil Disturbance	Yes	No
Electromagnetic Pulse	Yes	No
Food Emergency	Yes	No

The HMPC evaluated the above list of hazards using existing hazard data, past disaster declarations, local knowledge, and information from the 2023 State Hazard Mitigation Plan and the 2020 Outer Banks Regional Hazard Mitigation 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 significant resource in this effort was the National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI) Storm Events Database, which contains an archive by county of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce. The database also provides a partial record of other significant meteorological events, such as record maximum or minimum temperatures or precipitation that occurs in connection with another event. The database contains records of tornado events since 1950, thunderstorm wind and hail events since 1955, and all other tracked event types since 1996. NCEI receives storm data from the National Weather Service (NWS), which receives their information from a variety of sources, which include but are 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. Due to its reliance on reporting from a variety of sources, the accuracy of NCEI data can be limited. It is not a comprehensive database of all storm and weather events that have occurred. However, it still provides a good starting point for assessing the occurrence of various hazard events in the planning area.

The NCEI Storm Events database contains 715 records of severe weather events that occurred in Currituck and Dare Counties in the 28-year period from 1996 through 2023. Table 4.2 summarizes these events.

Table 4.2 – NCEI Severe Weather Reports for Currituck and Dare Counties, 1996 – 2023

Type	# of Events	Property Damage	Crop Damage	Deaths	Injuries
Blizzard	2	$0	$0	0	0
Coastal Flood	48	$18,885,000	$0	0	0
Cold/Wind Chill	4	$0	$0	0	0
Drought	6	$0	$0	0	0
Excessive Heat	4	$0	$0	0	0
Flash Flood	27	$0	$0	0	0
Flood	14	$500,000	$0	0	0
Frost/Freeze	4	$0	$0	0	0
Hail	70	$0	$0	0	0
Heat	4	$0	$0	0	0
Heavy Rain	31	$0	$0	0	0
Heavy Snow	6	$0	$0	0	0

Type	# of Events	Property Damage	Crop Damage	Deaths	Injuries
High Surf	9	$0	$0	5	0
High Wind	67	$601,000	$0	0	0
Hurricane	44	$381,213,000	$136,880,000	2	0
Ice Storm	0	$0	$0	0	0
Lightning	15	$614,000	$0	4	6
Rip Current	30	$0	$0	28	0
Strong Wind	3	$11,000	$0	0	0
Storm Surge/Tide	15	$55,950,000	$0	0	0
Thunderstorm Wind	168	$796,000	$0	0	9
Tornado	20	$1,397,000	$0	0	6
Tropical Storm	55	$19,884,000	$0	0	0
Wildfire	0	$0	$0	0	0
Winter Storm	57	$22,500,000	$0	0	0
Winter Weather	34	$0	$0	0	0
Total:	**715**	**$502,301,000**	**$136,880,000**	**39**	**21**

Source: National Center for Environmental Information Events Database, accessed June 2024

Note: Losses reflect totals for all impacted areas for each event.

The HMPC also researched past events that resulted in a federal and/or state emergency or disaster declaration for Currituck and Dare Counties to identify significant hazards. Two types of disaster declarations are provided in the Stafford Disaster Relief and Emergency Assistance Act of 1988: emergency declarations and major disaster declarations. If a disaster is so severe that both the local and state government capacities are exceeded, a federal emergency or disaster declaration allows for the provision of federal assistance.

— Emergency declarations: When federal assistance is needed, the President of the United States can declare an emergency for any occasion or disaster. Emergency declarations aide State and local efforts in providing emergency services that help protect human lives.

— Major disaster declarations: When a local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Federal and/or state disaster declarations may be granted when the Governor certifies that the combined local, county, and state resources are insufficient and the situation is beyond their recovery capabilities.

Records of designated counties for FEMA emergency declarations and major disaster declarations start in 1964. Since then, Currituck and Dare Counties have been designated in 15 major disaster declarations and 13 emergency declarations. Not all events impacted the entire region; several declarations list only Dare County. Emergency and disaster declarations for the Outer Banks Region are detailed in Table 4.3.

Table 4.3 – FEMA Emergency and Disaster Declarations, Currituck and Dare Counties

County*	Declaration Type	Disaster #	Declaration Date	Incident Type	Event Title
C, D	EM	3586	10/1/2022	Hurricane	Hurricane Ian
C, D	EM	3534	8/2/2020	Hurricane	Hurricane Isaias
C, D	DR	4487	3/25/2020	Biological	COVID-19 Pandemic
C, D	EM	3471	3/13/2020	Biological	COVID-19
C, D	DR	4465	10/4/2019	Hurricane	Hurricane Dorian
C, D	EM	3423	9/3/2019	Hurricane	Hurricane Dorian
D	DR	4412	1/31/2019	Hurricane	Tropical Storm Michael

County*	Declaration Type	Disaster #	Declaration Date	Incident Type	Event Title
D	DR	4393	9/14/2018	Hurricane	Hurricane Florence
C, D	EM	3401	9/10/2018	Hurricane	Hurricane Florence
C, D	DR	4285	10/10/2016	Hurricane	Hurricane Matthew
C, D	EM	3380	10/7/2016	Hurricane	Hurricane Matthew
C, D	DR	4019	8/31/2011	Hurricane	Hurricane Irene
C, D	EM	3327	8/25/2011	Hurricane	Hurricane Irene
C	DR	1969	4/19/2011	Severe Storm(s)	Severe Storms, Tornados, and Flooding
C, D	EM	3314	9/1/2010	Hurricane	Hurricane Earl
D	DR	1608	10/7/2005	Hurricane	Hurricane Ophelia
C, D	EM	3254	9/14/2005	Hurricane	Hurricane Ophelia
C, D	EM	3222	9/5/2005	Hurricane	Hurricane Katrina Evacuation
C, D	DR	1490	9/18/2003	Hurricane	Hurricane Isabel
C, D	DR	1292	9/16/1999	Hurricane	Hurricane Floyd Major Disaster Declarations
C, D	EM	3146	9/15/1999	Hurricane	Hurricane Floyd Emergency Declarations
D	DR	1291	9/9/1999	Hurricane	Hurricane Dennis
C, D	EM	3141	9/1/1999	Hurricane	Hurricane Dennis
C, D	DR	1240	8/27/1998	Hurricane	Hurricane Bonnie
D	DR	1200	1/15/1998	Severe Storm(s)	Severe Storms and Flooding
D	DR	1003	9/10/1993	Hurricane	Hurricane Emily
D	EM	3110	3/17/1993	Snowstorm	Severe Snowfall & Winter Storm
C, D	DR	818	12/2/1988	Tornado	Severe Storms & Tornados

Source: FEMA Disaster Declarations Summary, updated June 19, 2024
*C = Currituck, D = Dare

Using the above information and additional discussion, the HMPC evaluated each hazard's significance to the planning area to decide which hazards to include in this plan update. Some hazard titles have been updated to be consistent with the State Hazard Mitigation Plan. Table 4.4 summarizes the determination made for each hazard.

Table 4.4 – Hazard Evaluation Results

Hazard	Included in this plan update?	Explanation for Decision
Flooding	Yes	The 2020 Outer Banks plan identified flooding as a high priority hazard, and the HMPC confirm its significance. The 2023 State plan notes that Dare County is one of four counties in the state with over 1,000 repetitive loss properties. Flooding is a significant component of hurricanes, which have resulted in most of the region's past disaster declarations. In keeping with the 2023 State plan, sea level rise is included with the flood hazard.
Hurricanes and Coastal Hazards	Yes	The 2020 Outer Banks plan identified hurricanes and tropical storms and coastal hazards (which included erosion, rip current, and sea level rise) as high priority hazards. The 2023 State plan combines these hazards; this hazard has been updated accordingly. The region is vulnerable to hurricane winds, rains, and storm surge as well as

Hazard	Included in this plan update?	Explanation for Decision
		nor'easters, erosion, and rip currents. Most of the region's past disaster declarations have been for hurricane events. Flood related risks are evaluated in the flood hazard profile.
Severe Winter Weather	Yes	The 2020 Outer Banks plan and 2023 State plan addressed this hazard, and the region identified it as a high priority hazard.
Excessive Heat	Yes	The 2020 Outer Banks plan and the 2023 State plan addressed this hazard. The region identified heat as a high priority hazard.
Earthquakes	Yes	The 2020 Outer Banks plan and the 2023 State plan addressed this hazard. Earthquake is a low priority hazard but still merits study.
Wildfires	Yes	The 2020 Outer Banks plan identified wildfire as a high priority hazard.
Dam Failures	No	The 2020 Outer Banks plan did not identify any dams in Currituck or Dare Counties. NC Dam Inventory does not list dams in either county. Similarly, the USACE's National Levee Database does not identify any USACE or non-USACE levees in the region
Drought	Yes	The 2020 Outer Banks plan addressed this hazard and rated drought as a moderate priority. The 2023 State plan shows that drought occurrence is lowest in the northeastern region of the state, but it is still a relevant hazard to the planning area.
Tornadoes & Thunderstorms (including Lightning and Hail)	Yes	The 2020 Outer Banks plan and 2023 State plan addressed this hazard. NCEI reports 343 severe weather-related events since 1996. The region has received two major disaster declarations for tornados.
Geological Hazards (Sinkhole, Landslide)	No	The 2023 State plan addressed this hazard but notes that risk is concentrated in the western portions of the state. The 2020 Outer Banks plan found minimal risk and did not identify sinkholes or landslide for inclusion in the risk assessment. USGS data does not indicate any geological basis for sinkhole risk in the region.
Infectious Disease	Yes	The State HMP reports the entire State is at risk, but vulnerability is low across all but two impact categories. Given the past disaster declaration resulting from the Covid-19 pandemic, this hazard was included in the risk assessment. However, the HMPC indicated that County Health Departments already plan effectively for infectious disease management.
Hazardous Substances	Yes	The 2023 State plan addresses this hazard, and the 2020 Outer Banks plan identified hazardous materials incidents as a moderate-high priority hazard. The HMPC indicated that the risk assessment should also evaluate the risk of offshore spills.
Radiological Emergency	Yes	The 2023 State plan addresses this hazard. A small portion of northern Currituck County is within the Ingestion Pathway Zone of Surry Power Station, located in Surry, Virginia.
Terrorism	Yes	The 2020 Outer Banks plan addressed this hazard. There have not been any instances of terrorism in Currituck or Dare Counties. However, the HMPC felt this threat warrants inclusion in the plan.

Hazard	Included in this plan update?	Explanation for Decision
Civil Disturbance	No	The 2023 State plan reports that risk is highest in areas with large population groupings or gatherings. There is no history of civil disturbances in the region.
Cyber Threat	Yes	The 2020 Outer Banks plan rated cyber threat as a moderate risk. Cyber hazards are profile in the 2023 State plan, and the HMPC felt this hazard should continue to be evaluated for the region.
Electromagnetic Pulse	No	The region considers this hazard more appropriately addressed at the State level.
Food Emergency	No	The region considers this hazard more appropriately addressed at the State level.
Infrastructure Failure	Yes	This threat is not addressed in the State plan. Infrastructure vulnerability is evaluated relative to each natural hazard that may impact it. However, the HMPC also wanted to continue to consider transportation infrastructure failure that may occur due to damages unrelated to other hazards. The HMPC broadened this hazard to include other types of infrastructure.

The final list of hazards included in this plan are as follows:

- Drought
- Earthquake
- Excessive Heat
- Flooding (including Sea Level Rise)
- Hurricane & Coastal Hazards (including Erosion, Rip Current, and Nor'easters)
- Infectious Disease
- Tornadoes & Thunderstorms (including Lightning & Hail)
- Severe Winter Storm
- Wildfire
- Hazardous Substances
- Radiological Emergency
- Cyber Threat
- Terrorism
- Infrastructure Failure

4.3 RISK ASSESSMENT METHODOLOGY AND ASSUMPTIONS

The Disaster Mitigation Act of 2000 requires that the HMPC 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 to determine its potential to cause significant human and/or economic 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 Outer Banks region.

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.

PAST OCCURRENCES

This section contains information on historical events, including the location and consequences of all past events on record within or near the Outer Banks Region.

PROBABILITY OF FUTURE OCCURRENCE

This section gauges the likelihood of future occurrences based on past events and any existing data on current or future trends. The historical 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).

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, from local and state resources;
- Hazard layer GIS datasets from state and federal agencies;
- Descriptions of inventory and risks provided by the 2023 State Hazard Mitigation Plan; and
- Descriptions of inventory and risks from the 2020 Outer Banks Regional Hazard Mitigation Plan.
- Exposure and vulnerability estimates provided by the North Carolina Emergency Management (NCEM) IRISK database.

Two distinct risk assessment methodologies were used in the formation of the vulnerability assessment: a quantitative analysis that relies upon best available data and technology and a qualitative analysis that relies on local knowledge and rational decision making.

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. Where hazard risk cannot be distinctly quantified and modeled, other information can be collected in regard to 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. The quantitative analysis for this plan update involved the use of NCEM's IRISK database, which provides modeled damage estimates for earthquake, flood, wind, and wildfire hazards.

NCEM's IRISK database incorporates county building footprint and parcel data. Footprints with an area less than 500 square feet were excluded from the analysis. To determine if a building is in a hazard area, the building footprints were intersected with each of the mapped hazard areas. If a building intersects two or more hazard areas (such as the 1-percent-annual-chance flood zone and the 0.2-percent-annual-chance flood zone), it is counted as being in the hazard area of highest risk. The parcel data provided building value and year built. Building value was used to determine the value of buildings at risk. Year built was used to determine if the building was constructed prior to or after the community had joined the NFIP and had an effective FIRM and building codes enforced.

Census blocks and Summary File 1 from the 2020 Census were used to determine population at risk. This included the total population, as well as the vulnerable elderly and children age groups. To determine population at risk, the census blocks were intersected with the hazard area. To better determine the actual number of people at risk, the intersecting area of the census block was calculated and divided by the total area of the census block to determine a ratio of area at risk. This ratio was applied to the population of the census block. For example, a census block has a population of 400 people. Five percent of the census block intersects the 1-percent-annual-chance flood hazard area. The ratio estimates that 20 people are then at risk within the 1-percent-annual-chance flood hazard area (5% of the total population for that census block).

Certain assumptions are inherent in any risk assessment. For this plan, three primary assumptions were discussed by the HMPC from the beginning of the risk assessment process: (1) that the best readily available data would be used, (2) that the hazard data selected for use is reasonably accurate for mitigation planning purposes, and (3) that the risk assessment will be regional in nature with local, municipal-level data provided where appropriate and practical.

Key methodologies and assumptions made for specific hazards analysis are described in their respective profiles.

PRIORITY RISK INDEX

The conclusions drawn from the hazard profiling and vulnerability assessment process can be used to prioritize all potential hazards to the Outer Banks region. 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 4.5.

The results of the PRI scoring are provided in each hazard profile and in Section 4.6 Conclusions on Hazard Risk.

Table 4.5 – 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 Outer Banks planning area as high, moderate, or low risk. The summary hazard classifications generated through the PRI allow for the prioritization of the high and moderate hazard risks for mitigation planning purposes.

4.4 ASSET INVENTORY

4.4.1 POPULATION

NCEM's IRISK database provided the asset inventory used for this vulnerability assessment. Population data in IRISK is pulled from the 2020 Census and includes a breakdown of population into two subpopulations considered to be a greater risk than the general population, the elderly and children. Table 4.6 details the population counts by jurisdiction used for the vulnerability assessment.

Table 4.6 – Population Counts by Jurisdiction, 2020

Jurisdiction	2020 Census Population	Elderly (Age 65 and Over)	Children (Age 5 and Under)
Currituck			
Currituck County	31,343	5,390	1,596
Dare			
Dare County (Unincorporated Area)	24,369	4,752	1,150
Town of Duck	1,722	582	53
Town of Kill Devil Hills	7,588	1,298	260
Town of Kitty Hawk	3,903	861	137
Town of Manteo	1,360	220	80
Town of Nags Head	3,178	1,084	70
Town of Southern Shores	2,536	858	78
Subtotal Dare	**44,656**	**9,655**	**1,828**
Region Total	**75,999**	**15,045**	**3,424**

Source: NCEM IRISK Database; 2020 Decennial Census

4.4.2 PROPERTY

Building counts were also provided by the IRISK database. These values were generated using locally-provided building footprint and parcel data as well as data generated by NCEM in 2010. The methodology for generating the building asset inventory is described in greater detail in Section 4.3. The IRISK building inventory reflects a 2.4% increase in total building count and a 4.1% increase in total exposed building value since the development of the 2020 plan. However, the exposure reflected in IRISK is likely an underestimate of actual present-day exposure because the region has experienced more growth and redevelopment than is reflected in these estimates. Chapter 3 Planning Area Profile describes the growth that has occurred since 2010 and provides a means of estimating the degree to which exposure and vulnerability may have increased.

Table 4.7 – Building Counts and Values by Jurisdiction

Jurisdiction	Building Count	Building Value
Currituck		
Currituck County	17,685	$3,350,427,837
Dare		
Dare County (Unincorporated Area)	14,019	$2,398,251,498
Town of Duck	2,409	$737,531,039
Town of Kill Devil Hills	6,033	$977,172,103
Town of Kitty Hawk	2,862	$640,242,261
Town of Manteo	943	$283,065,661
Town of Nags Head	4,868	$1,105,653,993
Town of Southern Shores	2,513	$685,764,229
Subtotal Dare	**33,647**	**$6,827,680,784**
Region Total	**51,332**	**$10,178,108,621**

Source: NCEM IRISK Database

To supplement the asset inventory and provide a clearer picture of the current asset exposure in the Outer Banks Region, current parcel data was evaluated to identify recent development since NCEM's IRISK database was last updated. The building footprint layer from IRISK was compared to current parcel data; any parcels with an improved value that did not already have a building in IRISK were appended the property inventory. This information is not incorporated into the risk assessment, which was prepared using IRISK. However, this summary of recent development provides some context to understand the degree to which the IRISK exposure and vulnerability numbers differ from current conditions.

Table 4.8 provides a summary of estimated property exposure in each participating community.

Table 4.8 – Current Improved Parcels, as of June 2024

Jurisdiction	Improved Parcel Count	Total Improved Value
Currituck County		
Currituck County	21,739	$5,072,341,006
Dare County		
Unincorporated Dare County	14,805	$2,899,953,848
Duck	2,530	$800,986,995
Kill Devil Hills	6,680	$1,230,546,630
Kitty Hawk	3,083	$748,719,370
Manteo	1,106	$335,489,696
Nags Head	5,125	$1,227,680,160
Southern Shores	2,749	$803,338,742
Region Total	**57,817**	**$13,119,056,447**

Source: County parcel data, retrieved June 2024; IRISK database building footprints

4.4.3 CRITICAL FACILITIES

The IRISK database also identifies Critical Infrastructure and Key Resources (CIKR) buildings. Critical infrastructure are assets, systems, networks, and functions that would have a debilitating impact on security, the economy, or public health and safety if disrupted. Key resources are public or private resources essential to operation of the economy and the government. These properties are detailed in Table 4.9.

Table 4.9 – Critical Infrastructure and Key Resources by Type and Jurisdiction

Jurisdiction	Food and Agriculture	Banking and Finance	Chemical & Hazardous	Commercial	Communications	Critical Manufacturing	EM	Healthcare	Government Facilities	Defense Industrial Base	Nuclear Reactors, Materials and Waste	Postal and Shipping	Transportation Systems	Energy	Emergency Services	Water	Total
Currituck County	443	186	0	715	4	206	24	0	104	0	1	1	54	5	10	14	**1,767**
Dare County (Unincorporated Area)	23	14	0	581	0	106	11	0	106	1	0	0	6	0	2	1	**851**
Town of Duck	1	4	0	69	1	4	0	0	2	0	1	0	32	4	1	5	**124**
Town of Kill Devil Hills	1	11	0	254	4	47	10	0	13	0	0	0	57	12	9	9	**427**
Town of Kitty Hawk	9	39	0	417	0	108	9	0	12	0	0	0	20	0	1	0	**615**
Town of Manteo	1	5	0	107	3	5	4	0	20	0	0	0	12	9	12	24	**202**
Town of Nags Head	6	27	0	855	12	48	48	0	39	0	0	0	21	0	9	3	**1,068**
Town of Southern Shores	0	6	0	54	3	48	3	0	6	0	**2**	**1**	**202**	**30**	**44**	**56**	**455**
Total	**484**	**292**	**0**	**3,052**	**27**	**572**	**109**	**0**	**302**	**1**	**2**	**1**	**202**	**32**	**51**	**81**	**5,208**

Source: NCEM Risk Management Tool

Using the existing CIKR inventory and local data, the HMPC and community staff refined and supplemented the IRISK asset inventory with a current list of critical facilities. These assets are considered community lifelines, which are defined by FEMA as the buildings and infrastructure that enable the continuous operation of critical business and government functions and are essential to human health and safety or economic security. Lifelines are the most fundamental services in the community that, when stabilized, enable all other aspects of society to function. These critical facilities are a priority for mitigation planning and were examined against known hazard areas, where possible, in this risk assessment.

Critical facilities are summarized by FEMA lifeline category in Table 4.10 and shown in Figure 4.1 and Figure 4.2. More detailed maps of critical facilities are provided in the community annexes.

Table 4.10 – Critical Facilities, Outer Banks Region

Jurisdiction	Facility Type								Total
	Communications	Energy	Food, Hydration, Shelter	Hazardous Materials	Health and Medical	Safety and Security	Transportation	Water Systems	
Currituck County	30	3	62	0	3	23	3	35	159
Unincorporated Dare County	0	1	7	0	2	30	5	17	62
Duck	3	0	0	0	1	4	0	1	9
Kill Devil Hills	0	2	7	0	1	2	0	8	20
Kitty Hawk	2	3	0	0	4	6	0	21	36
Manteo	0	0	8	0	4	3	1	1	17
Nags Head	1	2	2	0	3	8	0	9	25
Southern Shores	3	0	1	0	0	8	0	2	14
Region Total	**39**	**11**	**87**	**0**	**18**	**84**	**9**	**94**	**342**

Figure 4.1 – Critical Facilities, Currituck County

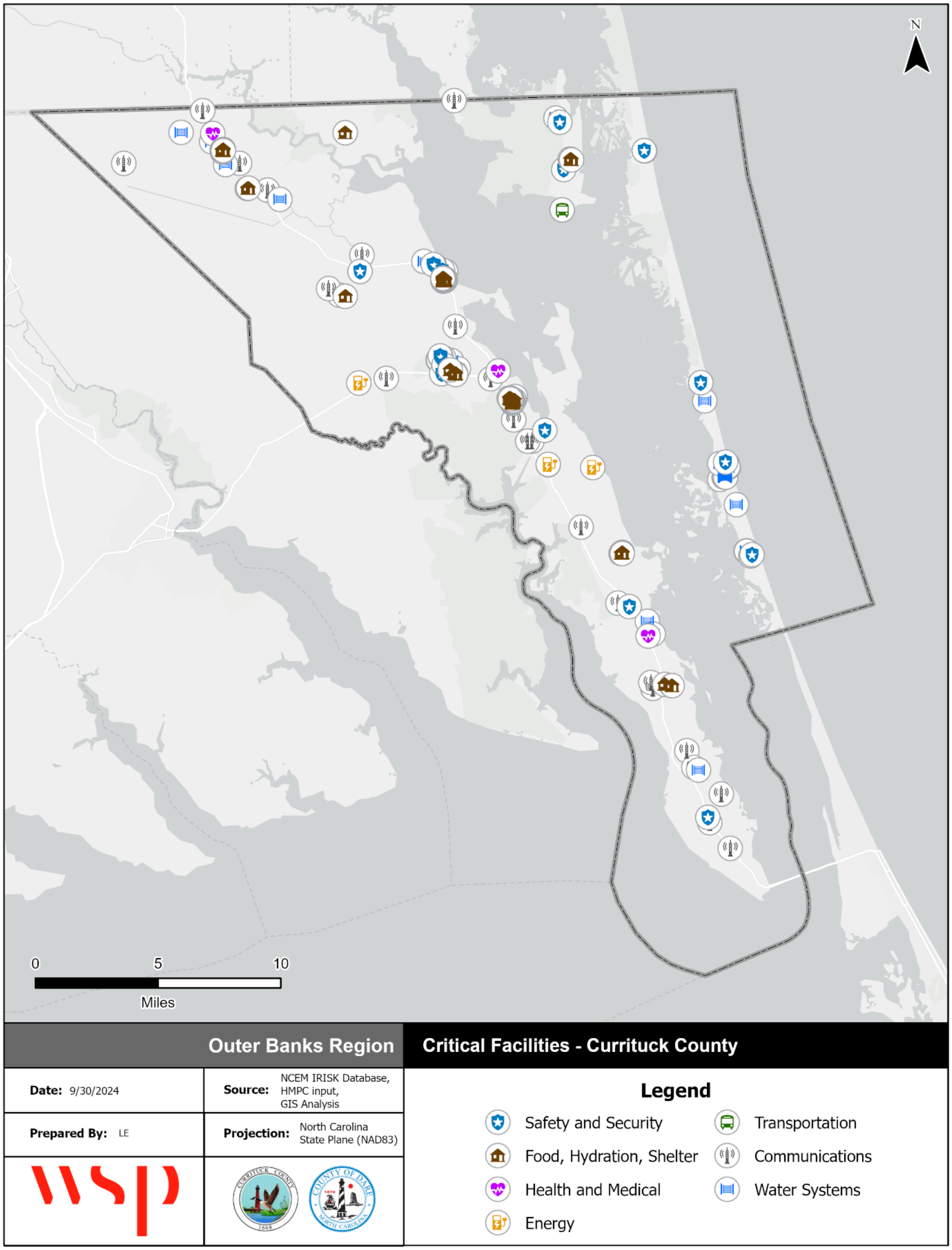
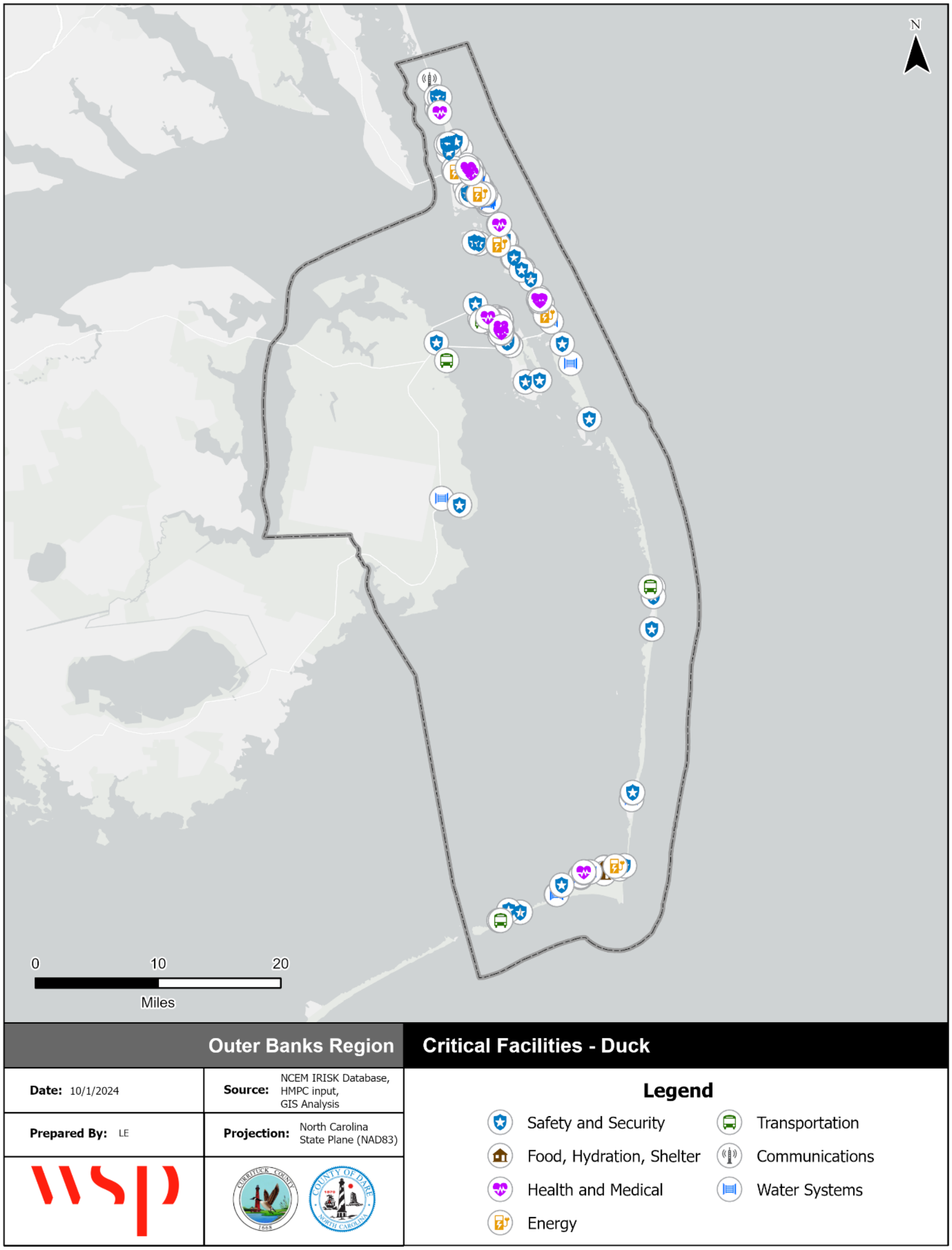


Figure 4.2 – Critical Facilities, Dare County



4.5 HAZARD PROFILES, ANALYSIS, AND VULNERABILITY

4.5.1 DROUGHT

HAZARD BACKGROUND

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 of time, 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 4.11.

Table 4.11 – Drought Classifications

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 a good exceeds supply as a result of a weather-related deficit in water supply.

Source: National Drought Mitigation Center

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 particular 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).

In addition to the calculated indices, the North Carolina Drought Management Advisory Council's (DMAC) Technical Drought Advisory Team compiles drought-related information each week including stream flows, groundwater and reservoir levels, wildfire activity, and crop conditions and send recommendations to the U.S. Drought Monitor for North Carolina's drought conditions.

The State of North Carolina has a Drought Assessment and Response Plan as an Annex to its Emergency Operations Plan. This plan provides the framework to coordinate statewide response to a drought incident.

Warning Time: 1 – More than 24 hours

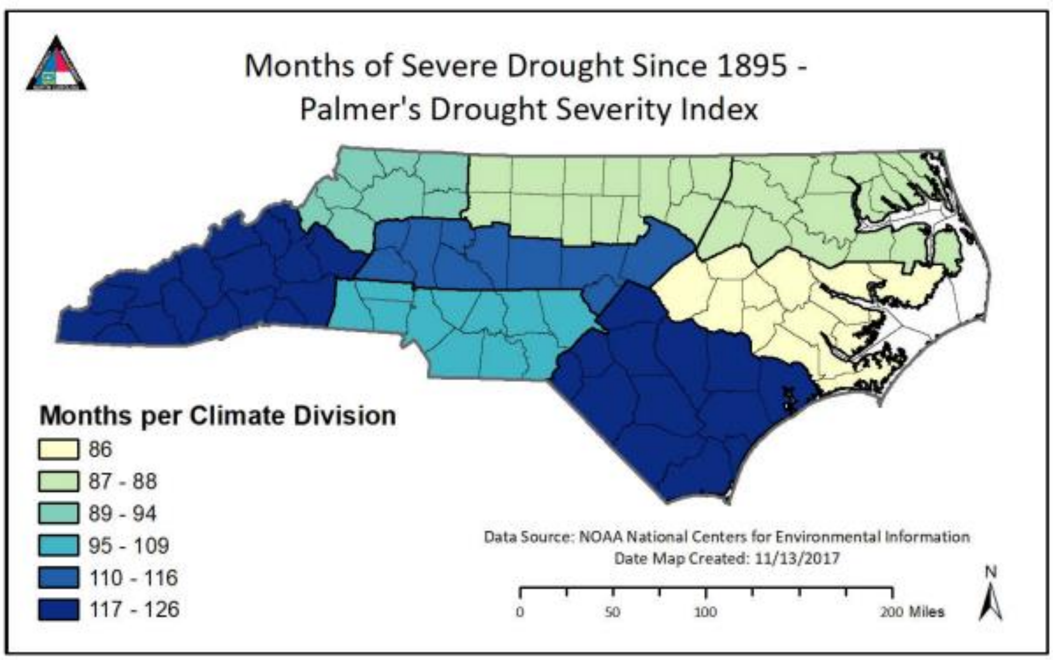
Duration: 4 – More than one week

LOCATION

Typically, the National Weather Service looks at drought and extreme heat as episodes that impact a widespread forecast "zone," and therefore it is not common to pinpoint a specific location within a planning area that is more susceptible to these hazards than others. From this viewpoint, each county is considered uniformly at risk to drought and extreme heat. However, the most significant financial losses are likely to occur in areas that are primarily agricultural. Areas with water-dependent recreational economies are also at higher risk.

Figure 4.3 shows the Palmer Drought Severity Index (PDSI) summary map for North Carolina since 1895. PDSI drought classifications are based on observed drought conditions and range from -0.5 (incipient dry spell) to -4.0 (extreme drought). As can be seen, northern North Carolina has historically not seen as many significant long-term droughts as the western and southeastern regions of the state. Specifically, the Outer Banks Region was in severe drought for 87-88 months during the identified timeframe.

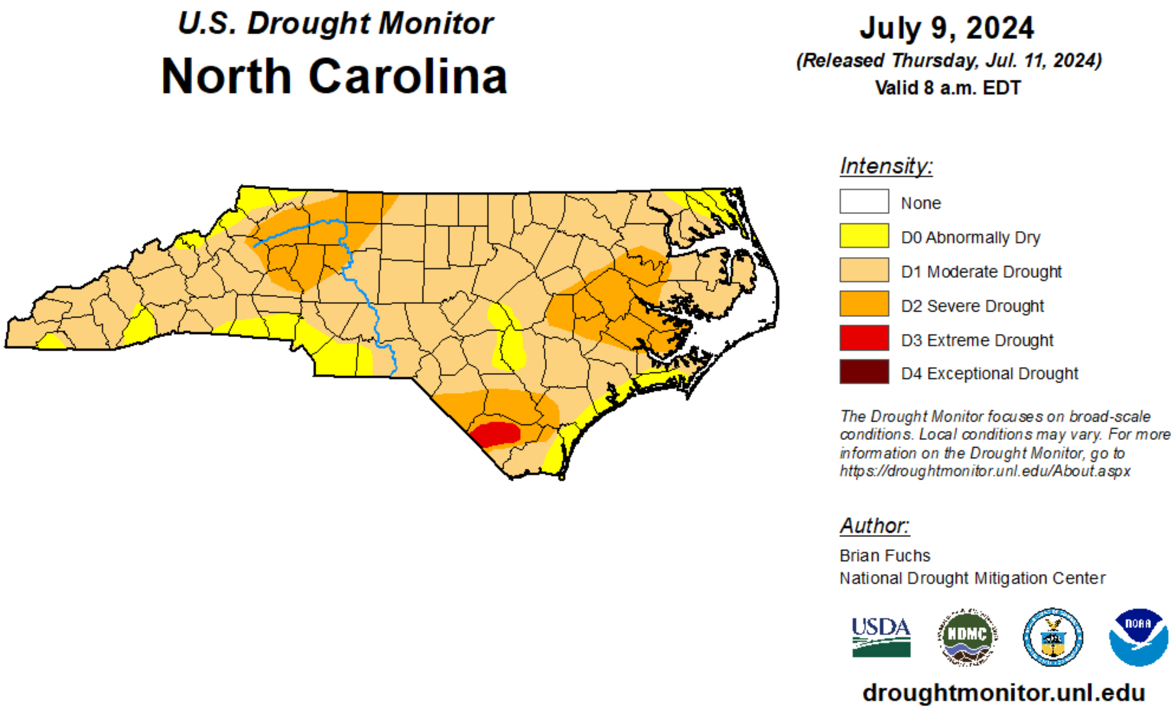
Figure 4.3 – PDSI Months of Severe Drought Since 1895



Source: State of North Carolina 2023 Hazard Mitigation Plan

Error! Not a valid bookmark self-reference. notes the U.S. Drought Monitor's drought ratings for North Carolina as of February 22, 2024; as of that date, neither Currituck County nor Dare County were experiencing abnormally dry (D0) conditions. This map illustrates the regional nature of drought when it occurs.

Figure 4.4 – US Drought Monitor for Week of July 9, 2024



Source: U.S. Drought Monitor

Spatial Extent: 4 – Large

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 4.5 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.

The Outer Banks Region is susceptible to any of the levels of drought on the U.S. Drought Monitor scale. The most severe period of drought since 2000 occurred in the summer of 2011 and reached extreme drought across 100% of Dare County and 15% of Currituck County.

Impact: 1 – Minor

Figure 4.5 – US Drought Monitor Classifications

			Ranges				
Category	Description	Possible Impacts	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

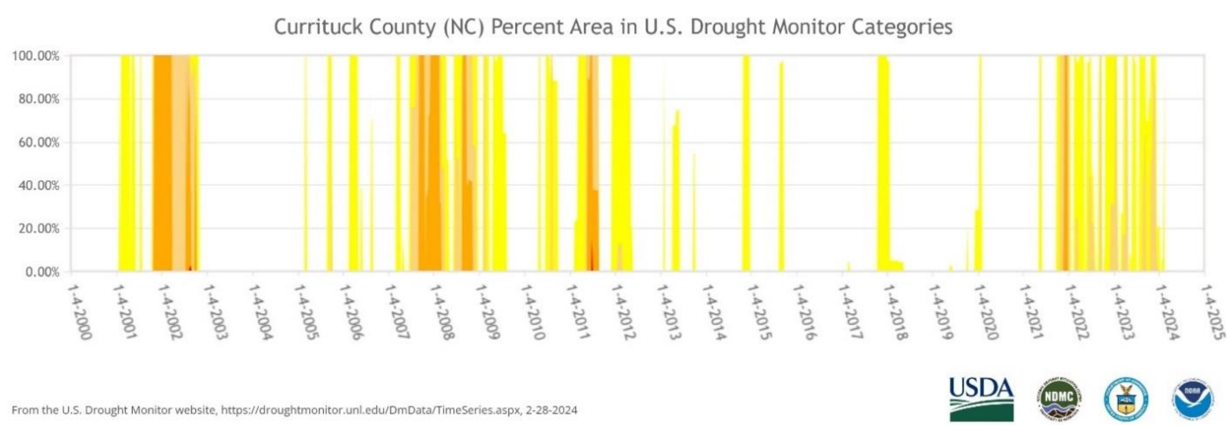
HISTORICAL OCCURRENCES

The U.S. Drought Monitor provides historical data on droughts in both Currituck and Dare Counties. The following figures show historical periods where each county was considered in some level of drought condition. The color key shown in Figure 4.5 indicates the intensity of the drought. According to the U.S. Drought Monitor, between January 1, 2000 and December 31, 2023, Currituck County was in some level of drought condition 35% of the time, or 443 of 1,252 weeks. Most this time was spent in "abnormally dry" or "moderate" drought conditions; Currituck County recorded four weeks in "extreme" drought:

— Week of July 5, 2011 – 14.94% of county in extreme drought
— Week of August 20, 2002 – 2.28% of county in extreme drought
— Week of August 27, 2002 – 2.41% of county in extreme drought
— Week of March 12, 2002 – 0.65% of county in extreme drought

The 2002 drought lasted 55 weeks, between the weeks of October 16, 2001 and October 29, 2002.

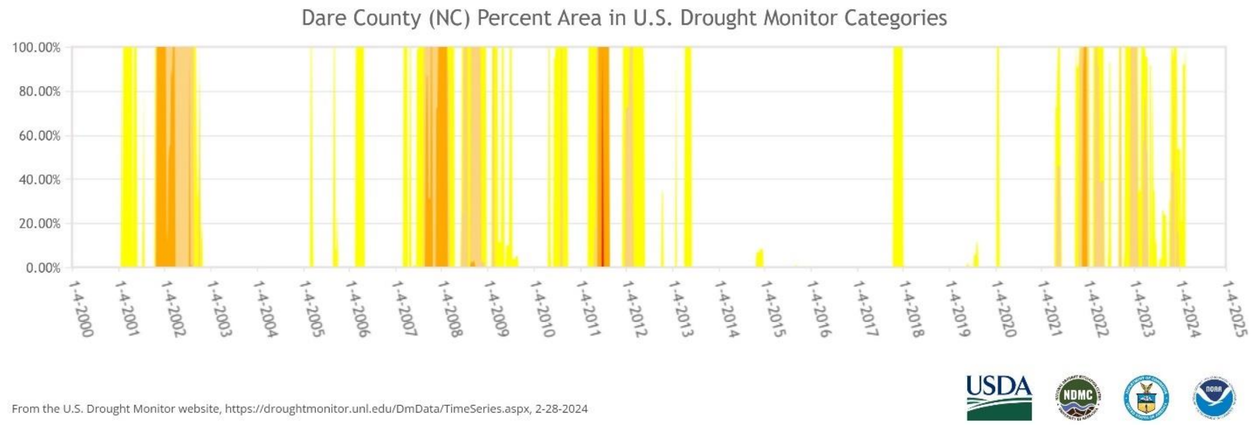
Figure 4.6 – US Drought Monitor Historical Trends – Currituck County 2000-2023



Source: U.S. Drought Monitor

According to the U.S. Drought Monitor, between January 1, 2000 and December 31, 2023, Dare County was in some level of drought condition 33% of the time, or 418 of 1252 weeks. The majority of this time was spent in “abnormally dry” or “moderate” drought conditions; Dare County recorded one instance, during the week of July 5, 2011, where 100% of the land area was considered in “extreme drought.” This corresponded to a larger drought event lasting from March through August of 2011.

Figure 4.7 – US Drought Monitor Historical Trends – Dare County 2000-2023



Source: U.S. Drought Monitor

The National Drought Mitigation Center’s Drought Impact Reporter Dashboard summarizes drought-related media reports starting in 2005. The following narratives were compiled from the Dashboard search results for Dare and Currituck Counties:

- In 2010, Dare County was among several North Carolina Counties declared to be natural disaster areas by the U.S. Department of Agriculture due to drought and high temperatures. The declaration permitted farmers, ranchers, and other agricultural producers to apply for low-interest emergency loans from the Farm Service Agency.
- In the late summer of 2011, a wildfire burning in the Great Dismal Swamp National Wildlife Refuge moved into North Carolina and parts of Currituck County. Local news reported that drought conditions, winds, and availability of fuel has allowed the fire to spread easily and burn deep into the soil.
- During the winter of 2020, abnormal dryness along the coast of North Carolina led the state Drought Management Advisory Council to strongly recommend the implementation of drought response actions for affected areas including Dare and Currituck Counties.
- The U.S. Forest Service implemented burn bans in the Counties in Summer 2019 and Fall 2021 due to dry conditions.

PROBABILITY OF FUTURE OCCURRENCE

Based on historical occurrences, the probability that the Region will experience some level of drought is likely, with Dare County in drought 40 percent of the time during the period from 2000 through 2023 and Currituck County in drought 35 percent of the time during that same period. However, the probability of extreme drought is much lower, with only one instance of extreme drought in Dare County and four instances of extreme drought in Currituck County. Overall, drought in the Outer Banks can be considered possible.

Probability: 2 – Possible

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.

The Fifth National Climate Assessment upholds the climate trends reported in the Fourth Assessment and presents additional patterns in the Southeast that exacerbate climate risk and impacts. These patterns include population growth, high proportion of the population with health issues or underlying health conditions, and a large, climate-dependent agricultural sector.

VULNERABILITY ASSESSMENT

METHODOLOGIES AND ASSUMPTIONS

This assessment of vulnerability to drought in the Outer Banks region is based on historical occurrences of drought in the planning area and generalized concerns regarding potential drought consequences. Agricultural vulnerability was estimated using data from the USDA Risk Management Agency crop insurance claims, specifically past claims related to drought.

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. 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. Between 2007-2023, the sum of claims paid for crop damage as a result of drought in Currituck County was $1,341,285, or an average of $78,899 in losses every year. There were $419,314 in recorded losses in Dare County, or an average of $24,666 in losses every year, though losses only occurred in four years. Table 4.12 summarizes the crop losses due to drought in reported in the RMA system.

Table 4.12 – Crop Losses Resulting from Drought, 2007-2023, Outer Banks

Year	Determined Acres	Indemnity Amount
Currituck County		
2007	948.60	$84,250.00
2008	1,590.10	$75,505.00
2009	388.90	$18,154.00

Year	Determined Acres	Indemnity Amount
Currituck County		
2010	703.08	$33,932.00
2011	3,055.63	$240,606.00
2013	699.40	$55,230.00
2014	123.80	$1,534.00
2015	947.37	$71,537.10
2016	156.60	$18,449.50
2017	395.70	$17,466.00
2019	572.90	$35,798.00
2020	3,563.52	$263,431.50
2022	2,772.14	$273,899.45
2023	3,635.98	$151,493.00
Subtotal Currituck	*19,553.17*	*$1,341,285.55*
Dare County		
2016	156.60	$18,449.50
2019	637.29	$97,611.15
2022	1,909.29	$254,797.00
2023	310.11	$48,484.00
Subtotal Dare	*3,013.28*	*$419,314.65*
Region Total	**22,566.45**	**$1,760,600.20**

Source: USDA Risk Management Agency

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.

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 4.13 summarizes the potential negative consequences of drought.

Table 4.13 – 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.

Category	Consequences
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. 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. Probability, warning time, duration and spatial extent are inherent to the hazard and are consistent across all jurisdictions. Most damages that result from drought are to crops and other agriculture-related activities as well as water-dependent recreation industries. The magnitude of the impacts is typically greater in unincorporated areas; thus, impacts could be higher in Currituck County, which has also experienced more crop losses due to drought. In 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
Currituck County	2	2	4	1	4	2.5	M
Dare County	2	1	4	1	4	2.2	M
Duck	2	1	4	1	4	2.2	M
Kill Devil Hills	2	1	4	1	4	2.2	M
Kitty Hawk	2	1	4	1	4	2.2	M
Manteo	2	1	4	1	4	2.2	M
Nags Head	2	1	4	1	4	2.2	M
Southern Shores	2	1	4	1	4	2.2	M

4.5.2 EARTHQUAKE

HAZARD BACKGROUND

An earthquake is a movement or shaking of the ground. Most earthquakes are caused by the release of stresses accumulated from 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 ten 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.

In some coastal areas, earthquakes can cause an additional risk of tsunamis. Per NOAA, a tsunami is a series of waves, which can have tens to hundreds of miles between crests, caused by a large and sudden displacement of the ocean from an earthquake or undersea volcanic eruption. Tsunamis radiate outward in all directions from the disturbance and can cause dangerous coastal flooding and currents for several hours to days when they reach the coast. Much like earthquakes, scientists cannot accurately predict when a tsunami will occur, but NOAA's Tsunami Warning Centers monitor seismic and water-level networks to detect tsunamis and issue warnings.

Warning Time: 4 – Less than six hours

Duration: 1 – Less than six hours

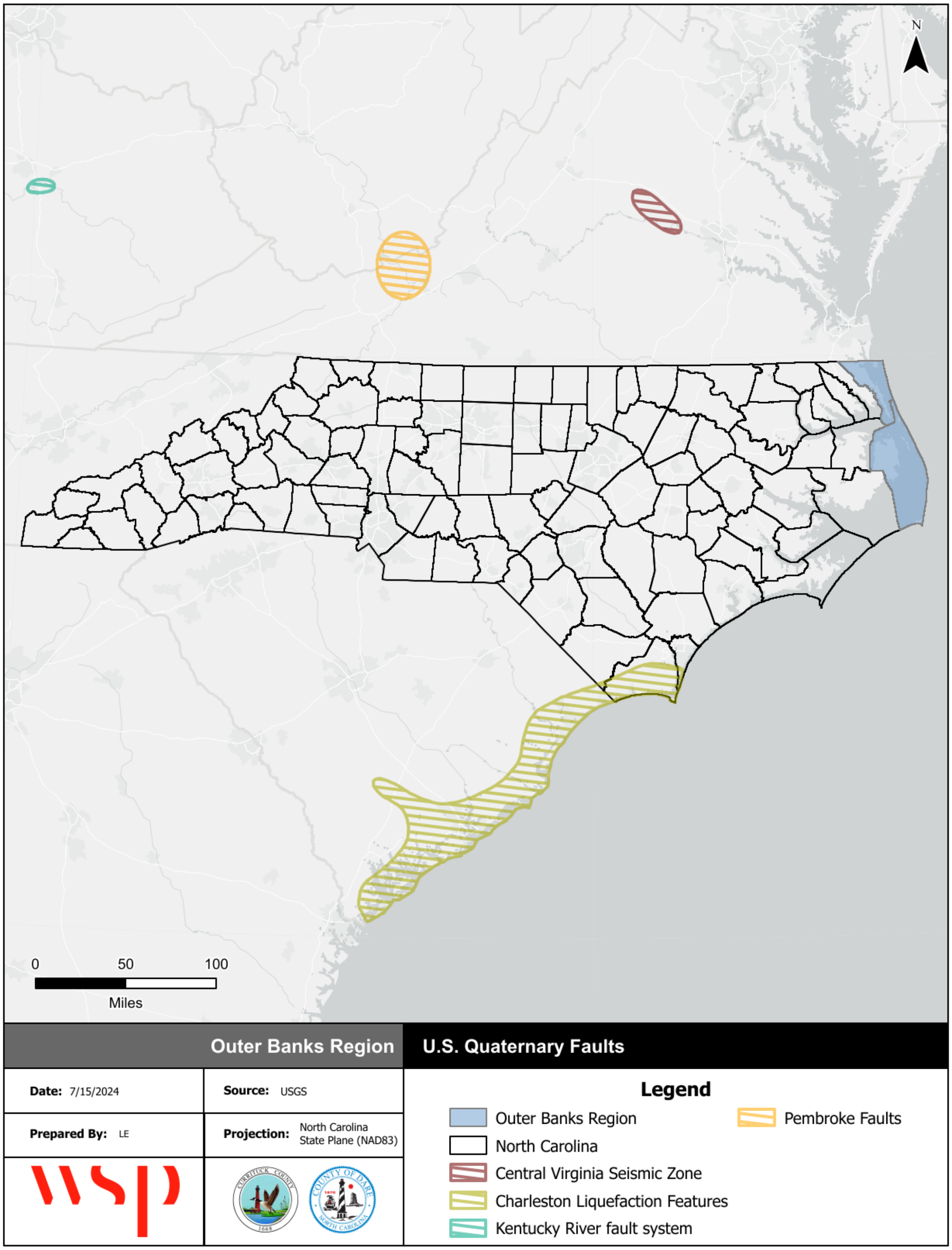
LOCATION

Figure 4.8 reflects the Quaternary faults that present an earthquake hazard for the Outer Banks planning area based on data from the USGS Earthquake Hazards Program.

All of North Carolina is subject to earthquakes, with the western and southern region most vulnerable to a damaging earthquake. The state is affected by both the Charleston Fault in South Carolina and New Madrid Fault in Tennessee. Both of these faults have generated earthquakes measuring greater than 8.0 on the Richter Scale during the last 200 years. In addition, there are several smaller fault lines in eastern Tennessee and throughout North Carolina that could produce less severe shaking.

Spatial Extent: 4 – Large

Figure 4.8 – US Quaternary Faults



Source: USGS Earthquake Hazards Program

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 4.14. The Richter scale is usually used by the news media when reporting the magnitude of earthquakes and is the scale most familiar to the public. However, intensity scales can provide a more meaningful measure of earthquake severity because intensity refers to the effects actually experienced in a given place. The scale currently used in the U.S. is the Modified Mercalli Intensity (MMI) scale. The MMI scale does not have a mathematical basis; instead it is an arbitrary ranking in which MMI values are assigned to specific sites after an earthquake based on observed impacts. Figure 4.9 shows descriptions for levels of earthquake intensity on the MMI scale. Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

Table 4.14 – 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

Figure 4.9 – Modified Mercalli Intensity (MMI) Scale

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

Source: USGS

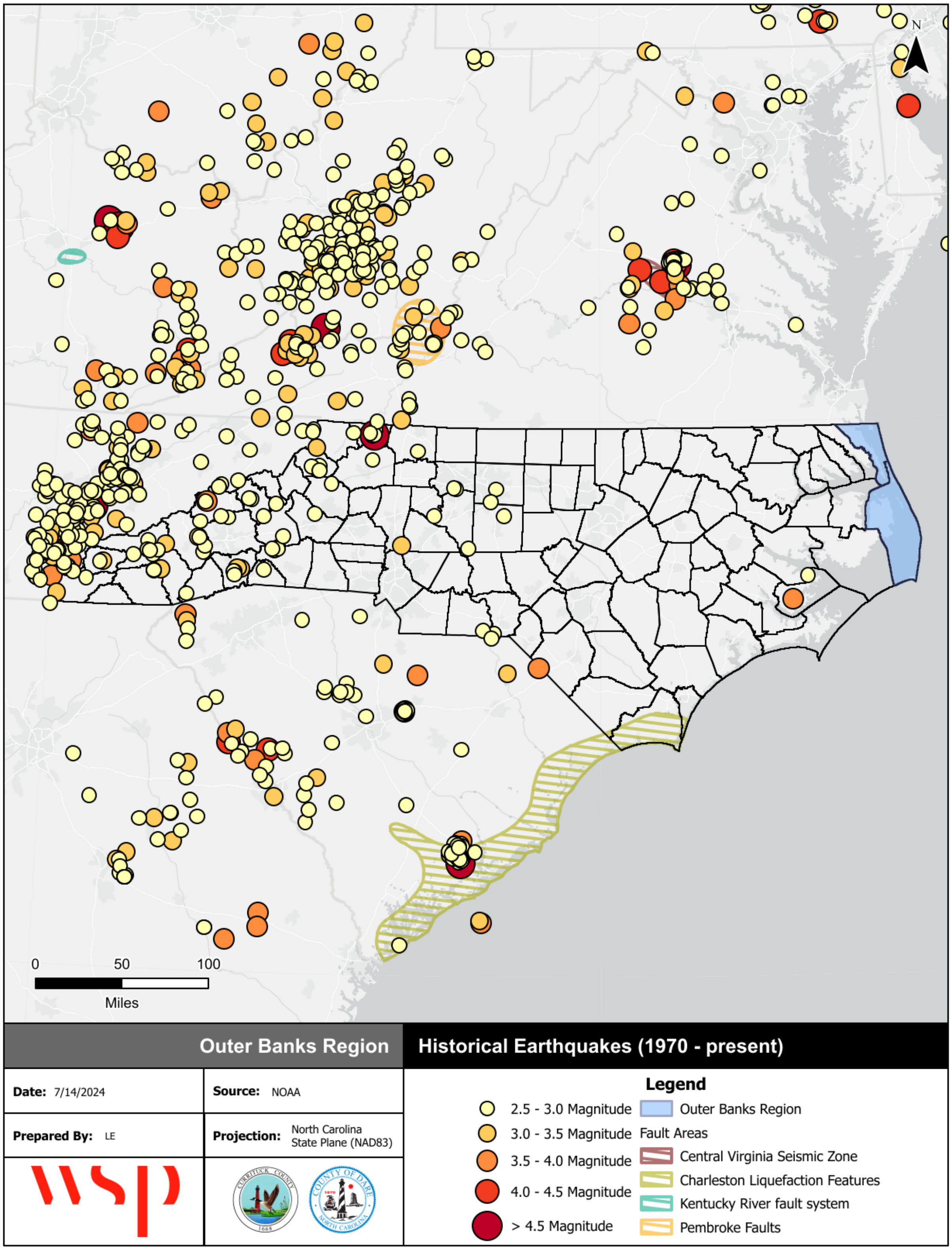
Tsunamis can be measured based on their size, speed, and number of waves, but tsunamis are generally described by their heights at the shore and the maximum runup of the tsunami waves on the land. NOAA developed and deployed DART – Deep-Ocean Assessment and Reporting of Tsunamis. DART is a tsunamograph that provides accurate, real-time data on tsunamis. There is an intensity scale – the New Tsunami Intensity Scale, which was introduced in 2001 by Papadopoulos and Umamura – but it is rarely used today.

Impact: 1 – Minor

HISTORICAL OCCURRENCES

The USGS Earthquake Hazards Program maintains a database of all historical earthquakes of a magnitude 2.5 and greater. These events are illustrated in Figure 4.10, which shows historical earthquakes by magnitude in relation to the Outer Banks Region, North Carolina, and the Quaternary Faults identified by USGS. This includes events from 1970 to 2024.

Figure 4.10 – Historical Earthquakes by Magnitude, 1970-2024



Source: USGS Earthquakes Hazard Program

The above map documents all earthquakes that have occurred within North Carolina but given the long distances across which earthquake impacts can be felt, these events do not encompass all earthquakes that have affected North Carolina. USGS maintains a "Did You Feel It?" (DYFI) database to collect information from people who felt an earthquake and create maps that show what people experienced and the extent of damage. However, there are no records in the past 50 years of any felt earthquake impacts in the Outer Banks region.

According to NOAA's Global Historical Tsunami Database[1], 109 definite or probable tsunamis have occurred in the U.S. since 1700, of which 31 reported tsunamis caused at least 1 death or $1 million in damage. None of these damaging tsunamis have impacted the Atlantic Coast.

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 of 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 particular frequency) that have a common given probability of being exceeded in 50 years.

Figure 4.11 reflects the seismic hazard for the Outer Banks 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.

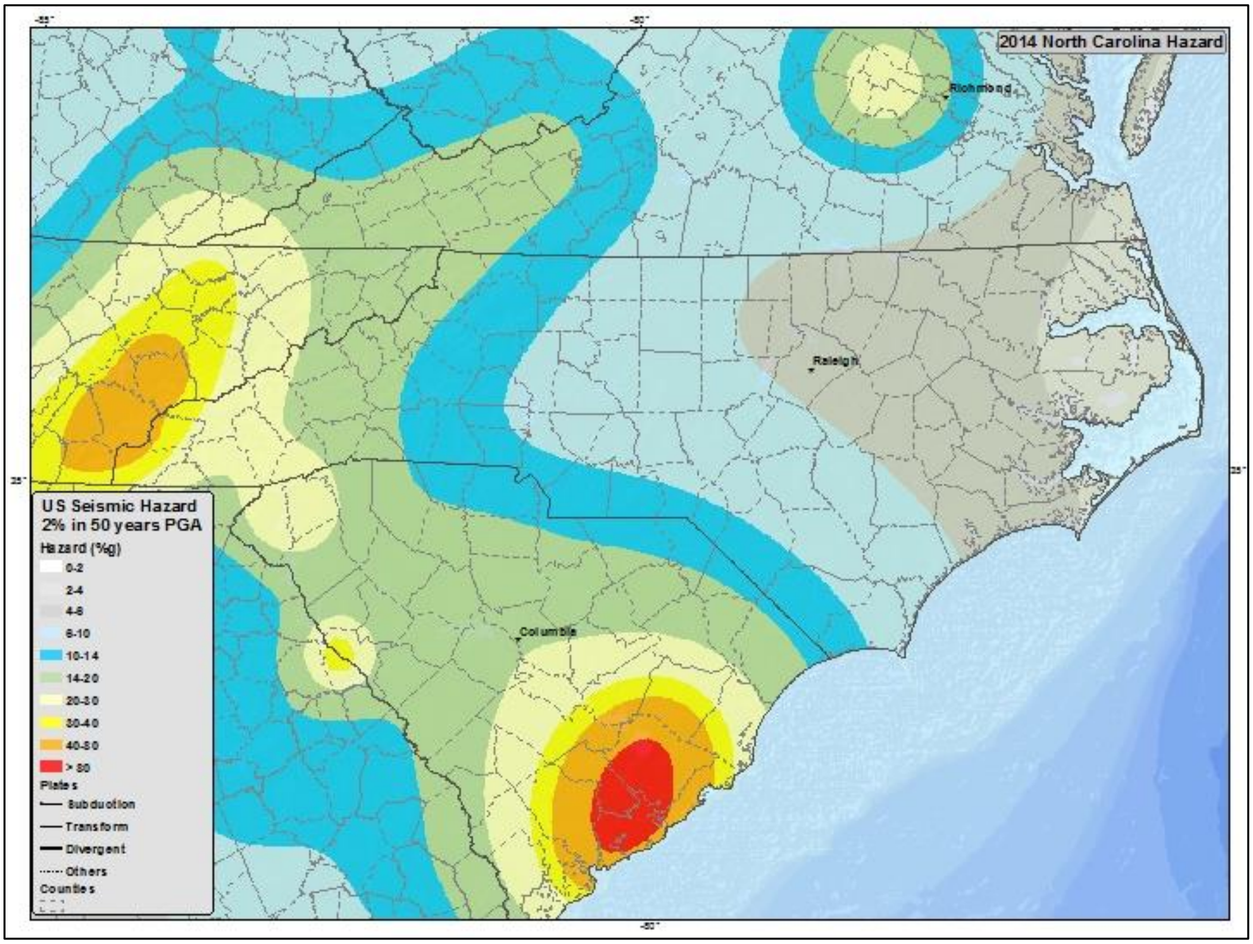
The Outer Banks are located within the light gray zone representing a very low peak acceleration of 0.02 to 0.04 g. Based on this data, it can be reasonably assumed that an earthquake affecting the Outer Banks is unlikely.

An assessment done by the National Tsunami Hazard Mitigation Program ranks the likelihood of a tsunami event on the Atlantic Coast as very low to low. Distant tsunamis may pose a threat to all U.S. coasts, but the hazard is greatest for coastlines near subduction zones, like those around the Pacific and Caribbean, where tsunamis can be generated by large earthquakes and associated landslides. The U.S. East and Gulf Coasts are not near subduction zones, and earthquakes are not as large or as frequent as in other regions. The most likely sources of tsunamis on these coasts are underwater landslides and meteotsunamis, which are tsunamis generated by air pressure disturbances from fast moving weather systems.

Probability: 1 – Unlikely

[1] National Geophysical Data Center / World Data Service: NCEI/WDS Global Historical Tsunami Database. NOAA National Centers for Environmental Information. doi:10.7289/V5PN93H7 [July 11, 2024]

Figure 4.11 – Seismic Hazard Information for North Carolina



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 the Outer Banks are unlikely to produce more than mild ground shaking; therefore, injury or death is unlikely. Objects falling from shelves generally pose the greatest threat to safety. Tsunamis are unlikely to occur in any magnitude that would threaten public safety.

Table 4.15 and Table 4.16 detail the population estimated to be at risk from a 250-year earthquake and a 500-year earthquake, respectively, according to the NCEM IRISK database.

Table 4.15 – Estimated Population Impacted by 250-Year Earthquake

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Currituck									
Currituck County	31,343	0	0%	5,390	0	0%	1,596	0	0%
Dare									
Unincorporated Dare County	24,369	0	0%	4,752	0	0%	1,150	0	0%
Town of Duck	1,722	0	0%	582	0	0%	53	0	0%
Town of Kill Devil Hills	7,588	0	0%	1,298	0	0%	260	0	0%
Town of Kitty Hawk	3,903	0	0%	861	0	0%	137	0	0%
Town of Manteo	1,360	0	0%	220	0	0%	80	0	0%
Town of Nags Head	3,178	0	0%	1,084	0	0%	70	0	0%
Town of Southern Shores	2,536	0	0%	858	0	0%	78	0	0%
Subtotal Dare	**44,656**	**0**	**0%**	**9,655**	**0**	**0%**	**1,828**	**0**	**0%**
Region Total	**75,999**	**0**	**0%**	**15,045**	**0**	**0%**	**3,424**	**0**	**0%**

Source: NCEM Risk Management Tool

Table 4.16 – Estimated Population Impacted by 500-Year Earthquake

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Currituck									
Currituck County	31,343	7,077	22.6%	5,390	1,217	22.6%	1,596	360	22.6%
Dare									
Unincorporated Dare County	24,369	716	2.9%	4,752	196	4.1%	1,150	47	4.1%
Town of Duck	1,722	0	0.0%	582	0	0.0%	53	0	0.0%
Town of Kill Devil Hills	7,588	67	0.9%	1,298	13	1.0%	260	3	1.2%
Town of Kitty Hawk	3,903	36	0.9%	861	9	1.0%	137	1	0.7%
Town of Manteo	1,360	44	3.2%	220	7	3.2%	80	3	3.8%
Town of Nags Head	3,178	37	1.2%	1,084	14	1.3%	70	1	1.4%
Town of Southern Shores	2,536	2	0.1%	858	1	0.1%	78	0	0.0%
Subtotal Dare	**44,656**	**902**	**2.0%**	**9,655**	**240**	**2.5%**	**1,828**	**55**	**3.0%**
Region Total	**75,999**	**6,489**	**8.5%**	**15,045**	**1457**	**9.7%**	**3,424**	**415**	**12.1%**

Source: NCEM Risk Management Tool

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 or infrastructure (a building, road, etc.) is built across a fault, the ground displacement during an earthquake could seriously damage it.

Earthquakes damages to infrastructure can result in secondary hazards. For example, 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.

The Outer Banks region has not been impacted by an earthquake with more than a moderate intensity, so damage to the built environment is unlikely. Similarly, tsunamis are unlikely to occur in any magnitude that would damage the built environment.

Table 4.17 through Table 4.18 detail the estimated buildings impacted from varying magnitudes of earthquake events.

Table 4.17 – Estimated Buildings Impacted by 250-Year Earthquake Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	2	0%	$0	1	0%	$7	0	0%	$0	1	0%	$7
Dare													
Unincorporated Dare County	14,019	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Duck	2,409	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Kill Devil Hills	6,033	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Kitty Hawk	2,862	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Manteo	943	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Nags Head	4,868	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Southern Shores	2,513	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Subtotal Dare	**2,513**	**0**	**0%**	**$0**	**0**	**0%**	**$0**	**0**	**0%**	**$0**	**0**	**0%**	**$0**
Region Total	**54,133**	**0**	**0%**	**$0**	**1**	**0%**	**$7**	**0**	**0%**	**$0**	**1**	**0%**	**$7**

Source: NCEM Risk Management Tool

Table 4.18 – Estimated Buildings Impacted by 500-Year Earthquake Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	3,591	20.3%	$11,018	1,413	8.0%	$52,225	153	0.9%	$15,190	5,157	29.2%	$78,434
Dare													
Unincorporated Dare County	14,019	530	3.8%	$1,133	249	1.8%	$5,462	75	0.5%	$3,724	854	6.1%	$10,319
Town of Duck	2,409	0	0.0%	$0	26	1.1%	$195	3	0.1%	$162	29	1.2%	$357
Town of Kill Devil Hills	6,033	43	0.7%	$507	93	1.5%	$3,424	6	0.1%	$813	142	2.4%	$4,744
Town of Kitty Hawk	2,862	29	1.0%	$119	37	1.3%	$1,103	7	0.2%	$386	73	2.6%	$1,608
Town of Manteo	943	24	2.5%	$156	45	4.8%	$1,205	16	1.7%	$801	85	9.0%	$2,162
Town of Nags Head	4,868	37	0.8%	$1,032	79	1.6%	$4,038	9	0.2%	$300	125	2.6%	$5,370
Town of Southern Shores	2,513	2	0.1%	$32	15	0.6%	$337	1	0.0%	$36	18	0.7%	$405
Subtotal Dare	**33,647**	**665**	**2.0%**	**$2,979**	**544**	**1.6%**	**$15,764**	**117**	**0.3%**	**$6,222**	**1,326**	**3.9%**	**$24,965**
Region Total	**51,332**	**4,256**	**8.3%**	**$13,997**	**1,957**	**3.8%**	**$67,989**	**270**	**0.5%**	**$21,412**	**6,483**	**12.6%**	**$103,399**

Source: NCEM Risk Management Tool

ENVIRONMENT

An earthquake is unlikely to cause substantial impacts to the natural environment in the Outer Banks. 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 4.19 summarizes the potential negative consequences of earthquake.

Table 4.19 – Consequence Analysis - Earthquake

Category	Consequences
Public	The public may experience some shaking or fallen objects but are not expected to experience threats to health or safety from an earthquake.
Responders	As minimal damages to structures or infrastructure are expected, responders are not expected to be impacted by earthquakes.
Continuity of Operations (including Continued Delivery of Services)	Continuity of operations should easily be maintained. Disruption of communications or utility lines could occur that may cause service interruptions.
Property, Facilities, and Infrastructure	Damage to facilities and infrastructure is not likely to occur from low intensity shaking that could be expected from an earthquake in this region.
Environment	The likelihood of an earthquake causing environmental damages is very low. Secondary impacts from significant shaking could include hazardous materials release or fire, but these impacts are unlikely.
Economic Condition of the Jurisdiction	Local economy and finances are unlikely to be adversely affected.
Public Confidence in the Jurisdiction's Governance	Earthquakes in the region would likely be low intensity if they occur. Therefore, public confidence is unlikely to be affected by an earthquake.

HAZARD SUMMARY BY JURISDICTION

The following table summarizes earthquake hazard risk by jurisdiction. All characteristics of earthquake risk are uniform across the planning area.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
All jurisdictions	1	1	4	4	1	1.9	L

4.5.3 EXTREME HEAT

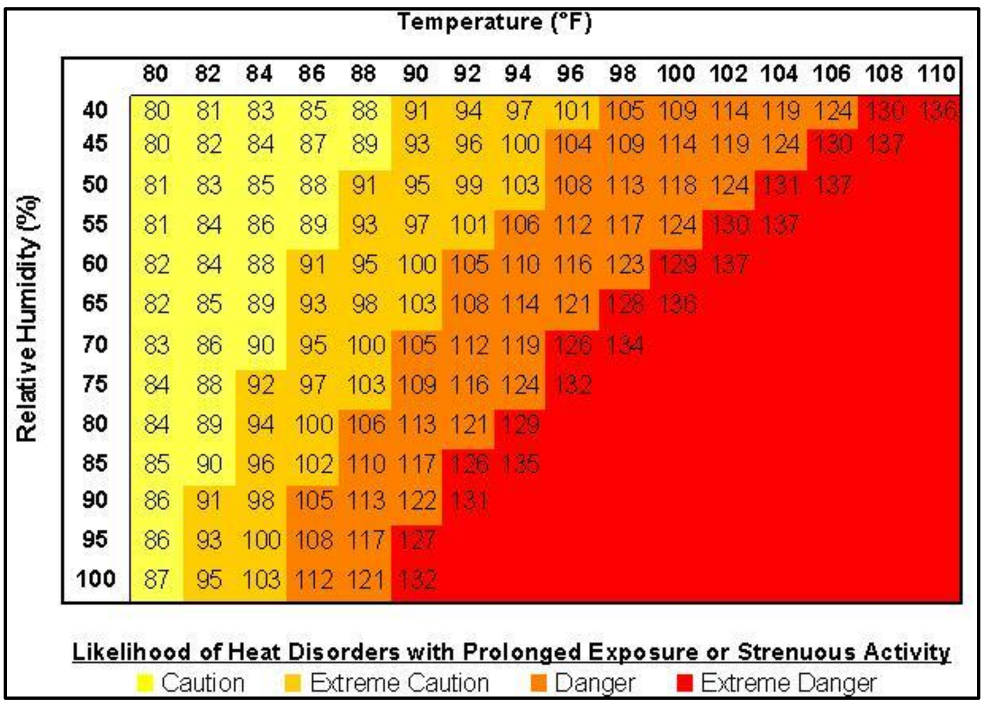
HAZARD BACKGROUND

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 4.12 uses both of these factors to produce a guide for the apparent temperature or relative intensity of heat conditions.

Figure 4.12 – Heat Index Chart



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										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: National Weather Service (NWS) http://www.nws.noaa.gov/os/heat/heat_index.shtml

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 over-exposed 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 4.20 lists typical symptoms and health impacts of exposure to extreme heat.

Table 4.20 – 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 National Weather Service 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.

Spatial Extent: 4 – Large

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 National Weather Service Forecast Office in Raleigh sets the following criteria for heat advisory and excessive heat warning:

- **Heat Advisory** – Heat Index of 105°F to 109°F for 3 hours or more. Can also be issued for lower values 100°F to 104°F for heat lasting several consecutive days
- **Excessive Heat Watch** – Potential for heat index values of 110°F or hotter within 24 to 48 hours. Also issued during prolonged heat waves when the heat index is near 110°F
- **Excessive Heat Warning** – Heat Index of 110°F or greater for any duration

Based on data from the North Carolina Climate Office, from January 1893 through January 2019, the highest temperature recorded in Dare County was 103°F in Manteo, which occurred in August 1942.

Impact: 2 – Limited

HISTORICAL OCCURRENCES

According to the National Oceanic and Atmospheric Administration (NOAA), 2017 was North Carolina's hottest year on record; that record stretches back 123 years to 1895.

The NCEI reports four heat incidents occurring in the Outer Banks; these incidents caused no injuries, fatalities, property damage or crop damage. The following event narratives are provided in the NCEI Storm Events Database:

July 21, 2011 – An extended period of excessive heat and humidity occurred across most of northeast North Carolina from July 21st to July 23rd. High temperatures ranged from 96 to 103 degrees during the afternoons, with heat index values ranging from 110 to 119. Overnight lows only fell into the lower 70s to lower 80s.

July 5, 2012 – High Pressure centered just to the west of the Middle Atlantic Region produced hot and humid weather over northeast North Carolina from July 5th through 8th. High temperatures ranged from the mid-90s to lower 100s, and low temperatures ranged from the mid-70s to lower 80s across the area.

September 3, 2020 – Intense heat and humidity combined to produce heat index values of 110 degrees or higher during the afternoon hours of September 2nd and 3rd. Heat index values peaked at around 113 degrees.

August 15, 2023 – A three-day heatwave ended with excessive heat being observed across Eastern NC. The heatwave began on Sunday, August 13th, with heat indices of 105 to 100 degrees. This pattern continued on Monday, August 14th with similar values. The heat and humidity intensified on Tuesday, August 15th ahead of a cold front that would move into Eastern NC. Widespread heat indices of 110 to 115 degrees were recorded, with some places even higher that 115 for a short time. The heatwave broke with the cold front moving in and producing widespread showers and thunderstorms during the evening hours. Dare Bomb Range soil monitor RAWS heat index peaked at 120 degrees.

Heat index records maintained by the North Carolina Climate Office indicate that the Region regularly experiences heat index temperatures above 100°F. Table 4.21 and Table 4.22 provide counts of heat index values by threshold recorded from 2000-2023 at the Dare County Airport weather station (KMQI) and from 2004-2023 at the First Flight Airport weather station (KFFA), respectively, used as indicators for the Outer Banks overall. Counts are provided as the number of hours in a given year where the heat index reached or exceeded 100°F.

Table 4.21 – Historical Heat Index Counts, Dare County Airport (KMQI) 2001-2023

Year	Heat Index Value				Total
	100-104˚F	105-109˚F	110-114˚F	≥115˚F	
2001	43	3	0	0	46
2002	69	61	14	5	149
2003	43	15	0	1	59
2004	42	45	7	1	95
2005	57	70	27	17	171
2006	60	23	15	3	101
2007	42	22	8	11	83
2008	18	3	0	0	21
2009	33	0	0	0	33

Year	Heat Index Value				Total
	100-104˚F	105-109˚F	110-114˚F	≥115˚F	
2010	117	49	20	11	197
2011	50	15	2	0	67
2012	53	21	0	0	74
2013	8	1	0	0	9
2014	5	1	0	0	6
2015	37	10	0	0	47
2016	84	49	6	2	141
2017	28	7	0	0	35
2018	16	0	0	0	16
2019	29	12	0	0	41
2020	44	9	1	0	54
2021	9	0	0	0	9
2022	36	2	0	0	38
2023	34	4	1	0	39
Sum	**957**	**422**	**101**	**51**	**1531**
Average	**42**	**18**	**4**	**2**	**67**

Source: North Carolina Climate Office, Heat Index Climatology Tool

Table 4.22 – Historical Heat Index Counts, First Flight Airport (KFFA) 2004-2023

Year	Heat Index Value				Total
	100-104˚F	105-109˚F	110-114˚F	≥115˚F	
2004	0	0	0	0	0
2005	31	19	3	0	53
2006	86	47	18	9	160
2007	35	14	7	6	62
2008	34	10	2	0	46
2009	17	0	0	0	17
2010	65	31	13	0	109
2011	7	5	0	0	12
2012	22	1	0	0	23
2013	2	0	0	0	2
2014	13	0	0	0	13
2015	53	35	6	0	94
2016	117	95	40	29	281
2017	30	4	0	0	34
2018	4	0	0	0	4
2019	28	5	0	0	33
2020	38	2	0	0	40
2021	7	0	0	0	7
2022	20	0	0	0	20
2023	14	2	0	0	16
Sum	**623**	**270**	**89**	**44**	**1026**
Average	**31**	**14**	**4**	**2**	**51**

Source: North Carolina Climate Office, Heat Index Climatology Tool

PROBABILITY OF FUTURE OCCURRENCE

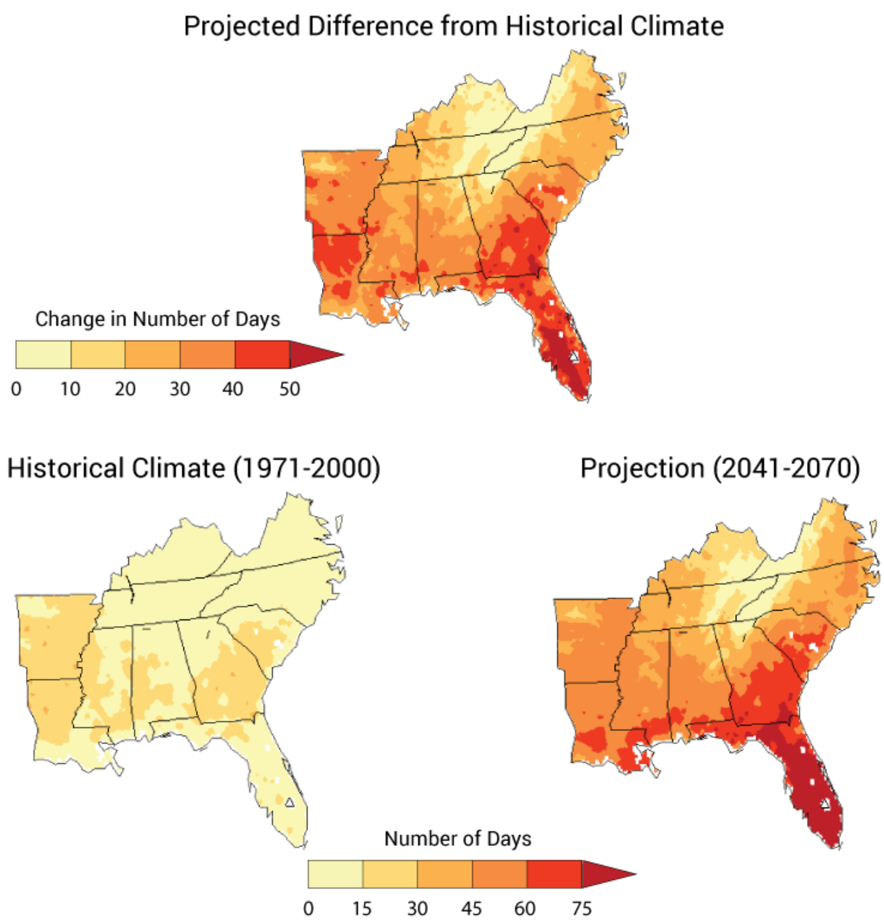
Data was gathered from the North Carolina State Climate Office's Heat Index Climatology Tool using the Dare County Airport and the First Flight Airport weather stations as approximations for the Outer Banks. Based on 23 and 20 years of available data, respectively, the Region averages 51-67 hours per year with heat index temperatures above 100°F. Heat index temperatures surpassed 100°F every year except for 2004 at the First Flight Airport; this occurred for at least 6 hours per year at the Dare County Airport station and at least 2 hours per year at the First Flight Airport station. Climate projections and observations from the State Climate Office of North Carolina, discussed below, indicate that extreme heat will continue to be a problem in the Outer Banks Region, with more days with maximum temperatures over 95 degrees F and more warm nights with minimum temperatures above 70 degrees F.

Probability: 4 – Highly Likely

CLIMATE CHANGE

Research shows that average temperatures will continue to rise in the Southeast United States and globally, directly affecting the Outer Banks region in North Carolina. 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 4.13.

Figure 4.13 – Projected Change in Number of Days Over 95˚F



Source: NOAA NCDC from 2014 National Climate Assessment

The Fifth National Climate Assessment found similar trends and reports that “heatwaves in the Southeast are happening more frequently and are occurring during a longer heat season, with some cities also showing increasing trends in their duration and intensity.” The Fifth National Climate Assessment also notes that warm nights (minimum temperatures at or above 70 degrees F) in the southeast have increased the most compared to all other continental U.S. regions.

According to historical data and climate projections provided by the State Climate Office of North Carolina on the North Carolina Resilience Exchange website, Currituck County has averaged 4 days per year with maximum temperatures over 95 degrees F. By the 2060s, that number is projected to increase to 15-22 days per year. Dare County has averages 2 days per year with temperatures above 95 degrees F and is projected to experience 9-13 days per year with these highs by the 2060s.

The number of warm nights is also projected to increase in the region. In Currituck County, warm nights may increase from 56 nights per year historically to 86-98 nights per year by the 2060s, and in Dare County, warm nights may increase from 72 nights per year historically to 102-113 nights per year by the 2060s.

VULNERABILITY ASSESSMENT

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. Table 4.6 in Section 4.4.1 provides an estimated count of elderly individuals and children living in each community, according to the 2020 Census. About 20 percent of the region’s population are elderly (age 65 and over) and about 5 percent of the population are children (age 5 and under). Table 4.23 shows the proportion of each community’s population that are elderly and children. In Duck, Kitty Hawk, Nags Head, and Southern Shores, more than a quarter of the population is considered to have increased vulnerability to extreme heat.

Table 4.23 – Vulnerable Population Counts and Percentages by Jurisdiction, 2020

Jurisdiction	Elderly (Age 65 and Over), Count	Elderly (Age 65 and Over), %	Children (Age 5 and Under), Count	Children (Age 5 and Under), %
Currituck				
Currituck County	5,390	17%	1,596	5%
Dare				
Dare County (Unincorporated Area)	4,752	20%	1,150	5%
Town of Duck	582	34%	53	3%
Town of Kill Devil Hills	1,298	17%	260	3%
Town of Kitty Hawk	861	22%	137	4%
Town of Manteo	220	16%	80	6%
Town of Nags Head	1,084	34%	70	2%
Town of Southern Shores	858	34%	78	3%
Subtotal Dare	**9,655**	**22%**	**1,828**	**4%**
Region Total	**15,045**	**20%**	**3,424**	**5%**

Source: U.S. Census Bureau, 2020 Decennial Census, via NC Risk Management Tool

Higher nighttime temperatures, referenced in the Fifth National Climate Assessment, interfere with the natural cooling of human bodies and the built environment which can impact human health significantly.

The Fifth National Climate Assessment also discusses equity issues surrounding heat exposure in the southeast region. While the region relies on air-conditioning especially in the warm months, the prevalence of air-conditioning access varies with racial background and economic status. The region also has high rates of energy insecurity with households paying the highest energy bills in the U.S. Because of this, extreme heat will result in disproportionate human health risks to low- and moderate-income households as well as communities of color.

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 agricultural losses. Between 2007-2023, the sum of claims paid for crop damage due to heat in Currituck County was $52,284.20, or an average of $3,075.54 in losses every year. There were no losses reported in Dare County. Table 4.12 summarizes the crop losses due to drought in reported in the RMA system.

Table 4.24 – Crop Losses Resulting from Heat, 2007-2023

Year	Determined Acres	Indemnity Amount
Currituck		
2010	44.12	$3,563.00
2012	429.60	$28,829.00
2020	213.52	$15,399.20
2022	101.36	$4,493.00
Total	**788.60**	**$52,284.20**

Source: USDA Risk Management Agency

ENVIRONMENT

Animals are vulnerable to heat disorders similar to humans, including mortality. Vegetation growth can be stunted by heat, or plants may be killed if temperatures rise above their tolerance extremes.

CONSEQUENCE ANALYSIS

Table 4.25 summarizes the potential negative consequences of extreme heat.

Table 4.25 – 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.

Category	Consequences
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. In Duck, Kitty Hawk, Nags Head, and Southern Shores, more than a quarter of the population is considered to have increased vulnerability to extreme heat. These communities were assigned a higher impact rating. Other characteristics of extreme heat risk do not vary significantly by jurisdiction.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Currituck County	4	2	4	1	3	3.0	H
Dare County	4	2	4	1	3	3.0	H
Duck	4	3	4	1	3	3.3	H
Kill Devil Hills	4	2	4	1	3	3.0	H
Kitty Hawk	4	2	4	1	3	3.0	H
Manteo	4	2	4	1	3	3.0	H
Nags Head	4	3	4	1	3	3.3	H
Southern Shores	4	3	4	1	3	3.3	H

4.5.4 FLOODING

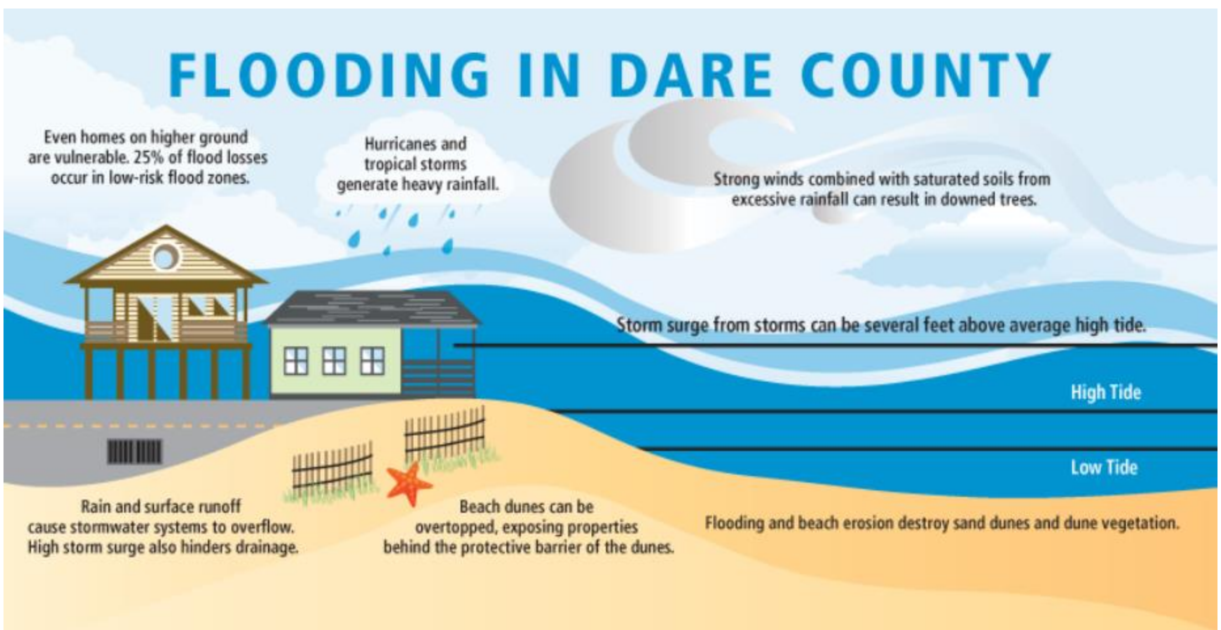
HAZARD BACKGROUND

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 causes more damage in the United States than any other severe weather related event, an average of $5 billion a year. 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 the majority of damages across the United States.

Figure 4.14 from the Dare County Planning Department summarizes flood related risks that are relevant to Dare County and Currituck County.

Figure 4.14 – Flood Related Risks in the Outer Banks Region



Source: Dare County Planning Department

SOURCES AND TYPES OF FLOODING:

The Outer Banks region can experience coastal flooding and storm surge, sea level rise, and localized stormwater flooding. Each of these types of flooding are described below, based on data from Flood Insurance Study (FIS) reports, Flood Insurance Rate Maps (FIRMs), NOAA, and the HMPC.

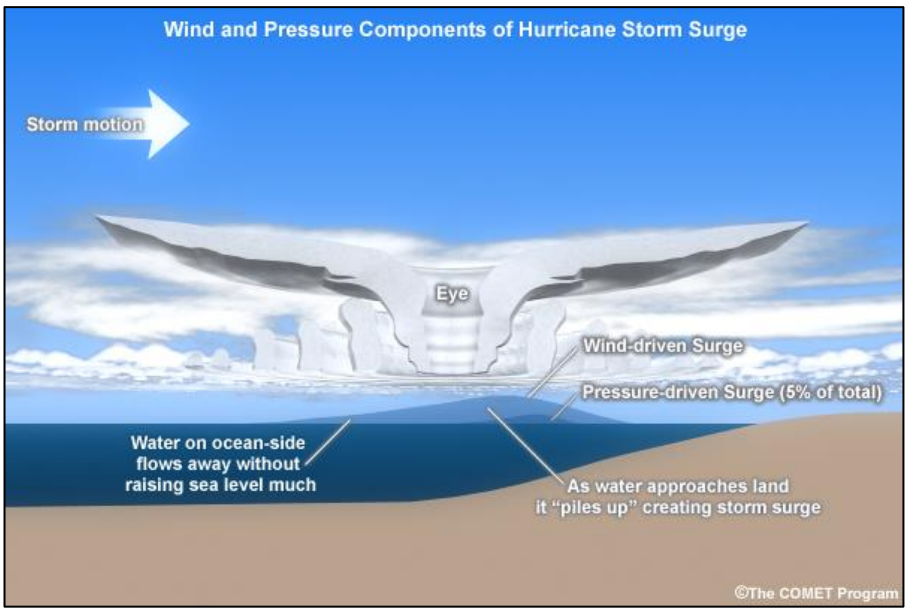
COASTAL FLOODING

All lands bordering the coast along the Atlantic Ocean and in low-lying coastal plains are susceptible to tidal effects and flooding. Coastal land such as sand bars, barrier islands and deltas provide a buffer zone that helps protect human life and real property relative to the sea much as floodplains provide a buffer zone along rivers and other bodies of water. Coastal floods usually occur because of abnormally high tides, storm surge, wind-driven waves, and heavy rains associated with tropical storms and hurricanes. Nor'easters have also been found to cause storm surge in both Dare and Currituck Counties.

Storm surge is water that is pushed toward the shore by the force of the winds swirling around the storm as shown in Figure 4.15. This advancing surge combines with the normal tides to create the 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 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. The Outer Banks region has a narrow continental shelf, with mile-deep waters generally only 20-30 miles off the coast.

Figure 4.15 – Components of Hurricane Storm Surge



Source: NOAA/The COMET Program

Wind-driven surge generated in the Atlantic Ocean and pushed into Pamlico and Albemarle Sounds and other waters is a primary source of flooding in the Outer Banks region. The wave action associated with storm surge can be even more damaging than the high water. The areas susceptible to surge flooding are summarized from each county's FIS as follows:

Currituck County: Surge propagates from the Albemarle Sound into the North River and Currituck Sound.

Dare County: Surge propagates from the Albemarle and Pamlico Sounds into the Alligator River, Croatan Sound, Currituck Sound, Davis Channel, East Lake, Old House Channel, Roanoke Sound, and South Lake.

During storm events in the Outer Banks, storm surge does not only occur on the Atlantic coast. It is not unusual for storm surge inundation to occur on the sound side of Outer Banks communities, as mentioned in the FIS. Sound side storm surge flooding can occur on the Currituck, Albemarle, and Pamlico Sounds. This was demonstrated in October 2019 when Tropical Storm Michael entered the sound and led to rapid sound side flooding equivalent to flood levels seen during Hurricane Matthew.

The Sea, Lake and Overland Surges from Hurricanes (SLOSH) model is a computerized numerical model developed by the National Weather Service to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account the atmospheric pressure, size, forward speed, and track data. These parameters are used to create a model of the wind field which drives the storm surge. The SLOSH model consists of a set of physics equations which are applied to a specific locale's shoreline, incorporating the unique bay and river configurations, water depths, bridges, roads, levees and other physical features. 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. SLOSH model surge maps are meant to represent a worst case scenario of surge for each storm category.

NOAA SLOSH maps are provided under the Extent section below to illustrate potential storm surge inundation resulting from each category of hurricane.

SEA LEVEL RISE

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. 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.

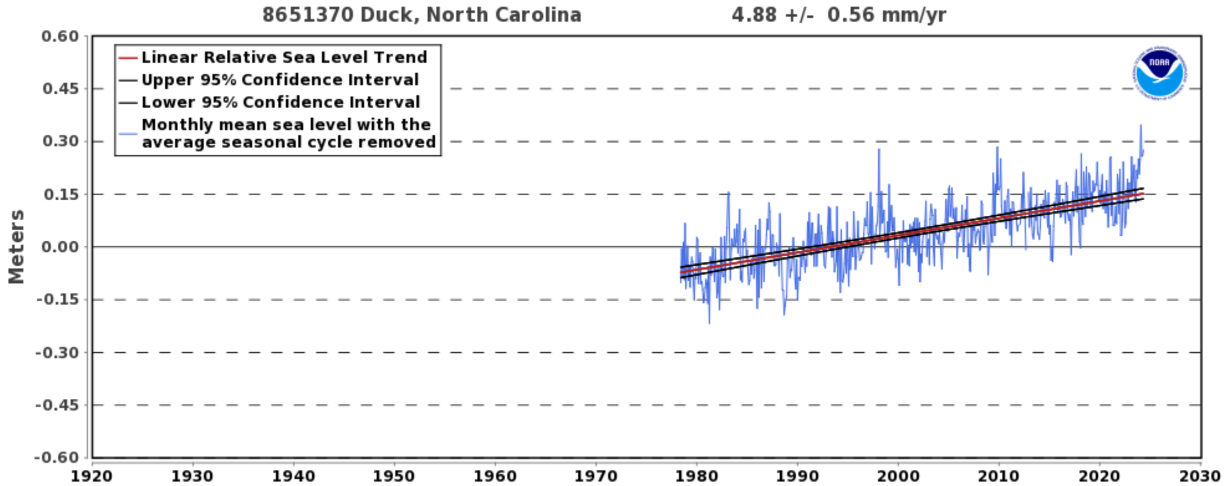
Historic trends in local MSL are best determined from tide gauge records. The Center for Operational Oceanographic Products and Services (CO-OPS) has been measuring sea level for over 150 years, with tide stations operating on all U.S. coasts. Changes in Mean Sea Level (MSL), either a sea level rise 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) to compute an accurate linear sea level trend. Stations in Duck, NC and Oregon Inlet Marina, NC provide data and projections relevant to the Outer Banks region.

Figure 4.16 and Figure 4.17 show the monthly mean sea level at NOAA’s Duck, NC and Oregon Inlet Marina, NC stations, respectively, without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The linear relative sea level 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.

At the Duck, NC station, the relative sea level trend is 4.88 mm/year with a 95% confidence interval of +/- 0.56 mm/year based on monthly mean sea level data from 1978 to 2023 which is equivalent to a change of 1.60 feet in 100 years. The 2020 Outer Banks plan reported a trend of 4.62 mm/year; therefore, the trend estimate has increased by 0.16 mm/year in the last five years.

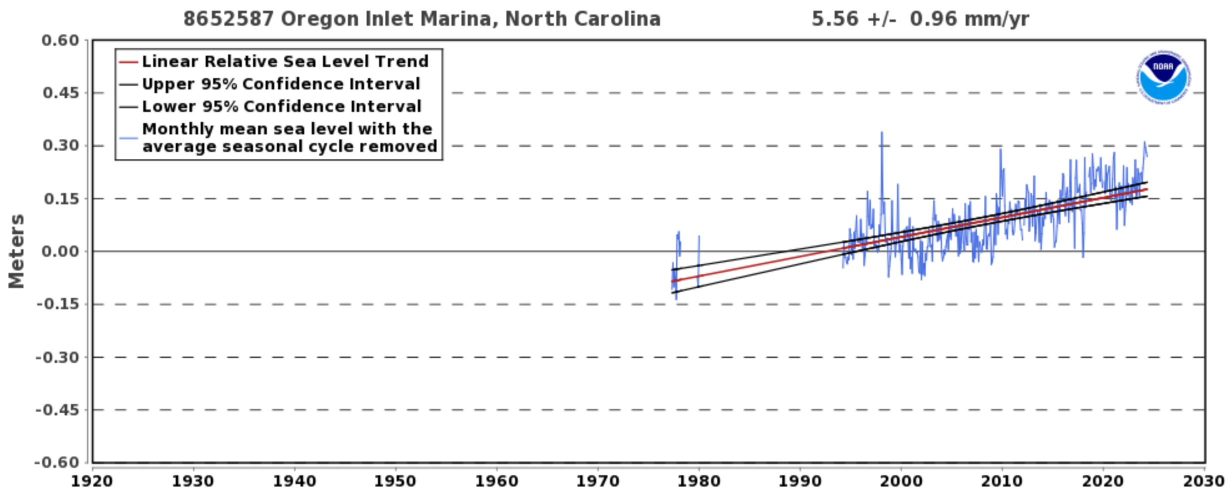
At the Oregon Inlet Marina, NC station, the relative sea level trend is 5.56 mm/year with a 95% confidence interval of +/- 0.96 mm/year based on monthly mean sea level data from 1977 to 2023 which is equivalent to a change of 1.82 feet in 100 years. The 2020 Outer Banks plan reported a trend of 4.69 mm/year; therefore, the trend estimate has increased by 0.87 mm/year in the last five years.

Figure 4.16 – Mean Sea Level Trends, Duck, NC



Source: NOAA Tides and Currents, July 2024

Figure 4.17 – Mean Sea Level Trends, Oregon Inlet Marina, NC



Source: NOAA Tides and Currents, July 2024

Warning Time: 1 – More than 24 hours

Duration: 4 – More than one week

LOCALIZED FLOODING

Localized flooding in the Outer Banks region consists of flash flooding and stormwater flooding caused by intense rainfall. All land in the region, including land outside of the mapped floodplain, is susceptible to localized flooding. Between 20 and 25% of all repetitive loss properties are located outside of the 1-percent-annual-chance floodplain.. In fact, communities in the Outer Banks have taken to using the slogan, "Low Risk is not No Risk" to emphasize this fact. Most of the Outer Banks Region, except for a small portion of northern Currituck County, has coastal FIRMs that only account for flood risk from storm surge events. However, the entire region is still susceptible to flooding from rainfall. The HMPC noted the importance of educating the public of these risks and encouraging property owners in moderate and low risk flood zones outside the SFHA to purchase flood insurance to protect against these other sources of flooding.

Flash flooding 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 storms and sometimes combined with saturated soil or impermeable surfaces. Flash flooding can happen in floodplains and 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 tear out trees, scour channels, and destroy buildings and bridges. Flash flooding can result in higher loss of life, both human and animal, than slower developing river and stream flooding.

Stormwater flooding is smaller scale flooding separate from coastal or riverine flooding that can occur anywhere in a community, including areas outside of the mapped floodplain. It can occur as the result of significant amounts of rainfall over a longer time frame. This flooding, sometimes called “nuisance flooding,” often occurs in low-lying areas after a heavy rain and can occur as a result of excessive runoff from increased impervious surface area, poor drainage, inadequate drainage infrastructure, clogged culverts, or obstructed drainageways, among other causes. Additionally, rain and surface runoff can cause stormwater systems to overflow. As rain falls for extended periods of time, the ground becomes saturated, and rain accumulates faster than the soils can absorb it. In the Outer Banks, this type of stormwater flooding is further complicated by the region’s low elevations, flat topography, and high groundwater table. In areas of particularly flat topography, rain can pond and leave behind areas of standing water even when flood waters have subsided.

While localized flooding does not involve the destructive wave energy of coastal flooding, it is nonetheless a chronic problem that can cause significant damage. 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 designed 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.

Flash and localized flooding may be attributed to 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.
- **High Groundwater Tables and Natural Topography** – The unique topography of portions of the barrier island creates a natural “bowl” in which water collects in low-lying areas between the primary dune system and sound side features such as the maritime forest. Additionally, the high groundwater table means that there is limited storage for rainfall in these areas, and ponding can easily occur after periods of frequent or prolonged rainfall.

FLOODING AND FLOODPLAINS

A floodplain, as shown in Figure 4.18 and Figure 4.19, is flat or nearly flat land adjacent to a stream, river, or body of water that experiences occasional or periodic flooding. In riverine floodplains, it includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows, and the flood fringe, which are areas covered by the flood, but which do not experience a strong current. Floodplains are made when floodwaters exceed the capacity of the main channel or escape the channel by eroding its banks. When this occurs, sediments (including rocks and debris) are deposited that gradually build up over time to create the floor of the floodplain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream. In coastal floodplains, zones are distinguished by wave heights.

Floodplain boundaries are designated and routinely updated through cooperation between local governments, states and the FEMA. Flood Insurance Study (FIS) findings are shown on Flood Insurance Rate Maps (FIRMs) and describe various flood hazard zones based on flood height exceedance return periods. Flood hazard zone designations depend on local conditions and map issue dates, but all will show the 100-year or base flood elevation (1-percent annual chance flood), as well as some areas of the 500-year floodplain (0.2-percent annual chance flood).

Figure 4.18 – Characteristics of a Riverine Floodplain

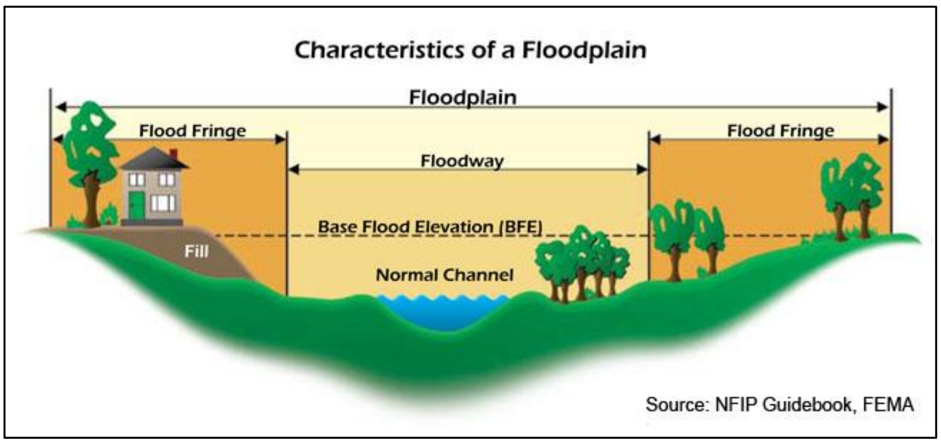
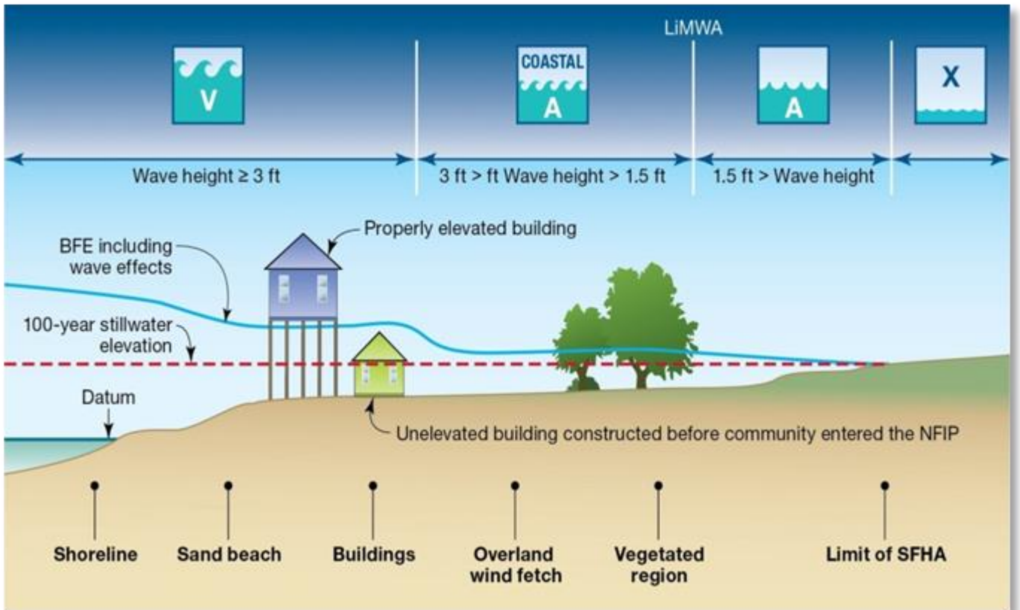


Figure 4.19 – Characteristics of a Coastal Floodplain



Source: FEMA

In its common usage, the floodplain most often refers to that area that is inundated by the "100-year flood," or 1-percent-annual-chance flood, as it is the flood that has a one percent 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. Flooding can also occur outside of mapped floodplains, especially local stormwater flooding, as discussed above.

The 1-percent-annual-chance 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

COASTAL FLOODING

Regulated floodplains are illustrated on FIRMs, which are the official maps 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 1-percent-annual-chance flood event. Table 4.26 summarizes the flood insurance zones identified by the Digital FIRMs (DFIRMs).

Table 4.26 – Mapped Flood Insurance Zones within the Outer Banks

Zone	Description
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.
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.
AO	Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between one and three feet. Average flood depths derived from detailed hydraulic analyses are shown in this zone. Mandatory flood insurance purchase requirements and floodplain management standards apply.
VE	Zone VE is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.
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.

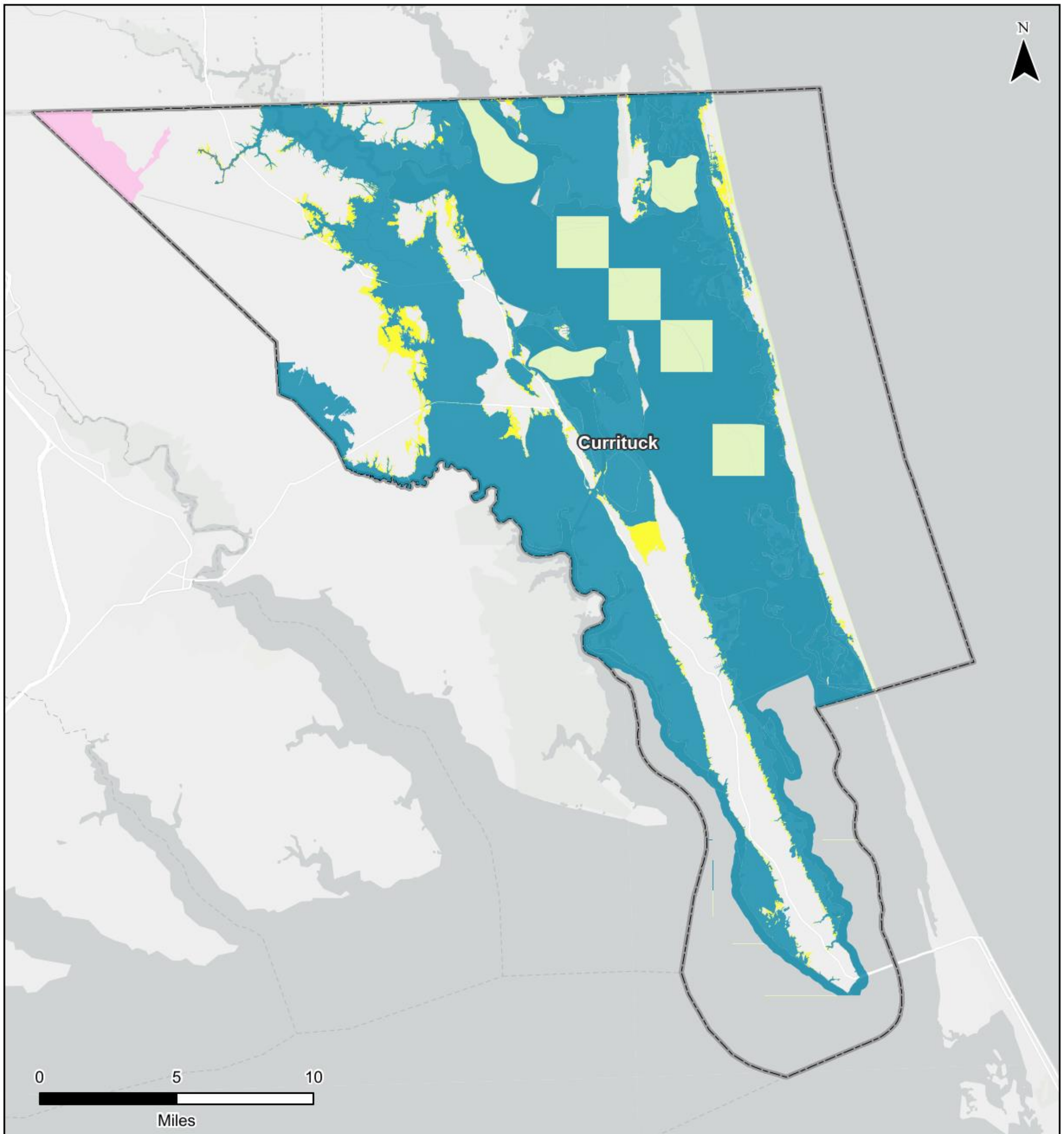
Figure 4.20 and Figure 4.21 reflect the 2018 FIRM flood zones for Currituck County and the 2020 FIRM flood zones for Dare County, respectively. NCEM's IRISK database references these FIRMs for estimated vulnerability to flooding. However, these FIRMs show a significant decrease in high-risk zones compared to the previous 2006 FIRMs for Currituck County and Dare County. The HMPC has expressed concerns that the changes presented in the current effective FIRMs greatly underestimate risk.

The HMPC indicated that the 2006 FIRMs are a more accurate depiction of flood risk. Therefore, the SFHA according to the 2006 FIRMs is mapped in Figure 4.22 and Figure 4.23 to illustrate locations most at risk of flooding.

Flooding can occur anywhere in the Outer Banks. Flood risk is not limited to the 1%-annual-chance floodplain.

Spatial Extent: 3 – Moderate

Figure 4.20 – FEMA Flood Hazard Areas in Currituck County, 2018 Effective FIRM



Outer Banks Region		FEMA Flood Hazard Areas
Date: 5/20/2024	**Source:** FEMA	**Legend**
Prepared By: LE	**Projection:** North Carolina State Plane (NAD83)	Floodway Zone A (1% Annual Chance) Zone AE (1% Annual Chance) Zone VE (1% Annual Chance) Zone X Shaded (0.2% Annual Chance)

Figure 4.21 – FEMA Flood Hazard Areas in Dare County, 2020 Effective FIRM

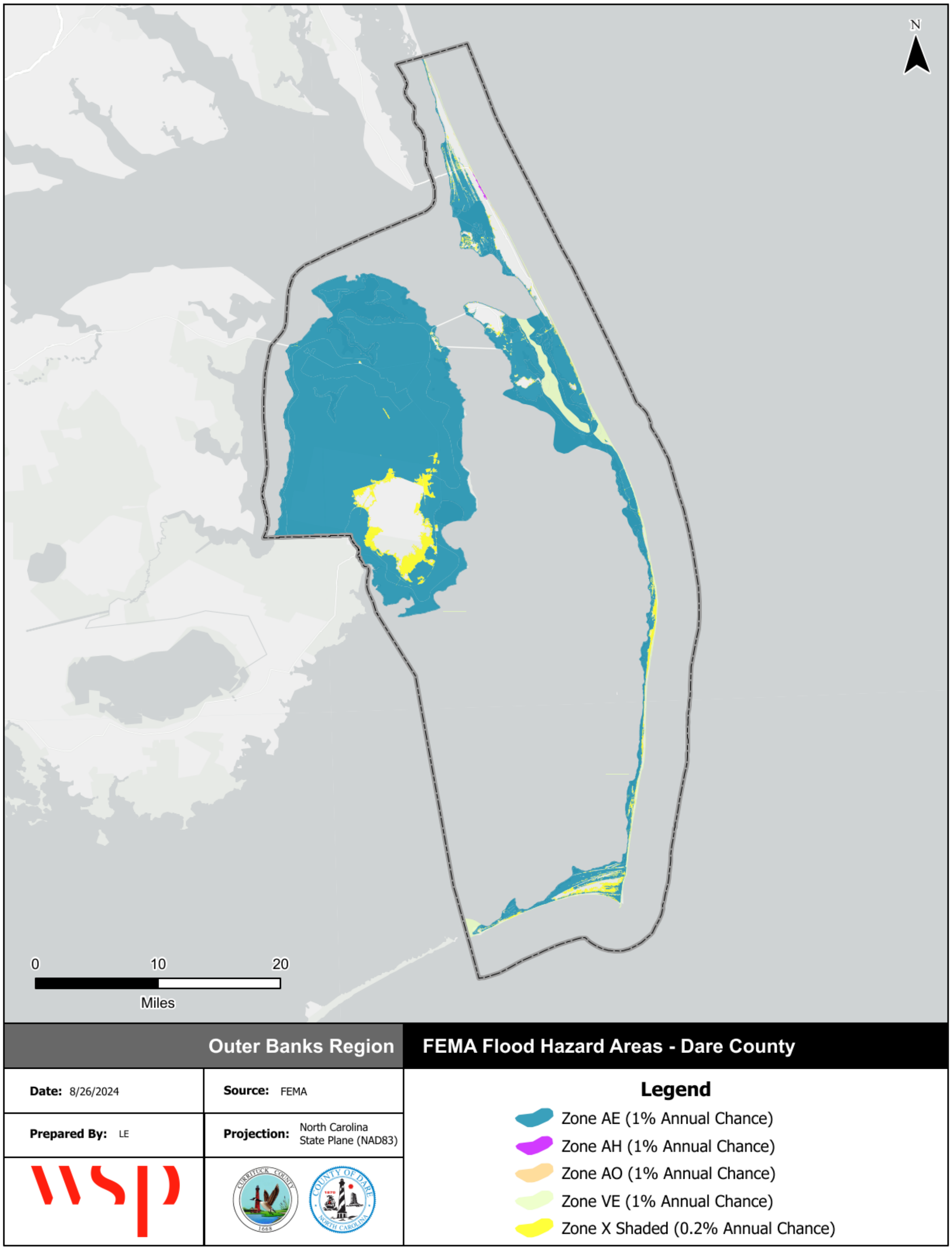


Figure 4.22 – FEMA Flood Hazard Areas in Currituck County, 2006 FIRM

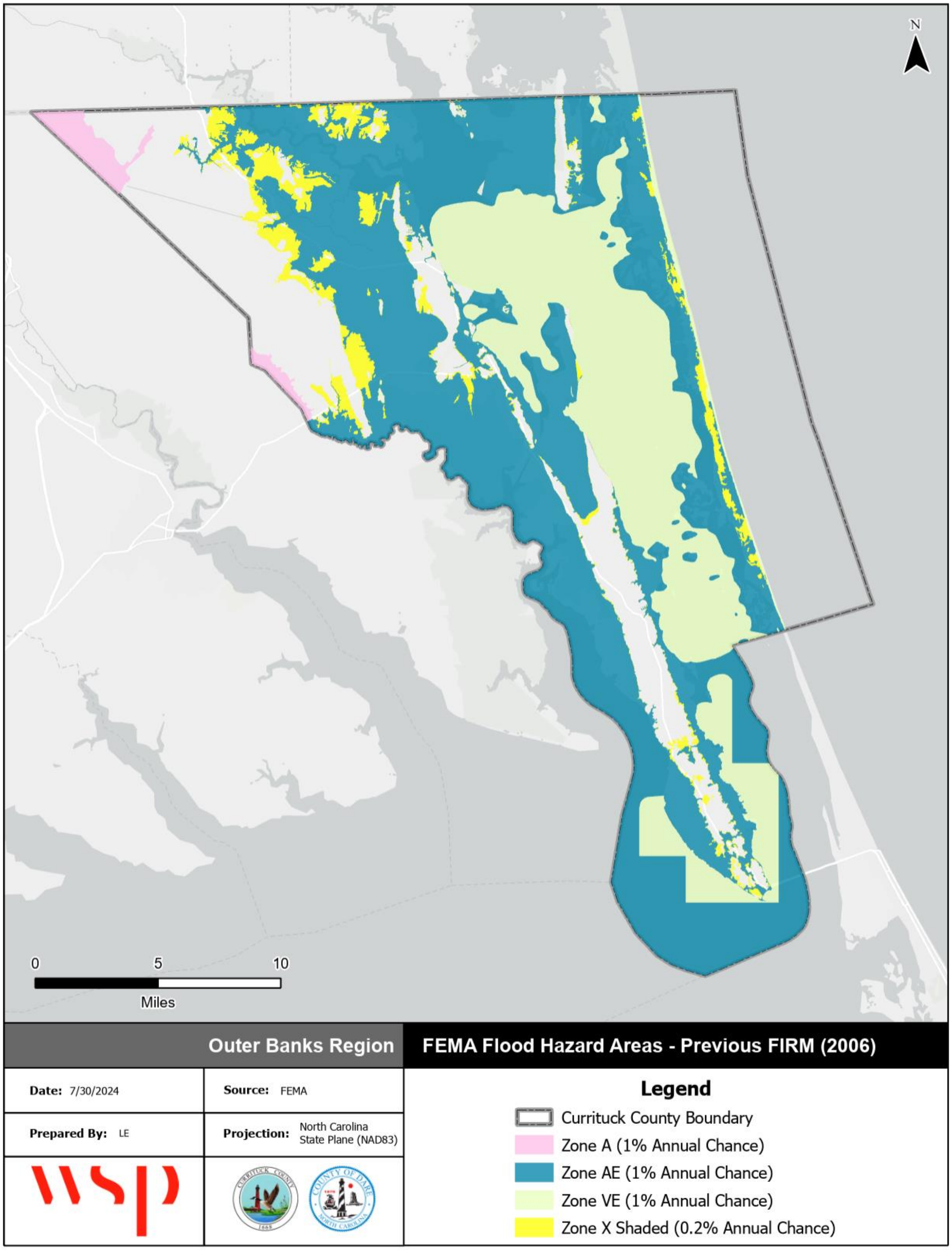
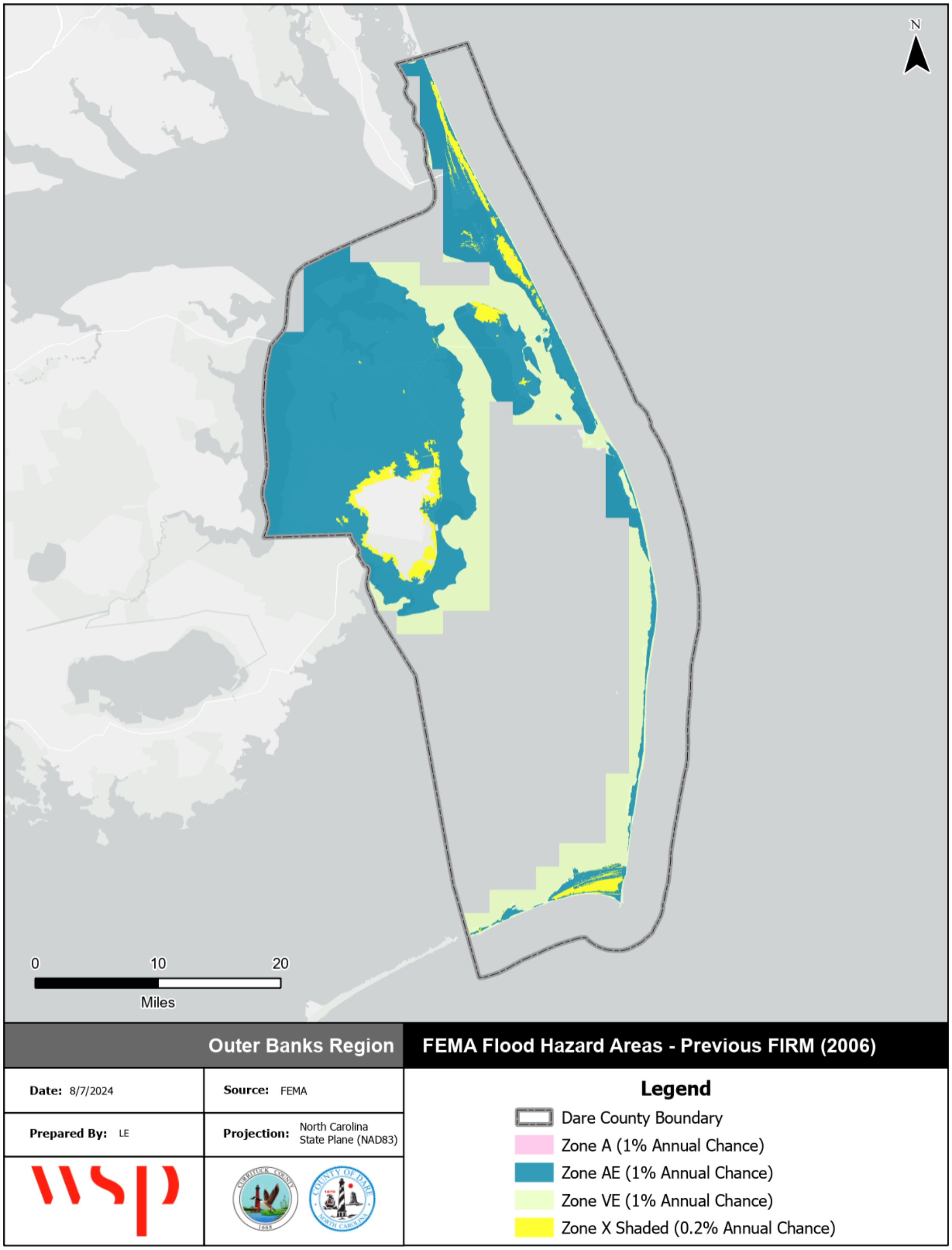


Figure 4.23 – FEMA Flood Hazard Areas in Dare County, 2006 FIRM

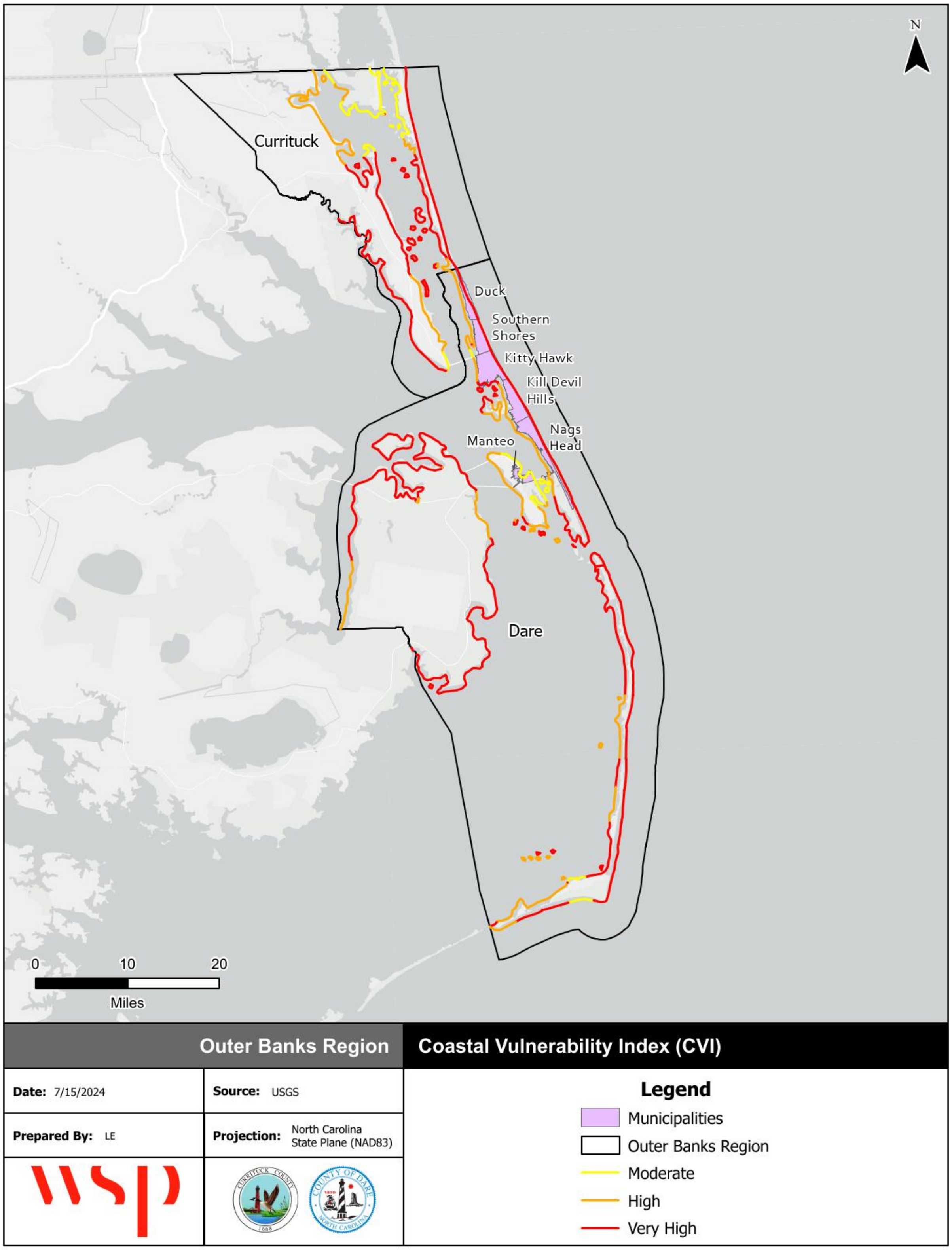


SEA LEVEL RISE

Sea level rise can affect any coastal areas in the Outer Banks region. 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 4.24 shows the CVI for the Outer Banks region. The entire ocean coastline from northern Currituck County to the tip of Cape Hatteras is rated very high on the CVI. Waterfront areas throughout the remainder of the region, including the rest of the Atlantic coast as well as along the Currituck, Albemarle, and Pamlico Sounds, are rated moderate to very high on the CVI.

Figure 4.24 – Coastal Vulnerability Index, Outer Banks Region



Source: USGS Coastal Change Hazards Portal

EXTENT

Flood extent can be defined by the amount of land in the floodplain and the potential magnitude of flooding as measured by flood depth and velocity. FEMA Flood Insurance Studies define the probability of flooding by flood events of a magnitude which are expected to be equaled or exceeded once on the average during a specific time period, or recurrence interval.

According to the 2006 FIRMs, approximately 70% of Currituck County and 50% of Dare County fall within the SFHA. Under the current effective FIRMs, nearly 59% of Currituck County and 30% of Dare County are in the SFHA. Acreage of Zone AE increased in Currituck County but decreased in Dare County. Acreage of Zone VE decreased dramatically in both counties. The shaded Zone X also decreased in both counties.

Table 4.27 provides a summary by county of the region's total area by flood zone on the 2006 DFIRM and current effective FIRMs. Figure 4.25 and Figure 4.26 show the depth of flooding predicted from a 1% annual chance flood. Figure 4.27 and figure show the flood depth for both counties based on the current effective DFIRMs.

Table 4.27 – Flood Zone Acreage in the Outer Banks by County

Flood Zone	2006 FIRMs		Current Effective FIRMs	
	Acreage	Percent of Total	Acreage	Percent of Total
Currituck County				
Zone A	4,294.32	1.51%	3,327.68	1.17%
Zone AE	123,599.50	43.44%	147,151.79	51.71%
Zone VE	70,531.84	24.79%	16,472.99	5.79%
Zone X (500-year)	15,108.54	5.31%	6,880.05	2.42%
Zone X (Unshaded)	51,271.99	18.02%	76,803.35	26.99%
Open Water	19,716.44	6.93%	33,934.38	11.92%
Subtotal	**284,522.63**	--	**284,570.23**	--
Dare County				
Zone A	25.20	0.00%	-	-
Zone AE	268,267.60	34.13%	229,324.15	29.13%
Zone AO	-	-	344.00	0.04%
Zone AH	-	-	118.75	0.02%
Zone VE	126,595.90	16.11%	10,433.14	1.33%
Zone X (500-year)	20,904.54	2.66%	11,618.71	1.48%
Zone X (Unshaded)	21,814.31	2.78%	33,579.20	4.27%
Open Water	348,447.40	44.33%	501,800.65	63.74%
Subtotal	**786,054.95**	--	**787,218.59**	--
Outer Banks Region Total				
Zone A	4,319.52	0.40%	3,327.68	0.31%
Zone AO	-	-	344.00	0.03%
Zone AH	-	-	118.75	0.01%
Zone AE	391,867.10	36.60%	376,475.93	35.13%
Zone VE	197,127.74	18.41%	26,906.13	2.51%
Zone X (500-year)	36,013.08	3.36%	18,498.76	1.73%
Zone X (Unshaded)	73,086.30	6.83%	110,382.55	10.30%
Open Water	368,163.84	34.39%	535,735.02	49.99%
Total	**1,070,577.58**	--	**1,071,788.83**	--

Figure 4.25 – Flood Depth, 1%-Annual-Chance Flood, 2006 FIRM, Currituck County

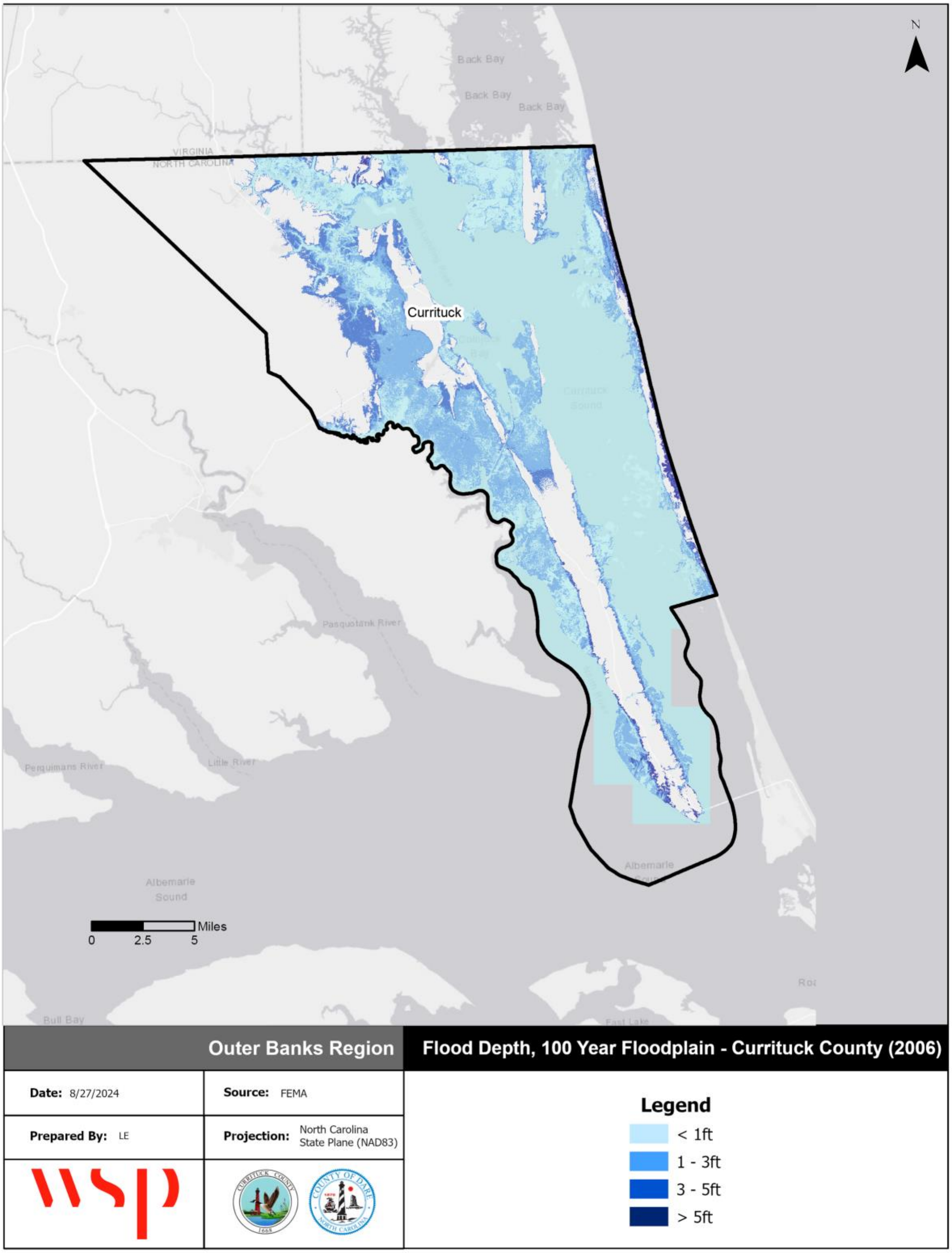


Figure 4.26 – Flood Depth, 1%-Annual-Chance Flood, 2006 FIRM, Dare County

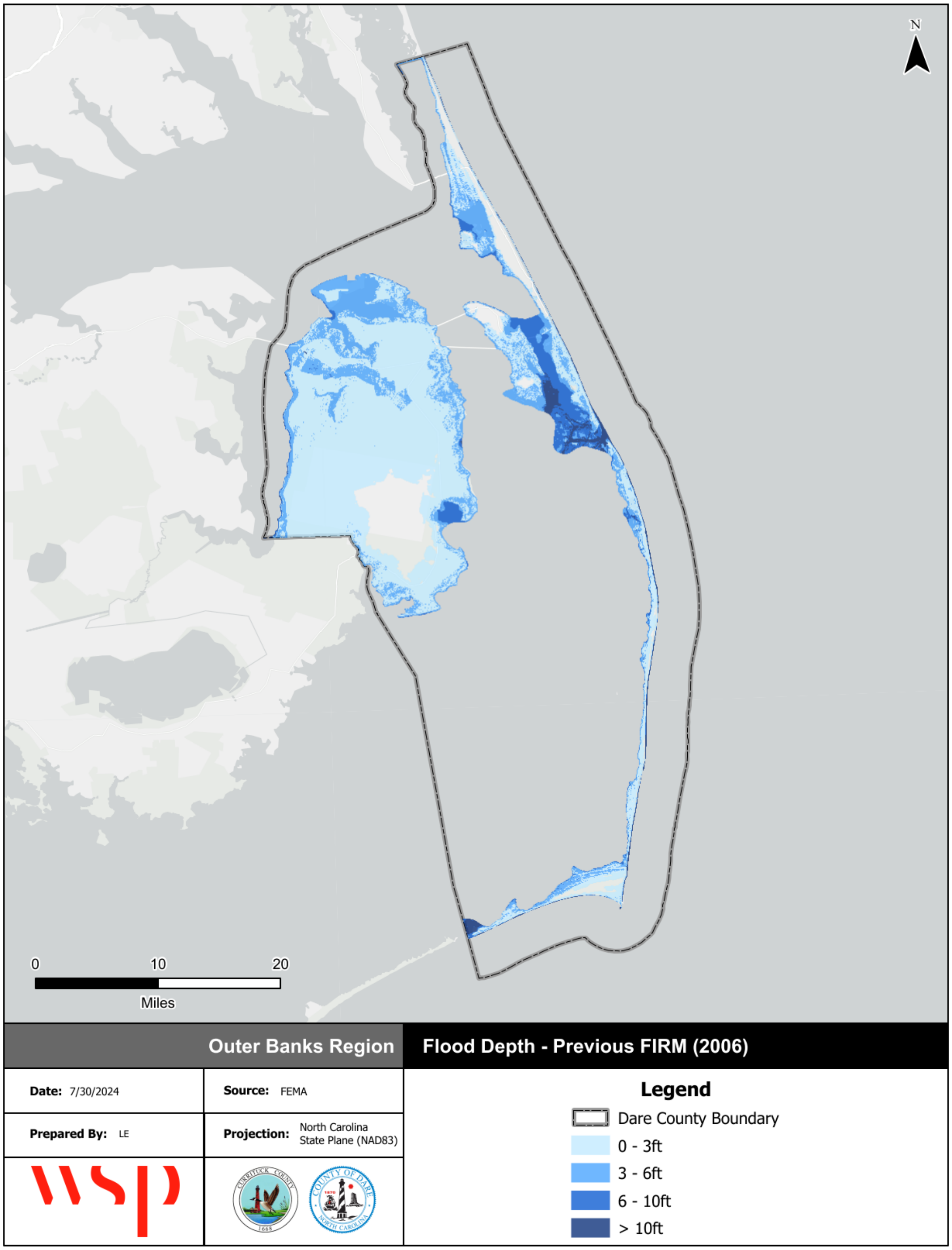


Figure 4.27 – Flood Depth, 1%-Annual-Chance Flood, 2018 DFIRM, Currituck County

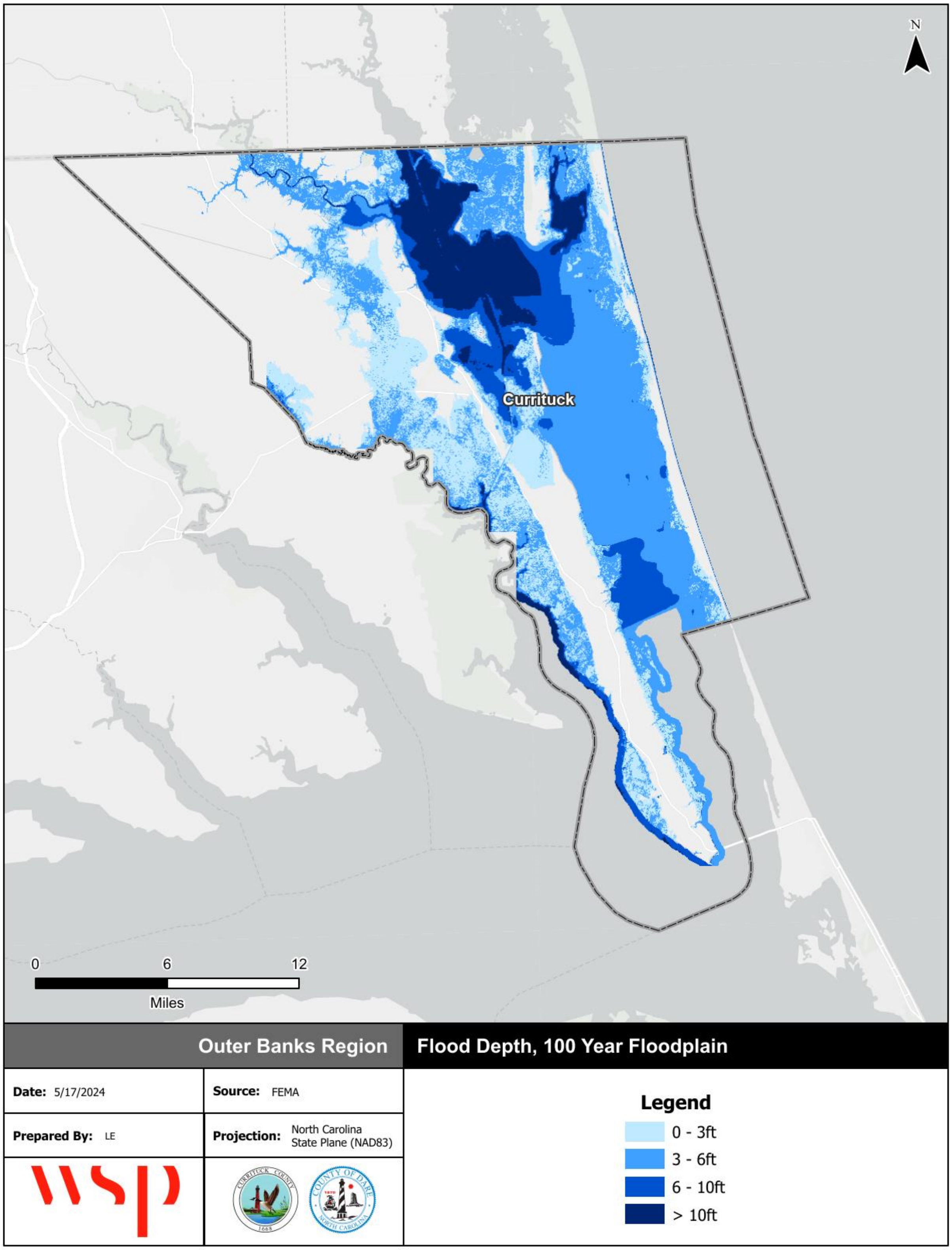
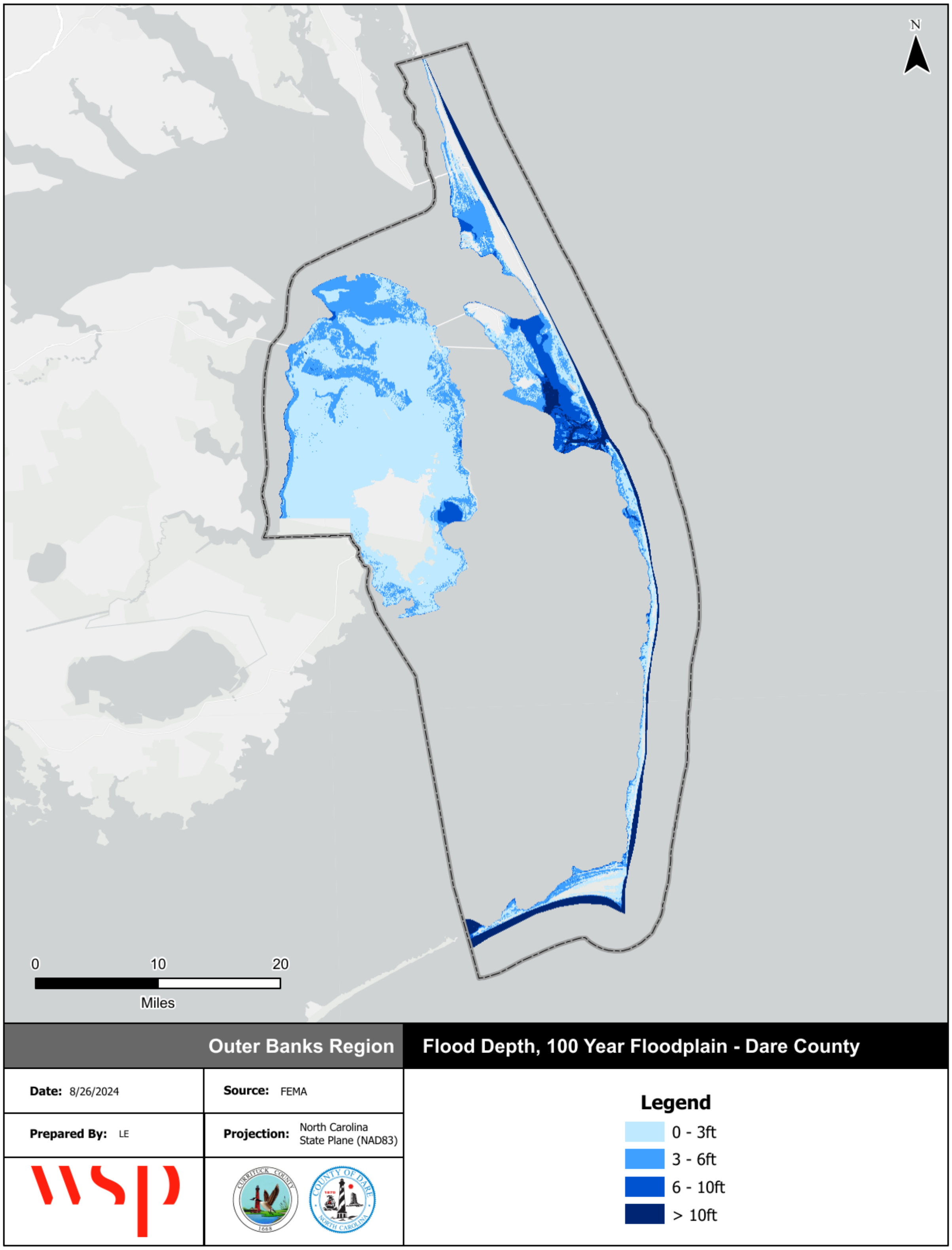


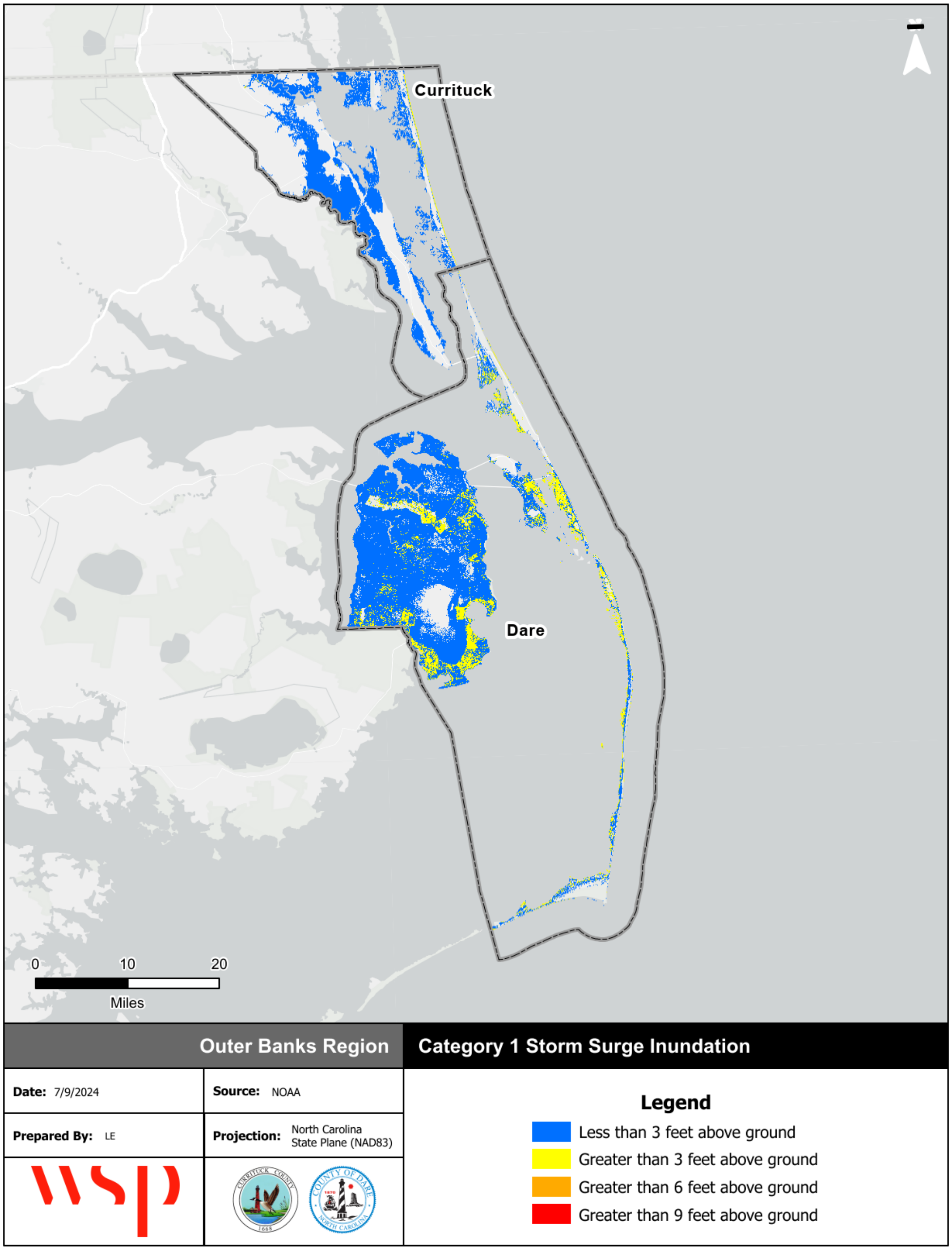
Figure 4.28 – Flood Depth, 1%-Annual-Chance Flood, 2020 DFIRM, Dare County



More than half of the planning area is within areas of high flood risk, as defined by the SFHA on FEMA's 2006 Flood Insurance Rate Maps as vulnerable to the 1-percent-annual-chance flood event. However, while the 1-percent-annual-chance flood is the basis for floodplain management under the NFIP, that does not mean that properties outside the SFHA are not at risk of flooding. Floods of other magnitudes may occur. The remainder of the planning areas is subject to moderate and low flood risk. Low risk is not no risk; areas outside the SFHA may still be flooded by heavy rain events and/or more severe coastal floods.

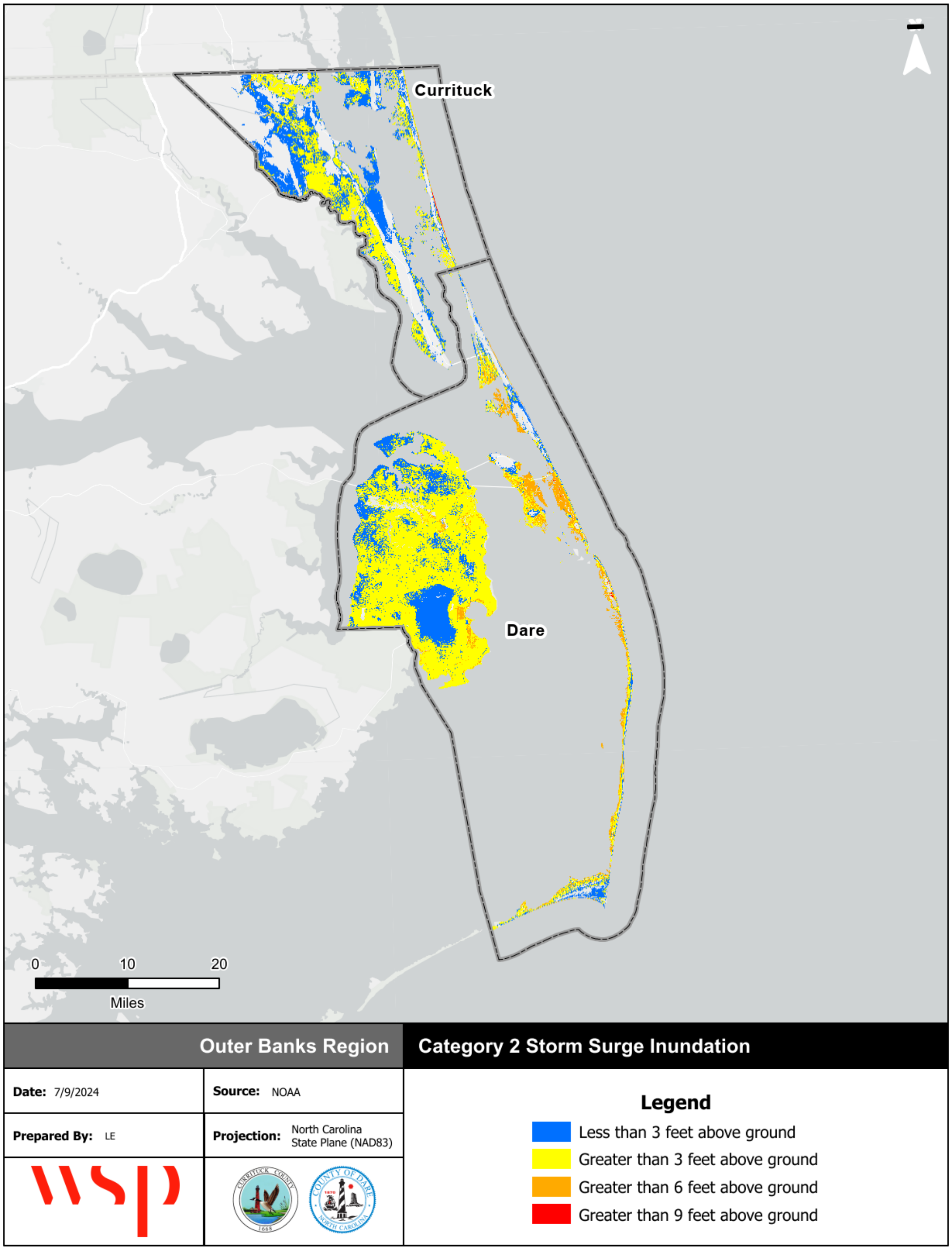
Storm surge affects areas along coastal and sound-side shorelines and further inland depending on the height of the surge. Figure 4.29 through Figure 4.33 show the estimated extent of surge by storm category according to NOAA's SLOSH model. Note that the SLOSH inundation results do not illustrate the storm surge that will occur from any given storm but rather the full potential extent of surge from all possible storms. However, SLOSH does not account for freshwater contribution, so it may underestimate total flooding that could results from a hurricane or tropical storm.

Figure 4.29 – Category 1 Storm Surge Inundation



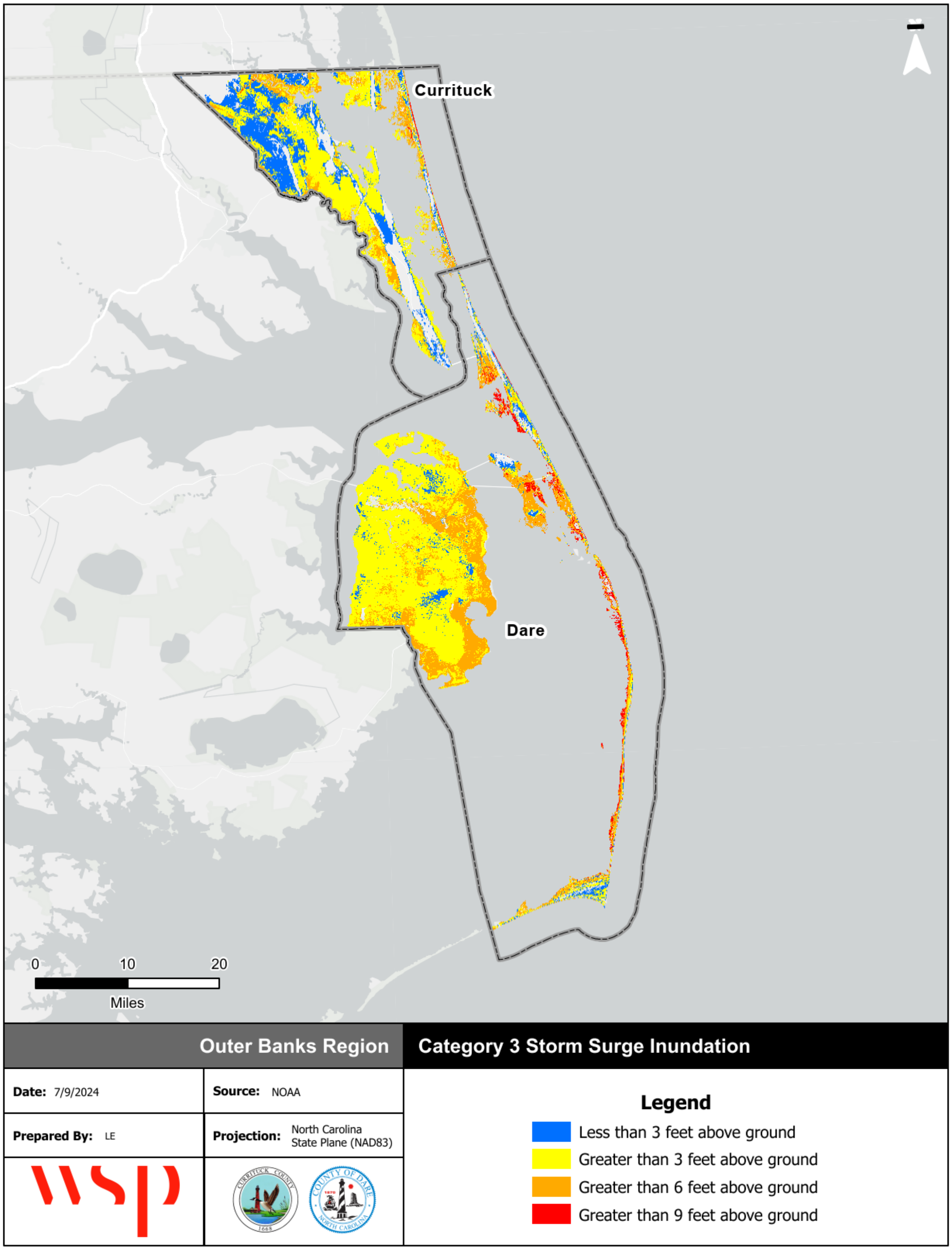
Source: NOAA National Storm Surge Hazard Maps – Version 2

Figure 4.30 – Category 2 Storm Surge Inundation



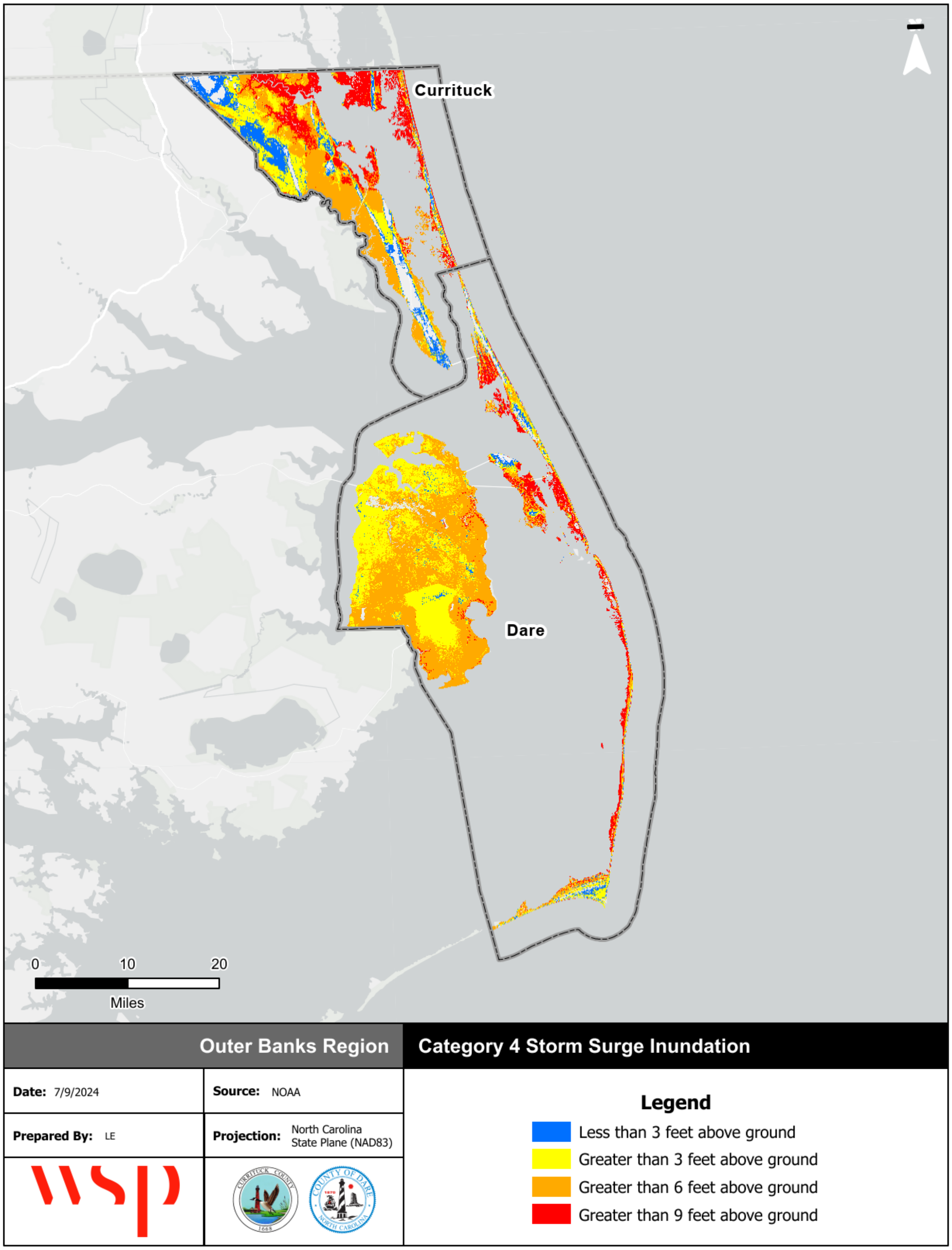
Source: NOAA National Storm Surge Hazard Maps – Version 2

Figure 4.31 – Category 3 Storm Surge Inundation



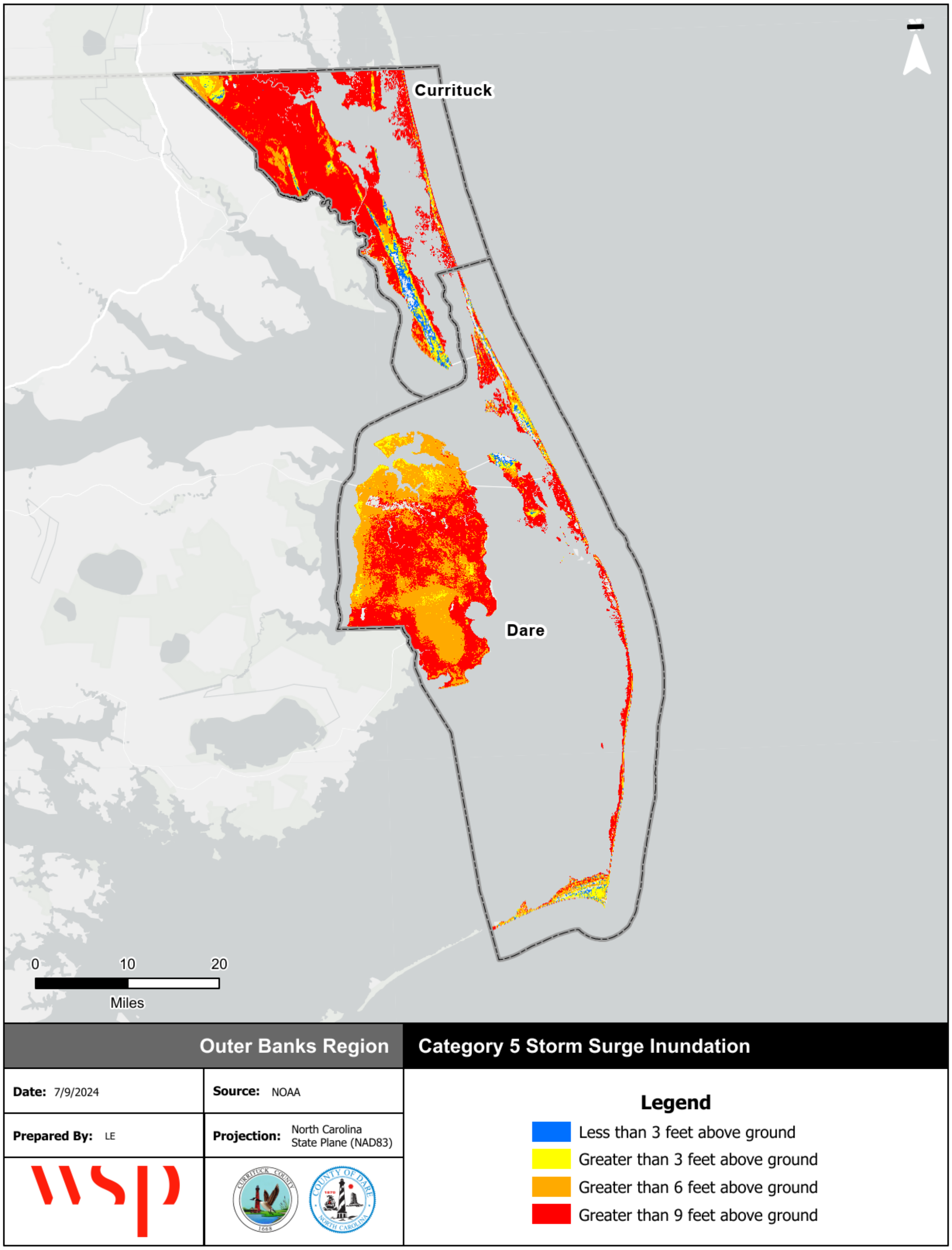
Source: NOAA National Storm Surge Hazard Maps – Version 2

Figure 4.32 – Category 4 Storm Surge Inundation



Source: NOAA National Storm Surge Hazard Maps – Version 2

Figure 4.33 – Category 5 Storm Surge Inundation

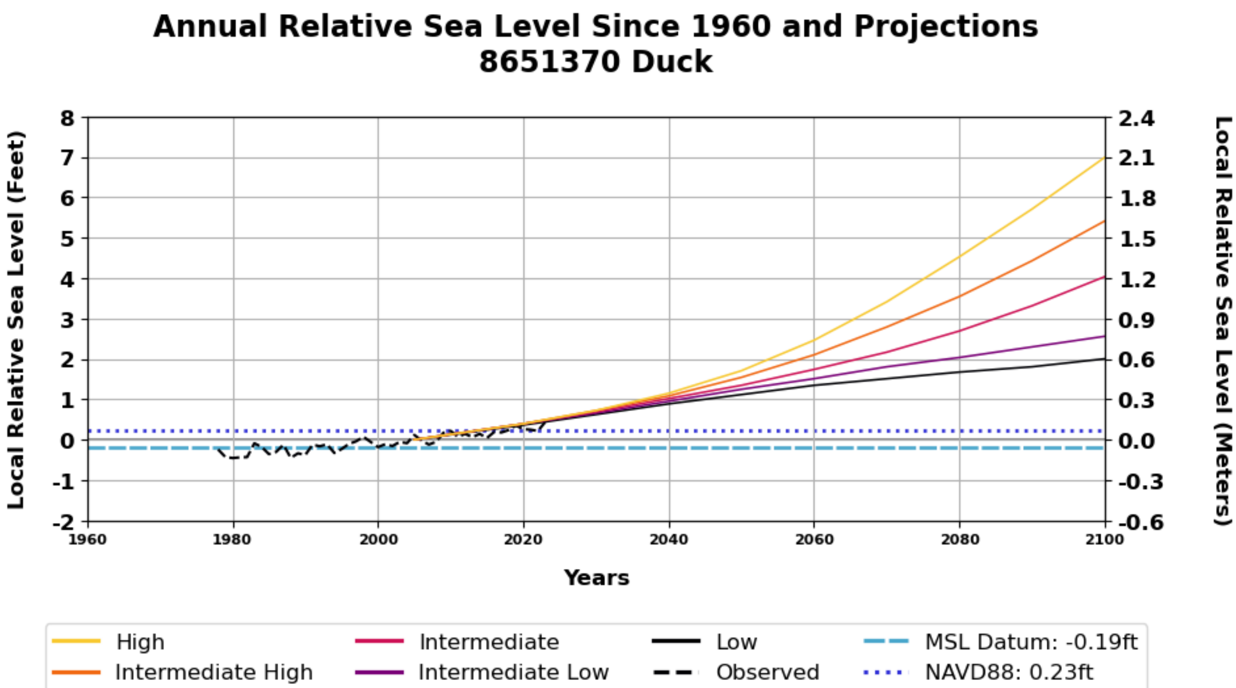


Source: NOAA National Storm Surge Hazard Maps – Version 2

SEA LEVEL RISE

Sea level rise is measured by the number of feet of relative rise and the areas that such rise would inundate. Projections for sea level rise at the Duck, NC tidal gauge station are shown in Figure 4.34. These projections are provided by NOAA and were released in 2022 by a U.S. interagency task force in preparation for the Fifth National Climate Assessment. Relative sea level rise projections are similar for the Oregon Inlet Marina, NC station. Under the intermediate scenario, the region could experience about 1.75 feet of sea level rise by 2060, 2.75 feet by 2080, and over 4 feet by 2100.

Figure 4.34 – Relative Sea Level Rise Projections, Duck, NC

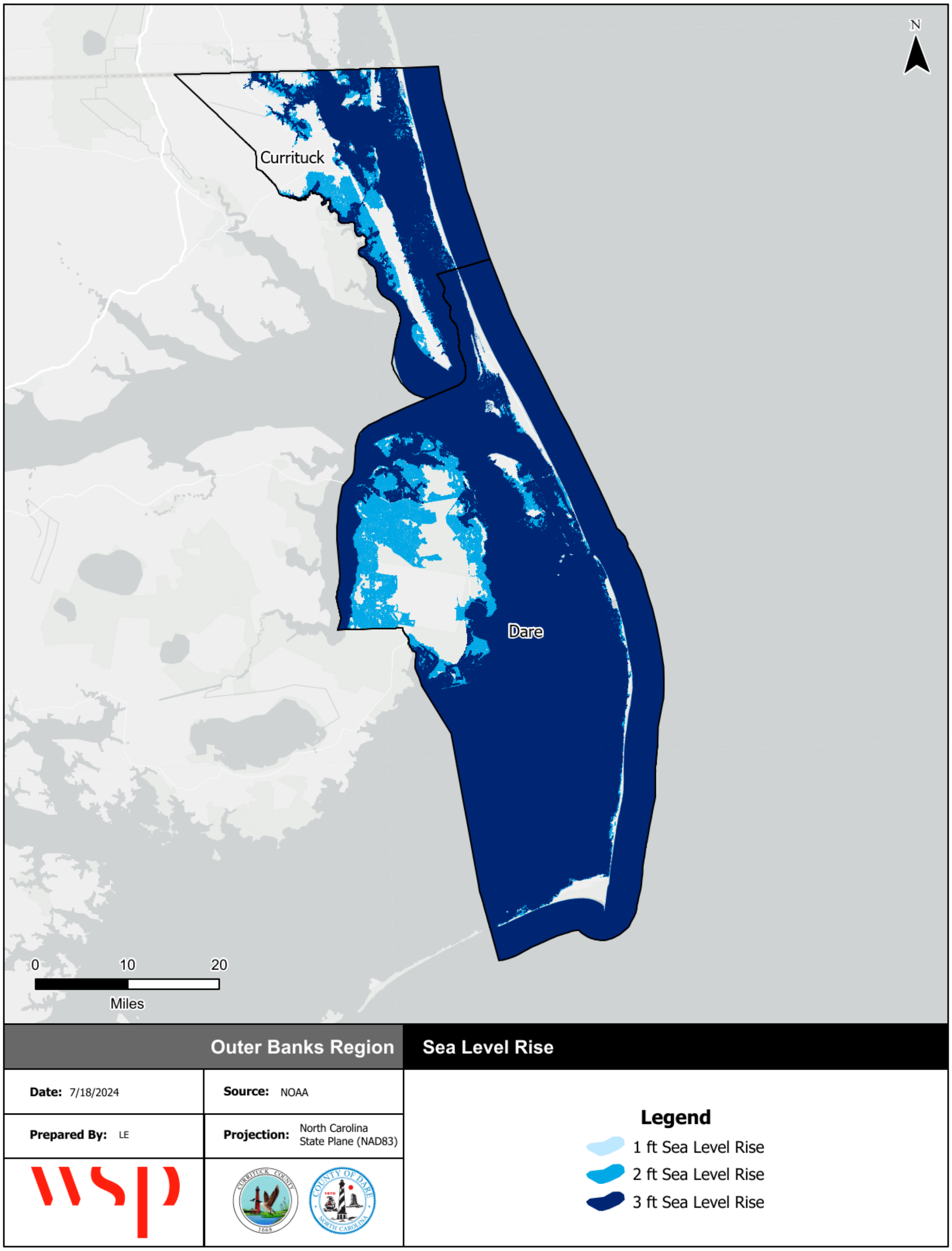


The estimated inundation extents of 1 foot, 2 feet, and 3 feet of sea level rise are shown in Figure 4.35. The sea level rise estimate map shows inundation above mean higher high water (the average of each day's higher high tide line). Sea level rise will likely affect the Atlantic coastline as well as the land adjacent to the Currituck, Albemarle, and Pamlico sounds. Much of southern Dare County could be inundated. Additionally, sea level rise will likely increase future risk of flooding from the other flood hazards discussed 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.

Sea level rise is a slow onset hazard, and 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, tidal flooding 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.

Impact: 3 – Critical

Figure 4.35 – Estimated Extent of 1 Foot, 2 Feet, and 3 Feet of Sea Level Rise on the Outer Banks Region



Source: NOAA Sea Level Rise Viewer

HISTORICAL OCCURRENCES

Table 4.28 details the historical occurrences of flooding identified from 1996 through 2023 by NCEI Storm Events database. It should be noted that only those historical occurrences listed in the NCEI database are shown here. Other, unrecorded events may have occurred within the planning area during this timeframe. The HMPC felt that these counts were a considerable underestimate of actual occurrences. Additionally, the HMPC decided not to include the reported property damage estimates from these events because the estimates for these events are significantly lower than actual losses and the HMPC did not want to misrepresent the severity of flood risk to the Region.

Table 4.28 – NCEI Records of Flooding by County and Event Type, 1996-2023

Type	Event Count	Deaths/Injuries
Currituck		
Coastal Flood	23	0/0
Flash Flood	10	0/0
Flood	9	0/0
Heavy Rain	26	0/0
Dare		
Coastal Flood	25	0/0
Flash Flood	17	0/0
Flood	5	0/0
Heavy Rain	1	0/0
Total	**116**	**0/0**

Source: NCEI

According to NCEI, 116 recorded flood events affected the planning area from 1996 to 2023 causing an estimated $19,385,000 in property damage, with no fatalities, injuries, or crop damage recorded.

Table 4.29 provides a summary of this historical information by location. It is important to note that many of the events attributed to a zone are countywide or cover large portions of the planning area. Similarly, though some events have associated 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. Again, the HMPC decided not to include the reported property damage estimates from these events because the estimates are significantly lower than actual losses.

Table 4.29 – Summary of Historical Flood Occurrences by Location, 1996-2023

Location	Event Count
Currituck	
Corolla	2
Countywide	1
Currituck	10
Currituck Co Airport	2
Eastern Currituck (Zone)	19
Grandy	4
Knotts Island	3
Moyock	10
Point Harbor	4
Poplar Branch	2
Sligo	3

Location	Event Count
Snowden	3
Tulls	1
Western Currituck (Zone)	4
Subtotal Currituck	**68**
Dare	
Buxton	2
Cape Hatteras	2
Duck	2
Eastern Dare (Zone)	19
Frisco	1
Hatteras Island (Zone)	4
Kill Devil Hills	2
Kill Devil Hills Arp	6
Kitty Hawk	2
Manteo	1
Nags Head	2
Northern Outer Banks (Zone)	3
Rodanthe	3
Subtotal Dare	**48**
Region Total	**116**

Source: NCEI

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

January 27, 1998 – A Nor'easter produced heavy rain and strong winds across northeast North Carolina on Tuesday, January 27th and Wednesday, January 28th. Rainfall totals generally ranged from 2 to 4 inches. This rainfall caused street flooding and flooding of poor drainage areas throughout the region.

November 22, 2006 – An intense low-pressure system off the North Carolina coast combined with an upper level cutoff low to provide very strong winds, heavy rains of 4 to 8 inches, and moderate to severe coastal flooding during times of high tide. Tidal departures were 4 to 5 feet above normal during the event. Route 12 was flooded with overwash in many areas. Significant coastal flooding was reported across Outer Banks Dare county, mainly for areas north of Buxton. Water levels of 4 to 6 feet above normal reported with significant beach erosion and ocean overwash. Several homes from Rodanthe to Nags Head were severely damaged with several condemned.

November 3, 2007 – The extratropical remnant low pressure of former Hurricane Noel moved northeast well offshore of the Carolina coast on November 2nd. Although the center of the low remained well off the coast, strong winds and moderate coastal flooding occurred across eastern North Carolina. Wind gusts of 40 to 60 mph were reported along the coast from Cape Lookout north. Water level rises of 3 to 4 feet above normal produced coastal flooding along the northern Outer Banks. Ocean overwash and coastal flooding was reported from Cape Hatteras north along the Outer Banks. Eight single family dwellings in Nags Head reported property damage. Eight ocean front properties on the north end of Rodanthe sustained severe beach erosion and some damage. Thirty-three private beach accesses were damaged near Nags Head. Highway 12 near Rodanthe was flooded with 4 to 5 feet of water closing the road for several hours. Total reported property damage for Dare county was estimated to be 72,000 dollars.

November 12, 2009 - An intense Nor'easter produced moderate to severe coastal flooding across much of the Outer Banks, causing over $11.5 million in damages. Significant ocean over-wash and coastal flooding developed over the northern Outer Banks. The large waves from the storm continued to batter the Outer Banks for several days after the storm system moved away.

Several streets, homes and businesses were flooded in low lying areas of Currituck County close or directly exposed to the Currituck Sound. Moyock experienced the heaviest flooding due to rising Sound waters, with 3 flooded neighborhoods and flood waters entering some homes. The peak tide height at Duck was 7.20 feet, which was 3.22 feet above the astronomical tide. Numerous streets, homes and businesses were flooded in low lying areas of the county close or directly exposed to the Atlantic Ocean, especially in the Corolla and Carova Beach areas. There was also severe beach erosion and loss of protective dunes. Areas from Buxton north to Duck had several episodes of coastal flooding, mainly during the high tide cycle. Overall 4 homes were destroyed, 61 had major damage and 465 had minor damage. Highway 12 was severely flooded and destroyed near Rodanthe due to the ocean over-wash.

October 4, 2015 – Large breaking waves due to strong onshore winds and large swells from distant Hurricane Joaquin produced significant beach erosion, ocean over wash and coastal flooding. There was also some flooding for sound side areas of Hatteras Island due to high water levels in the Pamlico Sound. 51 residences and businesses had minor to moderate damage producing 590,000 dollars in damages.

October 8-9, 2016 – Hurricane Matthew moved northeast offshore of the North Carolina coast late on October 8th through October 9th. Widespread heavy rain developed on October 8th and continued through early on October 9th as Matthew approached and moved offshore of the coast. Rainfall ranged from 7 to 11 inches in the Outer Banks, and was reported at 10.73 inches at Point Harbor, leading to numerous creeks and streams to be out of their banks and causing significant flash flooding. Numerous roads were impassable or closed for several days, and many homes and businesses were impacted. In Kill Devil Hills and Nags Head, water was 2 to 3 feet deep on roads and several homes and businesses flooded with up to 2 feet of water in some.

March 4, 2018 – Strong low pressure passed just to the north of eastern North Carolina on March 2nd then continued to deepen while only slowly moving offshore March 3rd and 4th. This system produced very strong west winds as it passed just to the north of the area and then gusty north winds for several days as it lingered well to the northeast. These winds produced high water levels over the eastern portion of the Pamlico Sound producing significant sound-side flooding of Outer Banks Dare County. Water levels reached 2 to 3 feet above ground level in spots flooding and closing some roads. Water reached a few residences and businesses with up to one foot of inundation reported. Areas most impacted extended from Rodanthe south to Hatteras Village including beach front property in the Avon area. Many sand dunes, some up to 30 feet, were destroyed. Ocean over-wash flooded portions of Highway 12 with water 2 to 3 feet deep with over 1 foot of sand and debris, closing it for long periods of time.

The Outer Banks region has also experienced extensive flooding from storm surge related to hurricanes, tropical storms, and nor'easters. Table 4.30 summarizes all recorded storm surge events from NCEI between 1999 and 2023. These events caused over $55 million in property damage. Narrative records on storm surge impacts are provided below.

Table 4.30 – Recorded Storm Surge Events in the Outer Banks Region, 1999-2023

Date	Location	Deaths/ Injuries	Reported Property Damage
3/6/2001	Manteo	0/0	$0
4/10/2003	Eastern Currituck (Zone)	0/0	$0
3/10/2004	Eastern Dare (Zone)	0/0	$10,000
4/3/2005	Eastern Dare (Zone)	0/0	$0
4/15/2005	Eastern Dare (Zone)	0/0	$50,000
5/6/2005	Eastern Dare (Zone)	0/0	$0
9/9/2007	Eastern Dare (Zone)	0/0	$0

Date	Location	Deaths/ Injuries	Reported Property Damage
7/20/2008	Eastern Dare (Zone)	0/0	$0
10/19/2008	Eastern Dare (Zone)	0/0	$10,000
9/2/2010	Eastern Dare (Zone)	0/0	$380,000
8/26/2011	Western Dare (Zone)	0/0	$1,000,000
8/26/2011	Eastern Dare (Zone)	0/0	$40,000,000
10/28/2012	Eastern Dare (Zone)	0/0	$13,000,000
6/6/2013	Eastern Dare (Zone)	0/0	$0
7/3/2014	Eastern Dare (Zone)	0/0	$1,500,000
	Total	**0/0**	**$55,950,000**

Source: NCEI

March 6, 2001 – Strong northwest winds of 40 mph caused soundside flooding of the causeway in Manteo, on Highway 12 in the town of Waves and flooding in Collington Harbor. These strong winds persisted for nearly 24 hours allowing the Pamlico Sound to cause soundside flooding.

March 10, 2004 – Significant overwash was reported north of Rodanthe during the late evening hours on the 10th continuing into the early morning hours on the 11th, resulting in the closure of Highway 12. Several homes near Kill devil hills received minor damage from flooding.

April 3, 2005 – Moderate sound-side flooding occurred across northern portions of the Outer Banks near Oregon Inlet during the early morning hours of Sunday, April 3rd. Highway 12 was closed for several hours with one foot of water reported over the road.

May 6, 2005 – An unseasonable and strong Nor'easter buffeted the North Carolina coast with damaging wind gusts, torrential rain, high surf, and coastal flooding. Winds were sustained as high as 45 to 55 mph with wind gusts to 80 mph across coastal counties of Eastern North Carolina. Water levels rose four to six feet above normal along Pamlico Sound. Storm total rainfall amounts ranged from 4 to 7 inches. During the peak of storm, the Diamond buoy reported 20 foot waves. Moderate beach erosion was reported along the Outer Banks. In Dare County, the public reported sound-side flooding with one foot of water on Highway 12 near Frisco.

August 26, 2011 – Hurricane Irene made landfall during the morning of the 27th, near Cape Lookout, as a large category 1 hurricane on the Saffir/Simpson Hurricane Wind Scale. Due to the large size of the hurricane, strong damaging winds, major storm surge, and flooding rains were experienced across much of eastern North Carolina. Wind gusts from 60 to 70 mph resulted in a 5 foot sound-side storm surge in Manteo. In eastern Dare County, wind gusts from 63 to 88 mph resulted in extensive structural damage. The highest surge was 7 to 10 feet on the sound-side from Buxton to Rodanthe and the highest ocean-side surge of 9.5 feet was recorded at Hatteras Village. The storm surge resulted in extensive damage to structures along the coast along with many dune breaches and damage to Highway 12.

October 28, 2012 – Hurricane Sandy was one of the largest hurricanes on record to affect eastern North Carolina. The main impacts were from a sound-side storm surge of 4 to 6 feet along portions of the Outer Banks and southern portions of the Pamlico Sound, and an ocean-side surge along the Dare County Outer Banks from Hatteras north to Kitty Hawk. Damages from surge were estimated near 13 million dollars with the main damages occurring along U.S. 158 north of Oregon Inlet in Kitty Hawk where Highway 12 was destroyed and had to be closed. 58 homes were left uninhabitable with eight completely destroyed from Hatteras north to Rodanthe. The highest storm surge measured, 3.94 feet, was recorded sound-side at the USCG Station in Hatteras on the 29th. An NWS storm surge team estimated the highest surge, 8.5 feet, ocean-side at Buxton. Large breaking waves on top of the surge resulted in moderate to major beach erosion and over-wash along the coast from Duck to Hatteras. A large section of Highway 12 north of Rodanthe was closed due to extensive Damage to the road, caused by wave action and ocean over-wash.

SEA LEVEL RISE

As noted in Figure 4.16 and Figure 4.17, relative sea level has been rising an estimated 4.88 mm/year at the Duck, NC station and 4.62 mm/year at the Oregon Inlet Marina, NC station.

PROBABILITY OF FUTURE OCCURRENCE

By definition, SFHAs are 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 the SFHA have a 26 percent chance of flooding over the life of a 30-year mortgage. The Shaded X Zone indicates areas that are estimated to be inundated by the flood event having a 0.2-percent chance of being equaled or exceeded in any given year. The SFHA and the Shaded X zone indicate areas of high and moderate risk according to FEMA guidelines; however, this does not mean that flood risk is limited to these areas. There is also potential for other magnitudes of flood events to impact these and other areas in the region.

While exposure to flood hazards varies across jurisdictions, all jurisdictions have high risk flood hazard areas and the entire planning area faces some level of flood risk. Based on past occurrences and HMPC input concerning known risk areas and additional flood hazard sources beyond the coastal flood as depicted on FIRMs, the likelihood of flooding is considered highly likely for all jurisdictions.

Sea level rise is also highly likely to occur; however, projections vary on the extent of future sea level rise.

Probability: 4 – Highly Likely

CLIMATE CHANGE

The potential for flooding can change and increase. Various land use changes and changes to land surface can result in changes to the floodplain and flood prone areas. For example, an increase in impervious surface can create localized flooding problems inside and outside of natural floodplains by altering or confining natural drainage channels. These changes are often created by human activity. However, changes in precipitation frequency and intensity can also result in changes to flood magnitudes and probabilities. For example, what we currently define as the 1-percent-annual-chance flood may occur more frequently in the future.

Per the 2023 North Carolina Hazard Mitigation Plan, changing climate and weather patterns, environmental conditions, and urban and rural development may affect the frequency and intensity of flooding. Historical data and climate projections provided by the State Climate Office of North Carolina on the North Carolina Resilience Exchange website indicate that days with extreme precipitation (2 inches or more of precipitation) are expected to increase in Currituck and Dare County. Dare County already averages 25 days per decade of extreme precipitation and this number is likely to increase to 31 days per decade by the 2060s. Currituck County averages 15 days of extreme precipitation per decade, which will increase to 18-19 days per decade by the 2060s. This increased likelihood of extreme precipitation events due to climate change will result in greater risks of flash flooding and impacts from stormwater runoff.

Sea level rise is a direct result of global climate change, and sea level rise projections are based on greenhouse gas emission scenarios and associated impacts on global temperature change. Regional estimates of relative sea level change account for changes in ocean currents, temperature and salinity, ice melt and its impacts, and localized changes in ground level due to subsidence or uplift. Given the variation in emissions scenarios and the numerous variables that affect sea level rise, 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

The following section provides an assessment of vulnerability to flooding by jurisdiction and flood return period.

METHODOLOGIES AND ASSUMPTIONS

Population and property at risk to flooding was estimated using data from the NCEM's IRISK database, which was compiled in NCEM's Risk Management Tool.

As a subset of the building vulnerability analysis, exposure of pre-FIRM structures was estimated. Table 4.31 below provides the NFIP entry date for each participating jurisdiction, which was used to determine which buildings were constructed pre-FIRM. Pre-FIRM structures were built prior to the adoption of flood protection building standards and are therefore assumed to be at greater risk to the flood hazard.

Table 4.31 – NFIP Entry Dates

Jurisdiction	NFIP Entry Date
Town of Duck	10/06/78
Town of Kill Devil Hills	05/04/73
Town of Kitty Hawk	10/01/83
Town of Manteo	01/05/83
Town of Nags Head	11/10/72
Town of Southern Shores	05/13/72
Currituck County	11/01/84
Unincorporated Dare County	10/06/78

Source: Federal Emergency Management Agency Community Status Book Report: Communities Participating in the National Flood Program, August 2013

Pre-FIRM structures are those built before a community's NFIP entry date, while those built after the entry date are post-FIRM. However, because only year built data was available for buildings rather than exact construction dates, the following methodology was used to estimate the number of pre-FIRM buildings. If the NFIP entry date for a given community is between January and June, buildings constructed the same year as the entry date are considered to be post-FIRM (e.g., if the NFIP entry date is 02/01/1991, buildings constructed in 1990 and before are pre-FIRM. Buildings constructed from 1991 to the present are post-FIRM.). If the NFIP entry date is between July and December, then the following year applies for the year- built cut-off (e.g., if the NFIP entry date is 12/18/2007, buildings constructed in the year 2007 and before are pre-FIRM, 2008 and newer are post-FIRM).

Effective FEMA DFIRM data was used to determine the flood hazard areas for all IRISK flood vulnerability estimates.

In addition to vulnerability estimates presented here, the Outer Banks is also vulnerable to flood impacts associated with sea level rise. 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). The Outer Banks region is particularly vulnerable to the effects of sea level rise, due to its coastal location, subtropical environment, low topography, and tourism economy.

For more information on flood hazard vulnerability, the South Atlantic Coastal Study from the U.S. Army Corps of Engineers (USACE) South Atlantic Division provides an assessment of coastal hazard risks and vulnerability. Back bay areas of Currituck County and areas along the Outer Banks and eastern peninsula in Dare County were identified as having high exposure, and Dare County has one of the highest projections of future risk in North Carolina, with economic damage projections nearly tripling between existing and future conditions. The SACS North Carolina Appendix report estimates future risk at nearly $125 million for Dare County and over $20 million for Currituck County.

PEOPLE

Flood events pose many threats to public health and safety. While such problems are often not reported, three general types of health hazards accompany floods: physical hazards from the water itself, environmental hazards in the aftermath of the flood, and long-term psychological hazards. These common health and safety hazards are detailed below:

- **Contaminated water**: 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. Floodwaters also saturate the ground, which leads to infiltration into sanitary sewer lines, or wastewater treatment plants may be flooded or over loaded. 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. Private sewer and septic systems may also introduce pollutants into floodwaters. Private wells may become contaminated through infiltration of polluted water. Given the many potential sources of contamination, direct or indirect contact with floodwaters poses a significant health risk for contraction of infectious disease.
- **Debris**: 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.
- **Unsafe food**: If floodwaters come into contact with food items, that food may no longer be safe for consumption due to the potential contaminants in the floodwaters. Foods stored in cardboard, plastic bags, jars, bottles, and paper packaging may all be subject to contamination. Even if foods don't come into direct contact with floodwaters, the introduction of mold and mildew from flooding may cause foods to spoil faster. Additionally, power outages may cause refrigerated and frozen foods to spoil.
- **Mosquitos and animals**: After most of the water has receded, stagnant pools can become breeding grounds for mosquitoes, which may carry infectious diseases such as West Nile virus or St. Louis encephalitis. Wild animals such as snakes or rodents may carried by floodwaters or lose their habitat and seek shelter in buildings. Snakes may also be swimming in floodwaters seeking higher ground. People may be at risk for bites or disease if they come in contact with these animals or animal carcasses.
- **Mold and mildew**: Areas of a building that were exposed to excessive moisture can breed mold and mildew. Molds can start to grow in only 24 to 48 hours and will continue to grow without steps to dry out and disinfect the affected surface. Some molds are allergens, while others can produce harmful mycotoxins. Exposure to mold can cause respiratory problems; nasal and sinus congestion; eye, nose, and throat irritation; aches and pains; and effects on the nervous system. Infants, children, immunocompromised individuals, elderly adults, pregnant women, and individuals with respiratory conditions are all at higher risk.

- **Reentering a flooded building**: Health hazards may occur 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 the public water systems lose pressure, public water supplies may be contaminated, and a boil order may be issued to protect people and animals from contaminated water.
- **Mental stress**: Long-term psychological impacts can result after 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 can also put a severe strain on people, especially individuals who were 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 particularly high risk when driving through flooded streets. According to NCEI records, however, there have been no deaths in the Outer Banks caused by flood events.

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

Table 4.32 through Table 4.36 detail the population at risk from various flood events, according to data from the NCEM IRISK database. Note that this analysis is based on the current effective DFIRM which the HMPC considers an underestimate of flood risk. Therefore, actual population at risk is likely higher.

Table 4.32 – Population Impacted by the 10-Year Flood Event

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Currituck									
Currituck County	31,343	1,421	4.5%	5,390	244	4.5%	1,596	72	4.5%
Dare									
Unincorporated Dare County	24,369	1,920	7.9%	4,752	374	7.9%	1,150	91	7.9%
Town of Duck	1,722	4	0.2%	582	1	0.2%	53	0	0.0%
Town of Kill Devil Hills	7,588	34	0.4%	1,298	6	0.5%	260	1	0.4%
Town of Kitty Hawk	3,903	175	4.5%	861	39	4.5%	137	6	4.4%
Town of Manteo	1,360	44	3.2%	220	7	3.2%	80	3	3.8%
Town of Nags Head	3,178	62	2.0%	1,084	21	1.9%	70	1	1.4%
Town of Southern Shores	2,536	4	0.2%	858	1	0.1%	78	0	0.0%
Subtotal Dare	**44,656**	**2,243**	**5.0%**	**9,655**	**449**	**4.7%**	**1,828**	**102**	**5.6%**
Region Total	**75,999**	**3,664**	**4.8%**	**15,045**	**693**	**4.6%**	**3,424**	**174**	**5.1%**

Source: NCEM Risk Management Tool

Table 4.33 – Population Impacted by the 25-Year Flood Event

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Currituck									
Currituck County	31,343	3,177	10.1%	5,390	546	10.1%	1,596	162	10.2%
Dare									
Unincorporated Dare County	24,369	3,196	13.1%	4,752	623	13.1%	1,150	151	13.1%
Town of Duck	1,722	11	0.6%	582	4	0.7%	53	0	0.0%
Town of Kill Devil Hills	7,588	61	0.8%	1,298	10	0.8%	260	2	0.8%
Town of Kitty Hawk	3,903	342	8.8%	861	75	8.7%	137	12	8.8%
Town of Manteo	1,360	73	5.4%	220	12	5.5%	80	4	5.0%
Town of Nags Head	3,178	90	2.8%	1,084	31	2.9%	70	2	2.9%
Town of Southern Shores	2,536	20	0.8%	858	7	0.8%	78	1	1.3%
Subtotal Dare	**44,656**	**3,793**	**8.5%**	**9,655**	**762**	**7.9%**	**1,828**	**172**	**9.4%**
Region Total	**75,999**	**6,970**	**9.2%**	**15,045**	**1,308**	**8.7%**	**3,424**	**334**	**9.8%**

Source: NCEM Risk Management Tool

Table 4.34 – Population Impacted by the 50-Year Flood Event

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Currituck									
Currituck County	31,343	3,647	11.6%	5,390	627	11.6%	1,596	186	11.7%
Dare									
Unincorporated Dare County	24,369	4,003	16.4%	4,752	781	16.4%	1,150	189	16.4%
Town of Duck	1,722	17	1.0%	582	6	1.0%	53	1	1.9%
Town of Kill Devil Hills	7,588	88	1.2%	1,298	15	1.2%	260	3	1.2%
Town of Kitty Hawk	3,903	430	11.0%	861	95	11.0%	137	15	10.9%
Town of Manteo	1,360	105	7.7%	220	17	7.7%	80	6	7.5%

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Town of Nags Head	3,178	115	3.6%	1,084	39	3.6%	70	3	4.3%
Town of Southern Shores	2,536	31	1.2%	858	10	1.2%	78	1	1.3%
Subtotal Dare	**44,656**	**4,789**	**10.7%**	**9,655**	**963**	**10.0%**	**1,828**	**218**	**11.9%**
Region Total	**75,999**	**8,436**	**11.1%**	**15,045**	**1,590**	**10.6%**	**3,424**	**404**	**11.8%**

Source: NCEM Risk Management Tool

Table 4.35 – Population Impacted by the 100-Year Flood Event

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Currituck									
Currituck County	31,343	4,174	13.3%	5,390	718	13.3%	1,596	213	13.3%
Dare									
Unincorporated Dare County	24,369	6,154	25.3%	4,752	1,200	25.3%	1,150	290	25.2%
Town of Duck	1,722	53	3.1%	582	18	3.1%	53	2	3.8%
Town of Kill Devil Hills	7,588	178	2.3%	1,298	30	2.3%	260	6	2.3%
Town of Kitty Hawk	3,903	861	22.1%	861	190	22.1%	137	30	21.9%
Town of Manteo	1,360	154	11.3%	220	25	11.4%	80	9	11.3%
Town of Nags Head	3,178	425	13.4%	1,084	145	13.4%	70	9	12.9%
Town of Southern Shores	2,536	88	3.5%	858	30	3.5%	78	3	3.8%
Subtotal Dare	**44,656**	**7,913**	**17.7%**	**9,655**	**1,638**	**17.0%**	**1,828**	**349**	**19.1%**
Region Total	**75,999**	**12,087**	**15.9%**	**15,045**	**2,356**	**15.7%**	**3,424**	**562**	**16.4%**

Source: NCEM Risk Management Tool

Table 4.36 – Population Impacted by the 500-Year Flood Event

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Currituck									
Currituck County	31,343	5,054	16.1%	5,390	869	16.1%	1,596	257	16.1%
Dare									
Unincorporated Dare County	24,369	10,541	43.3%	4,752	2,056	43.3%	1,150	497	43.2%
Town of Duck	1,722	89	5.2%	582	30	5.2%	53	3	5.7%
Town of Kill Devil Hills	7,588	286	3.8%	1,298	49	3.8%	260	10	3.8%
Town of Kitty Hawk	3,903	1,184	30.3%	861	261	30.3%	137	42	30.7%
Town of Manteo	1,360	336	24.7%	220	54	24.5%	80	20	25.0%
Town of Nags Head	3,178	664	20.9%	1,084	226	20.8%	70	15	21.4%
Town of Southern Shores	2,536	182	7.2%	858	62	7.2%	78	6	7.7%
Subtotal Dare	**44,656**	**13,282**	**29.7%**	**9,655**	**2,738**	**28.4%**	**1,828**	**593**	**32.4%**
Region Total	**75,999**	**18,336**	**24.1%**	**15,045**	**3,607**	**24.0%**	**3,424**	**850**	**24.8%**

Source: NCEM Risk Management Tool

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. The increased number of flood days and general encroachment of shoreline associated with sea level rise will likely cause additional flood-related 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.

Properties within the SFHA are estimated to have a one percent probability of being exposed to flooding equaling or exceeding the base flood 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. Regardless of insurance status, pre-FIRM properties, those built before the community's first FIRM, may be more vulnerable to flood damage because they were built prior to the enforcement of flood damage prevention regulations. These properties may be a priority for mitigation.

Table 4.37 provides counts of critical facilities by FEMA lifeline located in the SFHA, according to the 2006 FIRMs. Details on critical facility vulnerability can be found in each community's annex to this plan.

Table 4.37 – Critical Facility Exposure to 1%-Annual-Chance Flood by Flood Zone

Facility Type	Critical Facility Count by SFHA Flood Zone		Total Facilities at Risk
	Zone AE	Zone VE	
Communications	8	0	8
Energy	1	0	1
Food, Hydration, Shelter	11	0	11
Health and Medical	6	0	6
Safety and Security	37	3	40
Transportation	5	1	6
Water Systems	37	7	44
Total	**105**	**11**	**116**

Table 4.38 summarizes critical facility exposure to storm surge by FEMA lifeline and storm category according to NOAA SLOSH inundation mapping. Facilities are counted according the lowest category storm that could cause impacts based on inundation extent. There are 23 critical facilities that do not fall within any storm surge inundation area. Note that this exposure analysis does not account for facility finished floor elevation. A facility might be located within an estimated storm surge extent without being damaged by flooding.

Table 4.38 – Critical Facility Exposure to Storm Surge by Storm Category

FEMA Lifeline	Storm Intensity				
	Category 1	Category 2	Category 3	Category 4	Category 5
Communications	5	6	12	8	5
Energy	1	3	4		1
Food, Hydration, Shelter	1	5	18	52	9
Health and Medical		5	5	3	2
Safety and Security	13	24	13	19	9
Transportation	1	3	2		1
Water Systems	12	18	26	14	19
Total	**33**	**64**	**80**	**96**	**46**

Table 4.39 lists critical facilities exposed to flooding from sea level rise. There are two facilities exposed to one foot of sea level rise and one more facility exposed to two feet of sea level rise. All three of these facilities are in Currituck County. An additional five facilities in unincorporated Dare County are exposed to three feet of sea level rise. Note that this exposure analysis does not account for facility finished floor elevation. A facility might be located within an estimated sea level rise extent without being damaged by flooding.

Table 4.39 – Critical Facility Exposure to Sea Level Rise

FEMA Lifeline	Facility Type/Description	Address
1 Foot Sea Level Rise		
Transportation	FERRY DOCK	173 Courthouse Rd
Transportation	FERRY DIVISION	153 Ferry Dock Rd

FEMA Lifeline	Facility Type/Description	Address
2 Foot Sea Level Rise		
Communications	Communications Tower	574 Poyners Rd
3 Foot Sea Level Rise		
Safety and Security	Fessenden Center (POD, shelter, etc), Dare County Public Services	46830 NC Hwy 12
Transportation	RWS Emergency Ferry Terminal / Helo Landing Pad	23170 Myrna Peters Rd
Water Systems	Treatment Plant	53282 NC 12 Hwy
Water Systems	Treatment Plant	53282 NC 12 Hwy
Water Systems	Treatment Plant	359 Water Plant Rd

Table 4.40 through Table 4.44 on the following pages detail the property at risk and loss estimates from various flood events, according to data from the NCEM IRISK database. Actual property at risk may be higher due to development that has occurred since the analysis for the IRISK dataset was performed. Additionally, given that these estimates are based on the current effective FIRM, which the HMPC considers an underestimation of risk, actual building damages from the 1%-annual-chance flood event would likely be higher.

Table 4.40 – Buildings Impacted by the 10-Year Flood Event

Jurisdiction	All Buildings	Number of Pre-FIRM Buildings at Risk		Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck															
Currituck County	17,685	466	2.6%	725	4.1%	$7,173,496	0	0.0%	$132,583	0	0.0%	$12,815	725	4.1%	$7,318,894
Dare															
Unincorporated Dare County	14,019	555	4.0%	1,039	7.4%	$2,979,599	8	0.1%	$117,629	5	0.0%	$125,772	1,052	7.5%	$3,222,999
Town of Duck	2,409	3	0.1%	5	0.2%	$32,893	1	0.0%	$5,237	0	0.0%	$0	6	0.2%	$38,129
Town of Kill Devil Hills	6,033	14	0.2%	26	0.4%	$47,798	0	0.0%	$0	0	0.0%	$0	26	0.4%	$47,798
Town of Kitty Hawk	2,862	70	2.4%	119	4.2%	$466,100	0	0.0%	$0	0	0.0%	$0	119	4.2%	$466,100
Town of Manteo	943	15	1.6%	26	2.8%	$79,068	2	0.2%	$6,894	0	0.0%	$0	28	3.0%	$85,962
Town of Nags Head	4,868	60	1.2%	89	1.8%	$570,904	1	0.0%	$4,463	0	0.0%	$0	90	1.8%	$575,367
Town of Southern Shores	2,513	0	0.0%	4	0.2%	$40,743	0	0.0%	$0	0	0.0%	$0	4	0.2%	$40,743
Subtotal Dare	**33,647**	**717**	**2.1%**	**1,308**	**3.9%**	**$4,217,105**	**12**	**0.0%**	**$134,223**	**5**	**0.0%**	**$125,772**	**1,325**	**3.9%**	**$4,477,098**
Region Total	**51,332**	**1,183**	**2.3%**	**2,033**	**4.0%**	**$4,973,185**	**12**	**0.0%**	**$134,223**	**5**	**0.0%**	**$125,772**	**2,050**	**4.0%**	**$5,233,178**

Source: NCEM Risk Management Tool

Table 4.41 – Buildings Impacted by the 25-Year Flood Event

Jurisdiction	All Buildings	Number of Pre-FIRM Buildings at Risk		Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck															
Currituck County	17,685	898	5.1%	1,621	9.2%	$3,200,049	15	0.1%	$12,436	1	0.0%	$4,449	1,637	9.3%	$3,216,934
Dare															
Unincorporated Dare County	14,019	922	6.6%	1,730	12.3%	$5,018,570	17	0.1%	$172,009	5	0.0%	$140,783	1,752	12.5%	$5,331,362
Town of Duck	2,409	6	0.2%	15	0.6%	$153,959	2	0.1%	$35,719	0	0.0%	$0	17	0.7%	$189,678
Town of Kill Devil Hills	6,033	26	0.4%	46	0.8%	$90,277	0	0.0%	$0	0	0.0%	$0	46	0.8%	$90,277
Town of Kitty Hawk	2,862	153	5.3%	233	8.1%	$828,295	1	0.0%	$8	0	0.0%	$0	234	8.2%	$828,302
Town of Manteo	943	23	2.4%	43	4.6%	$188,796	6	0.6%	$47,818	0	0.0%	$0	49	5.2%	$236,614
Town of Nags Head	4,868	74	1.5%	128	2.6%	$893,305	2	0.0%	$11,116	1	0.0%	$5,894	131	2.7%	$910,315
Town of Southern Shores	2,513	1	0.0%	19	0.8%	$84,639	0	0.0%	$0	0	0.0%	$0	19	0.8%	$84,639
Subtotal Dare	**33,647**	**1,205**	**3.6%**	**2,214**	**6.6%**	**$7,257,841**	**28**	**0.1%**	**$266,670**	**6**	**0.0%**	**$146,677**	**2,248**	**6.7%**	**$7,671,187**
Region Total	**51,332**	**2,103**	**4.1%**	**3,835**	**7.5%**	**$10,457,890**	**43**	**0.1%**	**$279,106**	**7**	**0.0%**	**$151,126**	**3,885**	**7.6%**	**$10,888,121**

Source: NCEM Risk Management Tool

Table 4.42 – Buildings Impacted by the 50-Year Flood Event

Jurisdiction	All Buildings	Number of Pre-FIRM Buildings at Risk		Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck															
Currituck County	17,685	1,002	5.7%	1,861	10.5%	$4,500,957	21	0.1%	$35,555	1	0.0%	$8,274	1,883	10.6%	$4,544,786
Dare															
Unincorporated Dare County	14,019	1,123	8.0%	2,166	15.5%	$6,743,625	38	0.3%	$295,860	5	0.0%	$148,915	2,209	15.8%	$7,188,400
Town of Duck	2,409	6	0.2%	23	1.0%	$315,776	2	0.1%	$111,052	0	0.0%	$0	25	1.0%	$426,828
Town of Kill Devil Hills	6,033	36	0.6%	67	1.1%	$140,166	0	0.0%	$0	0	0.0%	$0	67	1.1%	$140,166
Town of Kitty Hawk	2,862	186	6.5%	293	10.2%	$1,214,755	2	0.1%	$4,952	0	0.0%	$0	295	10.3%	$1,219,706
Town of Manteo	943	32	3.4%	61	6.5%	$375,918	9	1.0%	$264,041	0	0.0%	$0	70	7.4%	$639,959
Town of Nags Head	4,868	86	1.8%	163	3.3%	$1,228,133	5	0.1%	$20,998	1	0.0%	$10,969	169	3.5%	$1,260,100
Town of Southern Shores	2,513	4	0.2%	30	1.2%	$112,036	0	0.0%	$0	0	0.0%	$0	30	1.2%	$112,036
Subtotal Dare	**33,647**	**1,473**	**4.4%**	**2,803**	**8.3%**	**$10,130,409**	**56**	**0.2%**	**$696,903**	**6**	**0.0%**	**$159,884**	**2,865**	**8.5%**	**$10,987,195**
Region Total	**51,332**	**2,475**	**4.8%**	**4,664**	**9.1%**	**$14,631,366**	**77**	**0.2%**	**$732,458**	**7**	**0.0%**	**$168,158**	**4,748**	**9.2%**	**$15,531,981**

Source: NCEM Risk Management Tool

Table 4.43 – Buildings Impacted by the 100-Year Flood Event

Jurisdiction	All Buildings	Number of Pre-FIRM Buildings at Risk		Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck															
Currituck County	17,685	1,114	6.3%	2,129	12.0%	$7,173,496	41	0.2%	$132,583	2	0.0%	$12,815	2,172	12.3%	$7,318,894
Dare															
Unincorporated Dare County	14,019	1,610	11.5%	3,313	23.6%	$26,606,656	177	1.3%	$7,071,694	30	0.2%	$686,073	3,520	25.1%	$34,364,423
Town of Duck	2,409	10	0.4%	72	3.0%	$2,582,730	6	0.2%	$305,005	0	0.0%	$0	78	3.2%	$2,887,736
Town of Kill Devil Hills	6,033	69	1.1%	134	2.2%	$1,542,563	5	0.1%	$113,317	0	0.0%	$0	139	2.3%	$1,655,880
Town of Kitty Hawk	2,862	320	11.2%	583	20.4%	$7,104,907	25	0.9%	$918,415	0	0.0%	$0	608	21.2%	$8,023,321
Town of Manteo	943	50	5.3%	90	9.5%	$597,249	14	1.5%	$703,816	0	0.0%	$0	104	11.0%	$1,301,065
Town of Nags Head	4,868	192	3.9%	586	12.0%	$11,056,782	31	0.6%	$1,082,657	4	0.1%	$407,646	621	12.8%	$12,547,085
Town of Southern Shores	2,513	15	0.6%	86	3.4%	$734,718	2	0.1%	$326,452	0	0.0%	$0	88	3.5%	$1,061,170
Subtotal Dare	**33,647**	**2,266**	**6.7%**	**4,864**	**14.5%**	**$50,225,605**	**260**	**0.8%**	**$10,521,356**	**34**	**0.1%**	**$1,093,719**	**5,158**	**15.3%**	**$61,840,680**
Region Total	**51,332**	**3,380**	**6.6%**	**6,993**	**13.6%**	**$57,399,101**	**301**	**0.6%**	**$10,653,939**	**36**	**0.1%**	**$1,106,534**	**7,330**	**14.3%**	**$69,159,574**

Source: NCEM Risk Management Tool

Table 4.44 – Buildings Impacted by the 500-Year Flood Event

Jurisdiction	All Buildings	Number of Pre-FIRM Buildings at Risk		Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck															
Currituck County	17,685	1,253	7.1%	2,575	14.6%	$43,634,661	106	0.6%	$4,704,550	8	0.0%	$256,784	2,689	15.2%	$48,595,995
Dare															
Unincorporated Dare County	14,019	2,297	16.4%	5,670	40.4%	$131,461,880	433	3.1%	$27,649,156	77	0.5%	$5,422,998	6,180	44.1%	$164,534,034
Town of Duck	2,409	15	0.6%	119	4.9%	$6,265,406	13	0.5%	$1,097,247	2	0.1%	$843,481	134	5.6%	$8,206,134
Town of Kill Devil Hills	6,033	85	1.4%	215	3.6%	$4,044,482	7	0.1%	$372,179	0	0.0%	$0	222	3.7%	$4,416,661
Town of Kitty Hawk	2,862	406	14.2%	801	28.0%	$15,254,725	51	1.8%	$2,506,662	5	0.2%	$275,924	857	29.9%	$18,037,311
Town of Manteo	943	92	9.8%	189	20.0%	$3,170,738	51	5.4%	$3,017,788	1	0.1%	$28,944	241	25.6%	$6,217,470
Town of Nags Head	4,868	257	5.3%	926	19.0%	$24,401,311	68	1.4%	$4,011,402	5	0.1%	$889,294	999	20.5%	$29,302,006
Town of Southern Shores	2,513	34	1.4%	177	7.0%	$2,358,059	7	0.3%	$738,270	0	0.0%	$0	184	7.3%	$3,096,330
Subtotal Dare	**33,647**	**3,186**	**9.5%**	**8,097**	**24.1%**	**$186,956,601**	**630**	**1.9%**	**$39,392,704**	**90**	**0.3%**	**$7,460,641**	**8,817**	**26.2%**	**$233,809,946**
Region Total	**51,332**	**4,439**	**8.6%**	**10,672**	**20.8%**	**$230,591,262**	**736**	**1.4%**	**$44,097,254**	**98**	**0.2%**	**$7,717,425**	**11,506**	**22.4%**	**$282,405,941**

Source: NCEM Risk Management Tool

To supplement the vulnerability assessment from IRISK, the planning team used the Federal Flood Risk Management Standard (FFRMS) Freeboard Value Approach (FVA) for evaluating future flood conditions. Using FEMA's standard FVA methodology, the planning team identified areas vulnerable to an additional one, two, and three feet of flooding above the base flood elevation and compared the asset inventory of current improved parcels to these flood exposure areas. This analysis was completed using the 2006 FIRMs and the current effective FIRMs as baselines. Each baseline scenario provides an estimate of current exposure to the 1%-annual-chance flood event, and the freeboard scenarios provide an approximation of exposure under possible future flood conditions. The analysis using the 2006 FIRMs is considered the more appropriate measure of current and future exposure because the baseline scenario is a more accurate representation of current flood risk. Table 4.45 summarizes exposure under each freeboard scenario using the 2006 FIRMs as a baseline, and Table 4.46 summarizes exposure using the current effective FIRMs as a baseline.

Table 4.45 – Current and Future Property Exposure to Flooding, 2006 FIRM Baseline

Occupancy	Estimated Parcel Count	Structure Value	Estimated Content Value	Total Value
+0 Foot Freeboard	**31,244**	**$6,998,021,089**	**$3,985,707,852**	**$10,983,728,941**
Agriculture	82	$3,766,533	$3,766,533	$7,533,066
Commercial	1074	$354,158,342	$354,158,342	$708,316,685
Education	17	$55,424,707	$55,424,707	$110,849,414
Government	336	$105,034,367	$105,034,367	$210,068,734
Industrial	136	$213,405,486	$320,108,229	$533,513,715
Religious	70	$28,199,692	$28,199,692	$56,399,384
Residential	29529	$6,238,031,962	$3,119,015,981	$9,357,047,943
+1 Foot Freeboard	**35,248**	**$8,014,372,733**	**$4,648,504,907**	**$12,662,877,639**
Agriculture	109	$5,082,213	$5,082,213	$10,164,427
Commercial	1262	$426,020,868	$426,020,868	$852,041,735
Education	19	$65,897,213	$65,897,213	$131,794,426
Government	353	$114,799,300	$114,799,300	$229,598,600
Industrial	166	$318,759,062	$478,138,593	$796,897,655
Religious	85	$33,319,362	$33,319,362	$66,638,724
Residential	33254	$7,050,494,715	$3,525,247,357	$10,575,742,072
+2 Foot Freeboard	**37,721**	**8,626,294,801**	**5,021,187,099**	**13,647,481,900**
Agriculture	121	$6,211,795	$6,211,795	$12,423,591
Commercial	1373	$504,788,591	$504,788,591	$1,009,577,182
Education	23	$91,128,548	$91,128,548	$182,257,096
Government	373	$125,077,526	$125,077,526	$250,155,052
Industrial	197	$326,575,448	$489,863,172	$816,438,620
Religious	94	$35,722,042	$35,722,042	$71,444,084
Residential	35540	$7,536,790,850	$3,768,395,425	$11,305,186,276
+3 Foot Freeboard	**39,457**	**$9,021,753,513**	**$5,252,251,948**	**$14,274,005,462**
Agriculture	123	$6,300,821	$6,300,821	$12,601,643
Commercial	1439	$534,805,825	$534,805,825	$1,069,611,650
Education	26	$104,864,361	$104,864,361	$209,728,722
Government	389	$130,457,319	$130,457,319	$260,914,638
Industrial	209	$335,116,458	$502,674,686	$837,791,144
Religious	95	$36,089,142	$36,089,142	$72,178,284
Residential	37176	$7,874,119,587	$3,937,059,794	$11,811,179,381

Table 4.46 – Current and Future Property Exposure to Flooding, Current Effective FIRM Baseline

Occupancy	Estimated Parcel Count	Structure Value	Estimated Content Value	Total Value
+0 Foot Freeboard	**24,674**	**$5,981,841,102**	**$3,421,228,703**	**$9,403,069,806**
Agriculture	59	$2,611,675	$2,611,675	$5,223,350
Commercial	946	$309,170,944	$309,170,944	$618,341,888
Education	11	$48,230,865	$48,230,865	$96,461,730
Government	299	$98,971,990	$98,971,990	$197,943,980
Industrial	120	$190,959,420	$286,439,130	$477,398,551
Religious	54	$19,711,990	$19,711,990	$39,423,980
Residential	23,185	$5,312,184,218	$2,656,092,109	$7,968,276,327
+1 Foot Freeboard	**30,786**	**$7,224,954,134**	**$4,095,634,856**	**$11,320,588,990**
Agriculture	82	$3,910,729	$3,910,729	$7,821,458
Commercial	1,127	$373,412,477	$373,412,477	$746,824,955
Education	13	$52,924,107	$52,924,107	$105,848,214
Government	320	$104,236,920	$104,236,920	$208,473,840
Industrial	141	$204,021,718	$306,032,577	$510,054,294
Religious	68	$23,787,909	$23,787,909	$47,575,818
Residential	29,035	$6,462,660,274	$3,231,330,137	$9,693,990,411
+2 Foot Freeboard	**34,794**	**$8,123,711,182**	**$4,630,875,614**	**$12,754,586,796**
Agriculture	117	$5,942,583	$5,942,583	$11,885,166
Commercial	1,254	$432,421,149	$432,421,149	$864,842,298
Education	17	$74,567,589	$74,567,589	$149,135,178
Government	347	$118,286,962	$118,286,962	$236,573,924
Industrial	178	$238,579,273	$357,868,909	$596,448,182
Religious	77	$29,663,219	$29,663,219	$59,326,438
Residential	32,804	$7,224,250,407	$3,612,125,204	$10,836,375,611
+3 Foot Freeboard	**39,030**	**$9,102,436,562**	**$5,274,162,360**	**$14,376,598,922**
Agriculture	166	$8,691,245	$8,691,245	$17,382,490
Commercial	1,402	$497,848,712	$497,848,712	$995,697,424
Education	24	$99,754,566	$99,754,566	$199,509,132
Government	364	$122,530,586	$122,530,586	$245,061,172
Industrial	206	$340,562,909	$510,844,363	$851,407,272
Religious	92	$35,937,232	$35,937,232	$71,874,464
Residential	36,776	$7,997,111,312	$3,998,555,656	$11,995,666,969

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. 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. Repetitive loss properties and severe repetitive loss properties are a priority for mitigation because they have a known flood risk and are a drain on the NFIP.

According to February 2024 NFIP records, there are a total of 1,932 repetitive loss properties within the Outer Banks Region, of which 1,748 are residential and 121 are commercial or non-residential. Only 1,036 repetitive loss properties, less than 54% of the total in the region, are insured. The number of insured repetitive loss properties has decreased in the last five years, which could be attributed to the new FIRMs which reduced the SFHA acreage in the region and potentially removed the mandatory purchase requirement for some property owners. There are 243 properties on the list classified as severe repetitive loss properties.

Table 4.47 summarizes repetitive loss properties by jurisdiction as identified by FEMA through the NFIP. Figure 4.36 shows the general areas where repetitive losses have occurred throughout the region.

Table 4.47 – Repetitive Loss Properties by Jurisdiction, February 2024

Jurisdiction	RL Property Count	Occupancy Type		Total Losses	% Insured	SRL Count
		Residential	Commercial			
Currituck County	195	192	3	633	56.9%	32
Dare County	945	827	118	3,163	51.1%	125
Duck	15	12	3	38	75%	1
Kill Devil Hills	159	152	7	493	52.8%	15
Kitty Hawk	304	291	13	993	67.4%	36
Manteo	47	31	16	119	83.0%	5
Nags Head	252	228	24	1,064	38.5%	29
Southern Shores	15	15	0	32	53.3%	0
Total	**1,932**	**1,748**	**121**	**6,535**	**53.60%**	**243**

Source: FEMA/ISO, March 2019

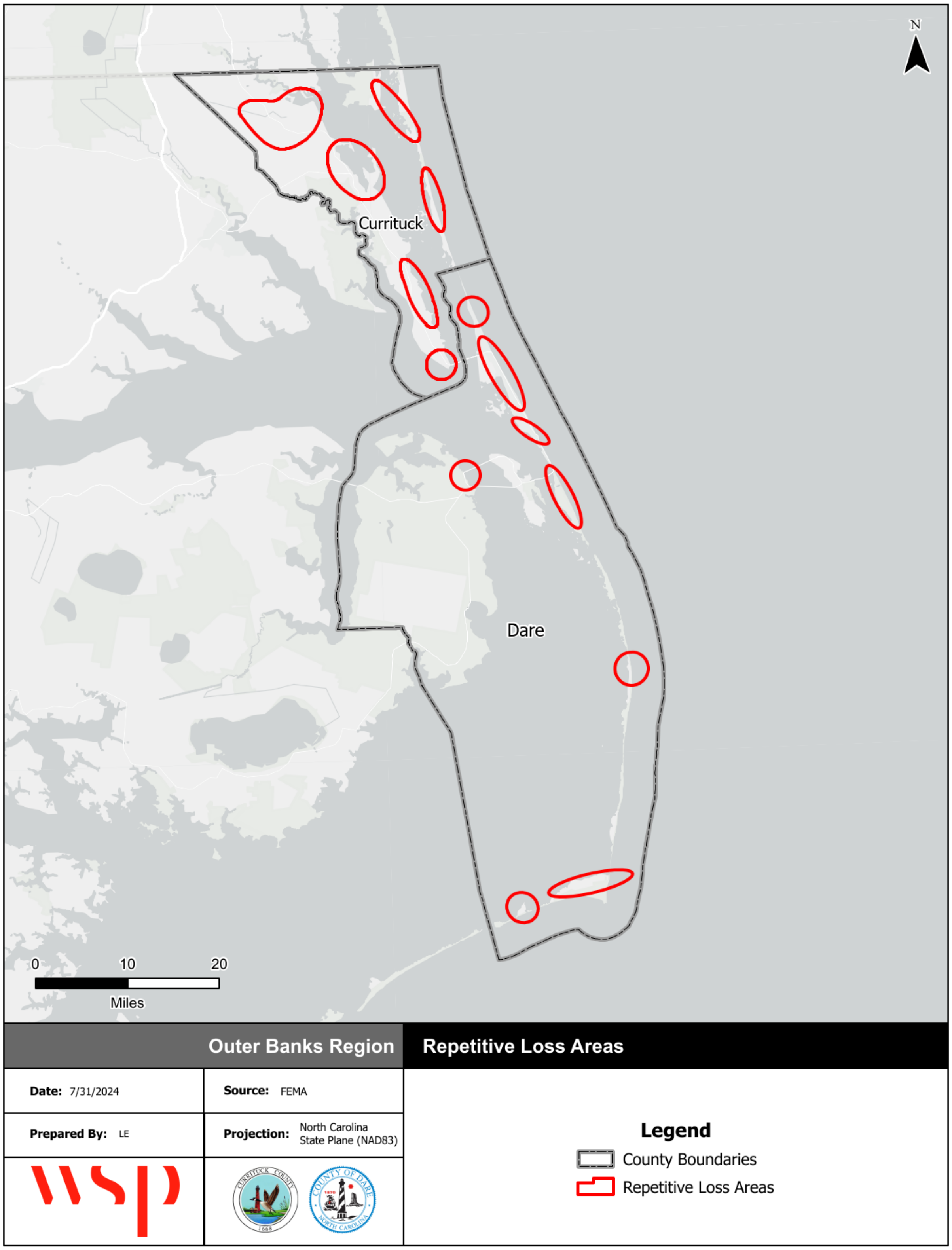
RL = Repetitive Loss; SRL = Severe Repetitive Loss

A review of the date of loss of repetitive loss claims provides insight as to which past flood events were particularly damaging in the region. Per this data, Table 4.48 lists the events that resulted in the most claims for repetitive loss properties in each participating community.

Table 4.48 – Events Resulting in the Most Flood Insurance Claims for Repetitive Loss Properties

Community	Event	Date	Claims
Currituck County (Corolla, Currituck)	Hurricane Matthew	October 7, 2016	75
Currituck County (Grandy)	Tropical Storm Michael	October 11, 2018	15
Dare County (Hatteras, Avon)	Hurricane Dorian	September 5, 2019	409
Dare County (Buxton, Frisco)	Tropical Storm	September 21, 2023	128
Dare County (Rodanthe, Salvo, Waves)	Hurricane Arthur	July 3, 2014	109
Duck	Hurricane Matthew	October 8, 2016	10
Kill Devil Hills	Hurricane Isabel	September 17, 2003	70
Kitty Hawk	Hurricane Sandy	October 28, 2012	154
Manteo	Tropical Storm Michael	October 10, 2018	34
Nags Head	Nor'easter	November 11, 2009	210
Southern Shores	Tropical Storm Michael	October 10, 2018	8

Figure 4.36 – Repetitive Loss Areas



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 waterbodies and potentially reducing their drainage capacity.

Sea level rise can have numerous negative consequences on the environment including increased erosion and associated impacts. 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. Sea level rise may also lead to saltwater intrusion as the groundwater table may also rise, potentially leading to contaminated drinking and agriculture water.

CONSEQUENCE ANALYSIS

Table 4.49 summarizes the potential detrimental consequences of flood.

Table 4.49 – Consequence Analysis - Flood

Category	Consequences
Public	Localized impacts could be severe. Flooding is likely to displace people from their homes. Water can become polluted such that if consumed, diseases and infection can be easily spread. Sea level rise may exacerbate public health risks associated with flooding. Additionally, sea level rise may cause psychological stress from loss of home, economy, and culture.
Responders	First responders are at risk when attempting to rescue people from flooding. 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. Impacts to responders are 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 flooded areas may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services. Sea level rise may also interrupt continuity of operations, such as delivery of services, by causing more regular, chronic flooding.
Property, Facilities and Infrastructure	Buildings and infrastructure, including transportation and utility infrastructure, may be damaged or destroyed by flooding. Sea level rise can damage property as flooding becomes more regular in the short term and as sea levels continue to rise in the long term. Sea level rise can also compromise infrastructure such as drainage systems and roads.
Environment	Flooding may release chemicals and other hazardous substances that can contaminate local water bodies. Wildlife deaths are possible. Localized impacts could be severe for areas affected by flooding or associated HazMat releases. Sea level rise can lead to increased erosion, saltwater intrusion, and inundation of wetlands and previous dry land.

Category	Consequences
Economic Condition of the Jurisdiction	Local economy and finances will be adversely affected, possibly for an extended period of time. Roads, bridges, farms, houses and automobiles can sustain costly damages. Response and recovery operations can be expensive. It may take years for 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. Due to the coastal geography of the region, flood risk due to storm surge, high tide flooding, flash flooding, and stormwater flooding is uniform across the region. All included jurisdictions are exposed to a high risk of flooding according to the 2006 FIRM, and because other sources of flooding and other levels of flooding may occur beyond these areas, the HMPC determined that the spatial extent of flooding is large for all jurisdictions. All communities also face a uniform probability of flooding.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Currituck County	4	3	4	3	3	3.5	H
Dare County	4	3	4	3	3	3.5	H
Duck	4	3	4	3	3	3.5	H
Kill Devil Hills	4	3	4	3	3	3.5	H
Kitty Hawk	4	3	4	3	3	3.5	H
Manteo	4	3	4	3	3	3.5	H
Nags Head	4	3	4	3	3	3.5	H
Southern Shores	4	3	4	3	3	3.5	H

4.5.5 HURRICANES & COASTAL HAZARDS

HAZARD BACKGROUND

This hazard profile includes hurricanes, nor'easters, coastal erosion, and rip currents.

HURRICANES AND NOR'EASTERS

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 tornados.

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. The majority of hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico during the Atlantic hurricane season, which is typically from 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.

The greatest potential for loss of life related to a hurricane is from the storm surge, which is discussed in Section 4.5.4. Damage during hurricanes may also result from spawned tornados, which are discussed in Section 4.5.6, and inland flooding associated with heavy rainfall that usually accompanies these storms, which is discussed in Section 4.5.4.

Similar to 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, a band of warm water that lies off the Atlantic coast. 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 have the potential for creating dangerously high winds and heavy seas. As the low-pressure system deepens, the intensity of the winds and waves increase and can cause serious damage to coastal areas as the storm moves northeast.

Warning Time: 1 – More than 24 hours

Duration: 3 – Less than one week

COASTAL EROSION

Coastal erosion is the wearing away and transportation of material away from one section of shoreline and deposited offshore or in another section of shoreline. Coastal erosion impacts both oceanfront and estuarine shorelines. Erosion can be caused by large storms, flooding, strong wave action, sea level rise, and human activities—such as land uses that over-develop the shoreline, alterations to the shoreline or dunes, and hard shoreline stabilization structures like breakwaters and seawalls—that wear away the beaches and estuarine shorelines 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.

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 region 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, 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. 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.

Warning Time: 1 – More than 24 hours

Duration: 4 – More than 1 week

RIP CURRENT

Rip currents are powerful, narrow channels of seaward flowing water along the coast, extending from the shoreline to outside the surf zone. Rip currents form when there are variations in wave breaking along the beach due to the flow of water from areas with more wave breaking and corresponding higher wave setup to areas with less wave breaking and corresponding lower wave setup.

The NWS describes three major types of rip currents:

- **Bathymetrically-controlled rip currents** are those that occur at relatively fixed locations due to sandbars, submarine canyons and ridges, reefs, or other offshore features. These rip currents can be referred to as channelized or focused. Channelized currents are the most documented and well understood and occur in deep channels through shallow sandbars. Channelized rip currents are typically between 5 to 100 yards wide, 3 to 10 feet deep, and anywhere from 50 to 500 yards apart.

Focused rip currents can occur along flat featureless beaches and appear as offshore directed plumes of turbulent water and sediment. These rip currents may last for days, weeks, or months.

— **Structurally-controlled rip currents** occur adjacent to man-made structures such as groins, jetties, and piers and natural features like rock outcrops.
— **Hydrodynamically-controlled rip currents** occur solely as a result of wave and current interactions, typically from waves originating from two different sources approaching the beach from different directions. These rip currents are transient and may only last for several minutes.

General warning of rip current risk may be provided by lifeguards or available via the NWS, but there is often little to no warning for individuals regarding specific rip current sites. Some rip currents may last for days while others may only last for minutes.

Warning Time: 4 – Less than six hours

Duration: 2 – Less than 24 hours

LOCATION

HURRICANES AND NOR'EASTERS

Hurricane winds and nor'easters can impact the entire Outer Banks region.

Spatial Extent: 4 – Large

COASTAL EROSION

Coastal erosion can occur along any shoreline in the region, including oceanfront and estuarine areas, and affects all jurisdictions. Erosion is likely to be frequent and severe along the Atlantic coast, but erosion of estuarine shorelines may be just as severe; however, data on rates of erosion along estuarine shorelines is very limited. Though estuarine erosion is not monitored as closely as ocean erosion, the amount of estuarine shoreline in the region is far greater. The estuarine coastline in the Outer Banks region includes areas within the Pamlico and Albemarle Sounds, including the Currituck Sound. The western coast of the barrier island directly abuts these estuaries, as does Roanoke Island and the eastern coast of the mainland. Table 4.50 details shoreline length in the region per the North Carolina Division of Coastal Management.

Table 4.50 – Shoreline Length

County	Estuarine Shoreline	Ocean Shoreline
Currituck	1,100 miles	20 miles
Dare	946 miles	110 miles

Source: NC Division of Coastal Management Estuarine Shoreline Mapping Project, 2012; HMPC input

Erosion impacts on infrastructure are also a major concern in the Outer Banks Region. Due to concerns regarding erosion, flooding, and sea level rise projections, and the increasing vulnerability of N.C. 12 to these hazards, in 2021, Dare County formed the N.C. 12 Task Force with members from Hyde County, the Cape Hatteras National Seashore, the Pea Island Wildlife Refuge, and the North Carolina Department of Transportation. The N.C. 12 Task Force identified hot spots, areas of high vulnerability along N.C. 12, and developed short- and long-term solutions for these hot spots. Hot spots within the planning area include the following:

— Northern Pea Island/Old Sandbag Area aka Canal Zone
— Pea Island Visitor Center
— Rodanthe S Curves

— Avon
— Buxton
— Frisco/Hatteras Village

The Canal Zone and Pea Island Visitor Center hotpots were among those considered most critical due to the frequency and regularity of impacts and that loss of these areas results in lost access to all points further south.

Spatial Extent: 3 – Moderate

RIP CURRENT

Rip currents can occur along any oceanfront or area that experiences breaking waves. These areas are present in every jurisdiction except Manteo. Although rip currents occur as highly localized events, the HMPC felt a larger spatial extent was appropriate given that risk warnings are issued for entire coastlines.

Spatial Extent: 3 – Moderate

EXTENT

HURRICANES AND NOR'EASTERS

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 force winds can extend outward by about 35 miles from the eye of a small hurricane to more than 150 miles from the center of a large hurricane. Tropical storm force winds may extend even further, up to approximately 300 miles from the eye of a large hurricane. In general, the front right quadrant of a storm, relative to its direction of movement, is the most dangerous part of the storm. Wind speeds are highest in this area due to the additive impact of the atmospheric steering winds and the storm winds.

Hurricane intensity is further classified by the Saffir-Simpson Scale, detailed in Table 4.51, which rates hurricane intensity on a scale of 1 to 5, with 5 being the most intense.

Table 4.51 – 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 4.52 describes the damage that could be expected for each category of hurricane. Damage during hurricanes may also result from spawned tornados, storm surge, and inland flooding associated with heavy rainfall that usually accompanies these storms. Tornadoes are discussed in Section 4.5.6; flooding and storm surge are discussed in Section 4.5.4.

Table 4.52 – 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

Located on the coast, both Dare and Currituck counties are susceptible to every category of hurricane.

Impact: 4 – Catastrophic

COASTAL EROSION

Erosion can be measured as a rate of change from a known previous condition. The North Carolina Division of Coastal Management (DCM) developed a Long-Term Average Annual Erosion Rate Update Study in 1979, which was most recently updated in 2019 based on updated shoreline measurements from 2016. Per this study, the average blocked erosion rate value increased slightly, relative to the average calculated in the previous 2011 DCM study. This data is used to develop DCM's erosion rate maps and setback factors, which are used to regulate development and which serve as another way to summarize expected erosion. DCM's setback factors were last updated and approved by the Coastal Resources Commission in 2019. Shoreline change rates and Setback Factors can be found in the North Carolina 2019 Oceanfront Setback Factors & Long-Term Average Annual Erosion Rate Update Study: Methods Report, dated January 16, 2019 and made available on the NC DEQ website.

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 4.53 provides data from the NOAA Coastal Change Analysis Program (C-CAP) showing land cover changes in the Region from 1996 to 2016.

Table 4.53 – Land Cover Changes, 1996-2010

Land Cover Type	Currituck County		Dare County	
	Net Change (sq. mi.)	Change (%)	Net Change (sq. mi.)	Change (%)
High Intensity Developed	0.63	34.44	1.18	20.98
Low Intensity Developed	1.07	14.85	0.5	3.12
Open Space Developed	2.11	51.6	0.28	7.42
Grassland	0.38	30.35	-0.21	-12.53
Agriculture	-2.32	-2.97	-0.18	-2.22
Forested	-0.64	-3.99	-0.39	-4.15
Scrub/Shrub	-0.46	-11.52	-0.29	-9.05
Woody Wetland	0.48	0.48	-2.4	-1.01
Emergent Wetland	-1.23	-2.86	1.52	1.83
Barren Land	-0.19	-4.02	-2.12	-4.61
Open Water	0.17	0.06	2.1	0.18

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

The C-CAP data indicates net increases in open water and net decreases in forested land, scrub/shrub land, and barren land, which includes sandy beaches. Additionally, both counties saw an 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.

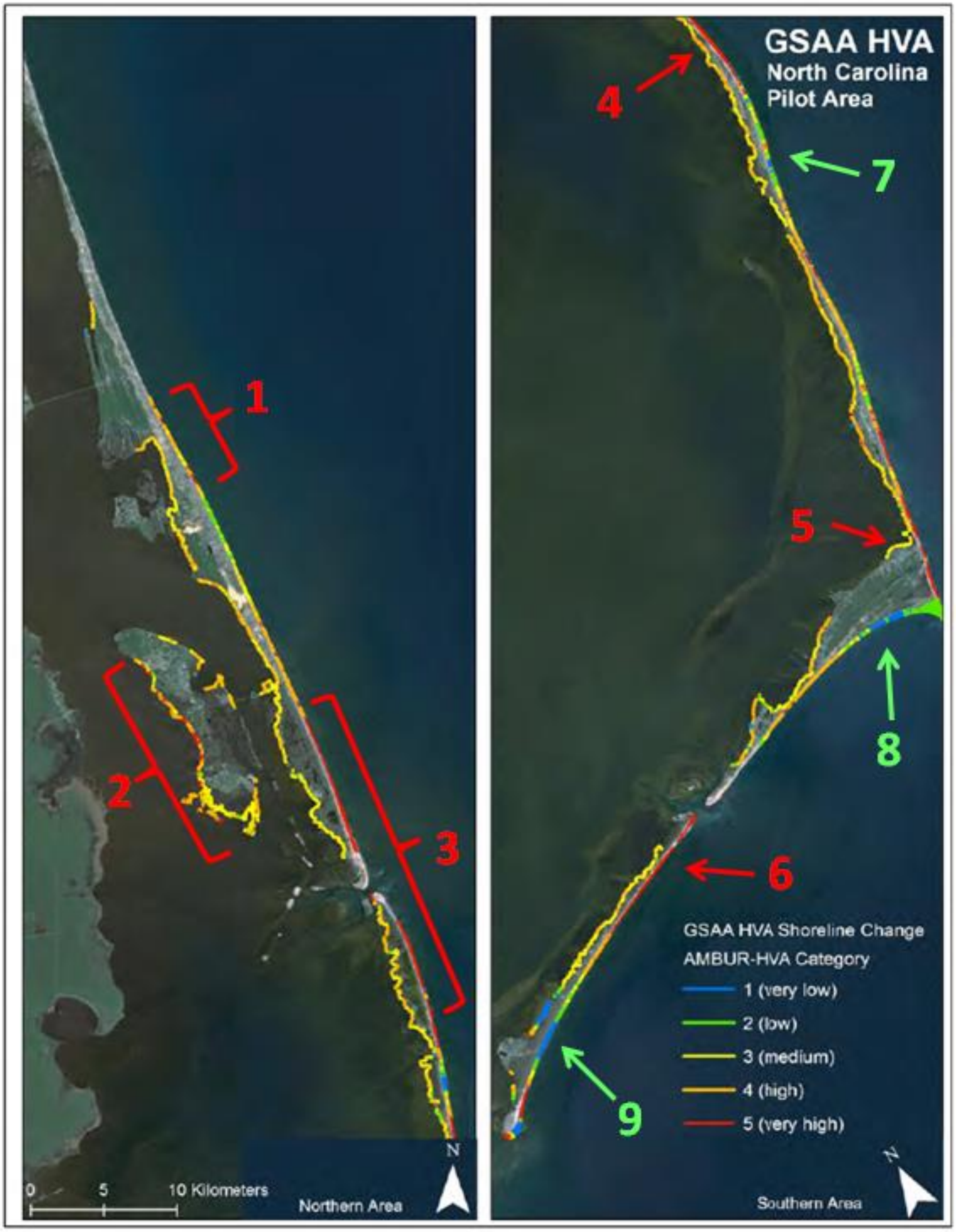
Another way to measure expected oceanfront erosion is by the North Carolina Division of Coastal Management's erosion rate maps and setback factors, which are used to regulate development. Per NC DEQ, "North Carolina's oceanfront construction setback factors are calculated using the long-term (approximately 50 years) average annual shoreline change rates for the purpose of establishing oceanfront construction Setback Factors and Ocean Erodible Areas of Environmental Concern, which were initially established by the Coastal Resources Commission (CRC) under the Coastal Area Management Act (CAMA) in 1979." Setback factors were last updated and approved by the Coastal Resources Commission in 2019. Shoreline change rates and Setback Factors can be found in the North Carolina 2019 Oceanfront Setback Factors & Long-Term Average Annual Erosion Rate Update Study: Methods Report, dated January 16, 2019 and made available on the NC DEQ website.

Estuarine erosion rates were measured as part of the development of the Hazard Vulnerability Assessment (HVA), a coastal hazard assessment tool created through the Governor's South Atlantic Alliance (GSAA). Per analysis by Corbett and Walsh, this data indicates long-term erosion on most estuarine shorelines and several hotspots of erosion, including the southern and western portions of Roanoke Island and stretches of coastline near Rodanthe and Buxton, shown in Figure 4.37.

Erosion may cause property and infrastructure damage but is unlikely to cause injury or death.

Impact: 2 – Limited

Figure 4.37 – Shoreline Erosion Rates in Southern Dare County



Source: Corbett and Walsh. GSAA Hazard Vulnerability Assessment Results

RIP CURRENT

One measure of rip currents is the flow speed of the current. Per NWS, channelized rip currents typically flow about 1-2 feet per second and can reach up to 8 feet per second. Rip currents do not have a steady flow but can experience rip pulses for short periods of time during which flows can suddenly accelerate to more than double their normal speed. Despite these measurable features, rip currents are not typically measured and recorded in these ways. Another way to consider the magnitude of a rip current is by its impacts. The HMPC is most concerned with rip currents causing deaths, injuries, or property damages.

The National Weather Service Forecast Offices provides rip current warnings as part of surf zone and beach forecasts. Forecasts for the Outer Banks are provided by the Newport-Morehead City Office and the Wakefield Office. Rip current risk levels carry the following descriptions, given as warnings to beach-goers:

- Low: Life threatening rip currents often occur in the vicinity of inlets, groins, jetties, and piers. Always supervise those who cannot swim and remember to heed the advice of the local beach patrol and flag warning systems.
- Moderate: Swim near a lifeguard. Remember to heed the advice of the local beach patrol and flag warning systems.
- High: The surf is dangerous for all levels of swimmers. Remember to heed the advice of the local beach patrol and flag warning systems.

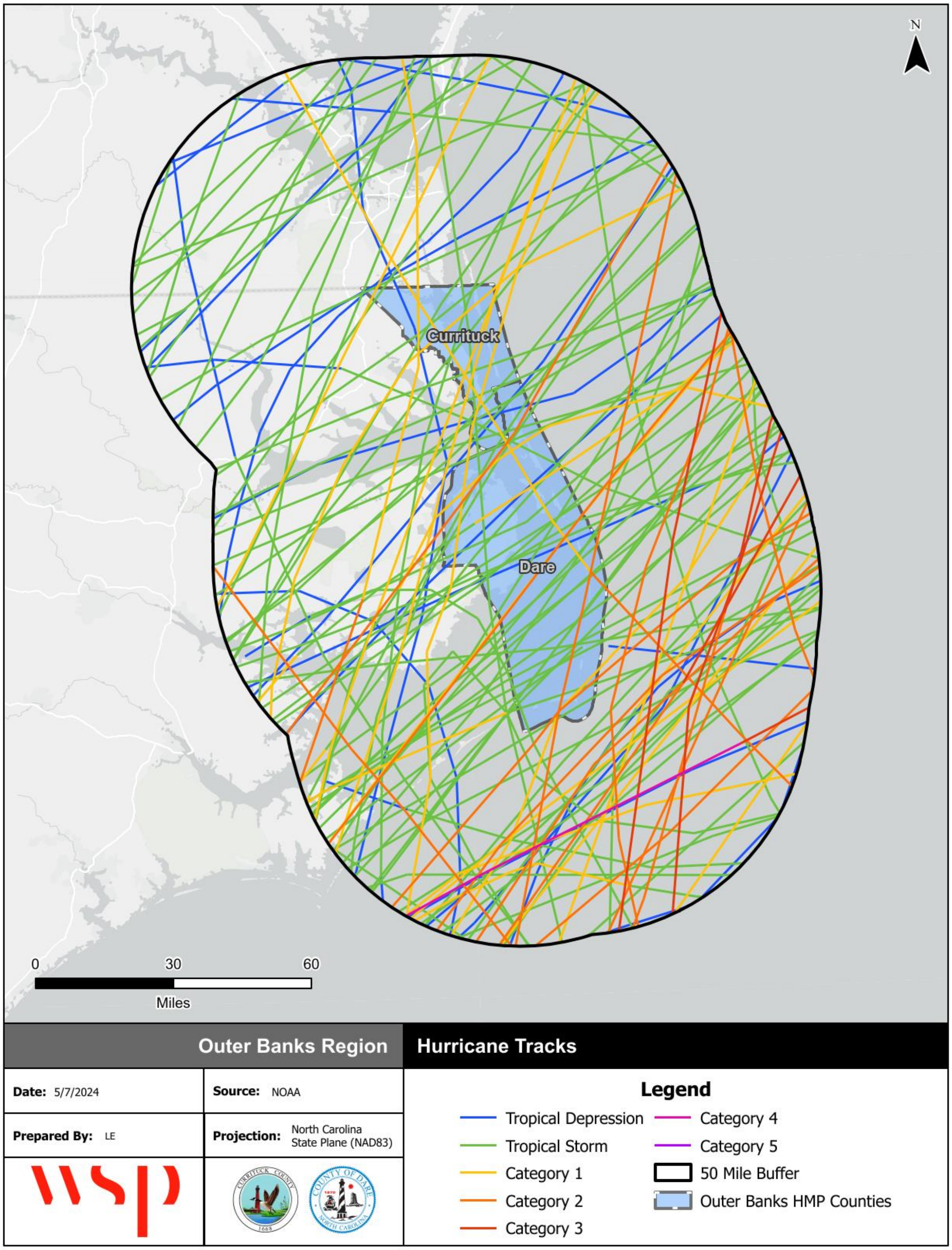
Impact: 3 – Critical

HISTORICAL OCCURRENCES

HURRICANES AND NOR'EASTERS

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, 104 hurricanes and tropical storms have passed within 50 miles of the Outer Banks Region since 1900. These storm tracks are shown in Figure 4.38. The date, storm name, storm category, and maximum wind speed of each event are detailed in Table 4.54.

Figure 4.38 – Tropical Cyclone Tracks Passing within 50 Miles of the Outer Banks Region, 1900-2021



Source: NOAA Office of Coastal Management

Table 4.54 – Tropical Cyclone Tracks Passing within 50 Miles of the Outer Banks Region, 1900-2021

Date	Storm Name	Max Storm Category*	Max Wind Speed (mph)
Unnamed	10/13/1900	Extratropical Storm	40
Unnamed	7/11/1901	Category 1	81
Unnamed	9/18/1901	Tropical Storm	40
Unnamed	6/29/1907	Extratropical Storm	58
Unnamed	5/29/1908	Category 1	75
Unnamed	7/31/1908	Category 1	81
Unnamed	9/1/1908	Tropical Storm	52
Unnamed	8/28/1910	Extratropical Storm	46
Unnamed	10/20/1910	Tropical Storm	63
Unnamed	6/15/1912	Extratropical Storm	40
Unnamed	5/17/1916	Extratropical Storm	46
Unnamed	8/24/1918	Category 1	75
Unnamed	8/26/1924	Category 2	104
Unnamed	9/17/1924	Extratropical Storm	46
Unnamed	9/30/1924	Extratropical Storm	69
Unnamed	12/2/1925	Extratropical Storm	75
Unnamed	9/12/1930	Category 1	92
Unnamed	9/16/1932	Extratropical Storm	58
Unnamed	8/23/1933	Category 2	104
Unnamed	9/16/1933	Category 2	109
Unnamed	9/3/1934	Tropical Storm	46
Unnamed	9/8/1934	Category 1	92
Unnamed	9/6/1935	Tropical Storm	58
Unnamed	9/18/1936	Category 2	98
Unnamed	7/31/1937	Tropical Storm	63
Unnamed	10/11/1942	Extratropical Storm	52
Unnamed	9/14/1944	Category 3	121
Unnamed	10/20/1944	Extratropical Storm	52
Unnamed	6/26/1945	Category 1	75
Unnamed	7/6/1946	Tropical Storm	52
Unnamed	10/10/1946	Extratropical Storm	40
Unnamed	9/25/1947	Extratropical Storm	40
Unnamed	8/24/1949	Category 2	104
Barbara	8/14/1953	Category 1	92
Unnamed	5/29/1954	Tropical Storm	46
Carol	8/31/1954	Category 2	109
Connie	8/12/1955	Category 2	98
Ione	9/19/1955	Category 2	104
Flossy	9/27/1956	Extratropical Storm	58
Unnamed	10/18/1956	Extratropical Storm	52
Helene	9/27/1958	Category 4	138
Cindy	7/10/1959	Tropical Storm	46
Unnamed	8/2/1959	Tropical Storm	46
Brenda	7/30/1960	Tropical Storm	63

Date	Storm Name	Max Storm Category*	Max Wind Speed (mph)
Donna	9/12/1960	Category 2	98
Unnamed	9/14/1961	Tropical Storm	40
Alma	8/28/1962	Category 1	75
Cleo	9/1/1964	Tropical Storm	46
Dora	9/14/1964	Tropical Storm	58
Isbell	10/16/1964	Category 1	75
Doria	9/16/1967	Tropical Storm	63
Gladys	10/20/1968	Category 1	81
Camille	8/20/1969	Tropical Storm	52
Gerda	9/9/1969	Category 1	81
Doria	8/27/1971	Tropical Storm	63
Agnes	6/22/1972	Tropical Storm	52
Hallie	10/27/1975	Tropical Storm	52
Bret	7/1/1981	Tropical Storm	58
Dennis	8/20/1981	Tropical Storm	69
Subtrop: Unnamed	6/19/1982	Subtropical Storm	69
Diana	9/14/1984	Tropical Storm	58
Gloria	9/27/1985	Category 2	104
Kate	11/22/1985	Tropical Storm	52
Charley	8/18/1986	Category 1	81
Bob	8/19/1991	Category 2	109
Danielle	9/25/1992	Tropical Storm	63
Emily	8/31/1993	Category 3	115
Allison	6/6/1995	Extratropical Storm	46
Arthur	6/19/1996	Tropical Storm	46
Bertha	7/13/1996	Category 1	75
Josephine	10/8/1996	Extratropical Storm	52
Danny	7/24/1997	Tropical Storm	46
Bonnie	8/27/1998	Category 1	86
Earl	9/4/1998	Extratropical Storm	58
Dennis	9/4/1999	Tropical Storm	69
Floyd	9/16/1999	Category 2	104
Irene	10/18/1999	Category 2	109
Helene	9/24/2000	Tropical Storm	46
Gustav	9/11/2002	Tropical Storm	63
Kyle	10/12/2002	Tropical Storm	46
Isabel	9/18/2003	Category 2	104
Alex	8/3/2004	Category 2	98
Charley	8/14/2004	Tropical Storm	69
Gaston	8/31/2004	Tropical Storm	40
Ophelia	9/15/2005	Category 1	81
Alberto	6/14/2006	Extratropical Storm	40
Ernesto	9/1/2006	Extratropical Storm	46
Barry	6/3/2007	Extratropical Storm	46
Gabrielle	9/9/2007	Tropical Storm	58

Date	Storm Name	Max Storm Category*	Max Wind Speed (mph)
Cristobal	7/20/2008	Tropical Storm	52
Irene	8/27/2011	Category 1	86
Andrea	6/7/2013	Extratropical Storm	46
Arthur	7/4/2014	Category 2	98
Colin	6/7/2016	Extratropical Storm	52
Hermine	9/3/2016	Extratropical Storm	69
Julia	9/20/2016	Tropical Depression	30
Matthew	10/9/2016	Category 1	81
Not Named	8/29/2017	Tropical Storm	37
Michael	10/12/2018	Tropical Storm	55
Dorian	9/6/2019	Category 2	85
Nestor	10/20/2019	Tropical Storm	40
Arthur	5/18/2020	Tropical Storm	45
Fay	7/9/2020	Tropical Storm	40
Claudette	6/21/2021	Tropical Storm	40

*Reports the most intense category that occurred within 50 miles of the Outer Banks Region, not for the storm event overall.

Source: Office of Coastal Management, 2024

The above list of storms is not an exhaustive list of hurricanes that have affected the Outer Banks Region. Several storms, including Hurricane Sandy, have passed further than 50 miles away from the Outer Banks Region yet had strong enough wind or rain impacts to affect the region. Storms with hurricane and tropical storm force winds that impacted the Outer Banks Region are recorded in NCEI across four zones: Eastern Dare, Western Dare, Eastern Currituck, and Western Currituck. During the 25-year period from 1999 through 2023, NCEI records 77 hurricane and tropical storm reports across 25 unique storms and 34 separate days. These events are summarized in Table 4.55 by storm. All death, injury, and damage records were combined from all zones. Where property damage estimates were broken out by type, NCEI reports only the value of wind-related damages.

Table 4.55 – Recorded Hurricane and Tropical Storm Winds in Currituck and Dare Counties, 1999-2023

Date	Storm	Deaths/ Injuries	Property Damage	Crop Damage
8/30 – 9/1/1999	Hurricane Dennis	0/0	$12,010,000	$0
9/14 – 9/15/1999	Hurricane Floyd	0/0	$4,300,000	$4,300,000
10/16 – 10/17/1999	Hurricane Irene	0/0	$8,000	$0
9/10/2002	Tropical Storm Gustav	0/0	$57,000	$0
9/17 – 9/18/2003	Hurricane Isabel	0/0	$347,700,000	$0
8/3/2004	Hurricane Alex	0/0	$2,500,000	$0
8/14/2004	Tropical Storm Charley	0/0	$125,000	$50,000
9/13/2005	Hurricane Ophelia	0/0	$100,000	$0
8/31/2006	Tropical Storm Ernesto	0/0	$60,000	$0
9/5 – 9/6/2008	Tropical Storm Hanna	0/0	$30,000	$0
9/2 – 9/3/2010	Hurricane Earl	0/0	$172,000	$0
8/26 – 8/27/2011	Hurricane Irene	0/0	$16,000,000	$15,500,000
10/28/2012	Hurricane Sandy	0/0	$1,000,000	$0
6/6/2013	Tropical Storm Andrea	0/0	$0	$0
7/3 – 7/4/2014	Hurricane Arthur	0/0	$680,000	$0

Date	Storm	Deaths/ Injuries	Property Damage	Crop Damage
9/2/2016	Hurricane Hermine	0/0	$5,415,000	$0
10/8/2016	Hurricane Matthew	0/0	$0	$0
9/13/2018	Hurricane Florence	0/0	$0	$0
10/11/2018	Hurricane Michael	0/0	$0	$0
9/5 – 9/6/2019	Hurricane Dorian	0/0	$150,000	$0
8/4/2020	Hurricane Isaias	0/0	$500,000	$0
7/8/2021	Tropical Storm Elsa	0/0	$20,000	$0
9/30/2022	Hurricane Ian	0/0	$0	$0
8/31/2023	Hurricane Idalia	0/0	$0	$0
9/22/2023	Tropical Storm Ophelia	0/0	$0	$0
	Total	**0/0**	**$390,827,000**	**$19,850,000**

Source: NCEI

The HMPC felt that the damage estimates reported by NCEI were underreported and diminished the severity of the hazard, particularly in light of personal experiences with these particular storms. Additionally, the HMPC wanted to include nor'easters that have also caused significant damage to the Region. Because of this, Dare County provided damage reports compiled from community data following noteworthy storms. The data, summarized in Table 4.56, represents damages attributed to wind and water, which explains some variation from NCEI. Note that this data does not include impacts to Currituck County.

Table 4.56 – Dare County Storm Damage Reports

Date	Storm	Property Damage
9/17 – 9/18/2003	Hurricane Isabel	$3,320,000
9/13/2005	Hurricane Ophelia	$19,500
8/31/2006	Tropical Storm Ernesto	$44,500
11/22/2006	Thanksgiving Storm, 2006	$2,073,400
11/2/2007	Hurricane Noel	$72,500
10/18 – 10/19/2008	Oct 2008 Coastal Storm	$1,687,800
11/11 – 11/14/2009	November 2009 Nor'easter	$5,788,174
9/2 – 9/3/2010	Hurricane Earl	$536,600
8/26 – 8/27/2011	Hurricane Irene	$53,975,960
10/28/2012	Hurricane Sandy	$13,221,440
7/3 – 7/4/2014	Hurricane Arthur	$2,167,750
10/3 – 10/5/2015	October 2015 Coastal Storm	$591,000
9/2/2016	Hurricane Hermine	$5,517,030
10/8/2016	Hurricane Matthew	$42,602,709
9/13/2018	Hurricane Florence	$502,500
3/2 – 3/6/2018	March 2018 Coastal Storm	$4,318,265
10/11/2018	Hurricane Michael	$7,306,538
9/6/2019	Hurricane Dorian	$14,754,644
8/4/2020	Tropical Storm Isaias	$9,193
	Total	**$143,745,626**

Source: Dare County

The following event narratives come from both NCEI and Dare County Damage Reports.

August 30 – September 1, 1999 – Hurricane Dennis, a minimal Category II Hurricane approached the coast of North Carolina on August 30th. When the storm was 75 miles south of Cape Hatteras it was downgraded to a Category I Hurricane and then to a tropical storm when it was 105 miles west of Cape Hatteras. The beach erosion and storm tide effects of Hurricane Dennis were on the Outer Banks. The hurricane approached eastern North Carolina during one of the highest astronomical tides of the month. The dune structure on Hatteras Island was breeched in numerous locations. That included the loss of a 3000-thousand-foot-long section of Highway 12 just north of Buxton and a new inlet along the Core Banks. Dennis also swallowed six homes along the northern Outer Banks in Rodanthe. The town of Nags Head estimated their dune loss at $16.5 million.

Ocean storm surges were 3 to 4 feet above normal. Many reported this was the highest water levels they had ever seen. The most damaging winds were found along the Outer Banks. For almost a week after Tropical Storm Dennis made landfall, associated rain fell on our inland counties. This allowed most of the rivers to rise above flood stage which set the stage for the next hurricane, Hurricane Floyd and its associated record flooding. The greatest rainfall occurred over Carteret, southern Craven, Outer Banks Hyde, and Outer Banks Dare County. Doppler radar estimates were near 6 to 8 inches with isolated areas of 8 to 10.

September 14-15, 1999 – Hurricane Floyd caused massive record flooding across inland sections of eastern North Carolina. At one time Floyd was classified as a category 4 hurricane on the Saffir/Simpson scale and will likely be categorized as one of the nation's most costly hurricanes in the 20th century. By the evening of September 14th, the entire North Carolina coast was under a hurricane watch and at midnight up-graded to a hurricane warning. That same night the first outer rainbands began affecting eastern North Carolina and in turn, reports of flooding began filtering into the National Weather Service office in Morehead City/Newport (MHX). At least 40 official shelters were open across the county warning area. Hurricane Floyd made landfall on the morning of September 16th near North Topsail Beach as a category 2 hurricane. The eye moved northeast over Jacksonville, New Bern, Washington, Plymouth and continued over the eastern shores of Virginia. As the hurricane moved over the eastern coast of North Carolina, it accelerated and weakened. The peak offshore wind report was 96 mph at Duck Pier.

Severe weather and rainfall preceded landfall. By Wednesday night September 16th, 20 tornado warnings had been issued with over half being verified. Estimates were near 6 to 10 inches with isolated areas of 12 to 15 inches. Extreme flooding was experienced across most counties. Unbelievable numbers of homes were covered with water and over half a million customers throughout the county warning area were without power. Unofficially the flooding from Hurricane Floyd has been compared to a 500-year flood.

September 17-18, 2003 – Hurricane Isabel made landfall early in the afternoon on September 18th as a category two hurricane across Core Banks in extreme eastern Carteret county. Isabel moved north northwest near 20 mph across eastern North Carolina during the afternoon. Areas mainly near and east of the storm center experienced significant wind and storm surge effects. Major ocean overwash and beach erosion occurred along the North Carolina Outer Banks where waves up to 20 feet accompanied a 6 to 8-foot storm surge. Almost 350 million dollars in damage occurred in Dare county alone where several thousand homes and businesses, several piers, and sections of Highway 12 were damaged or washed away.

Wind damage was more significant across Hyde, Washington, Tyrell, Martin, and the Outer Banks counties where wind gusts of around 100 mph occurred. Hurricane force winds resulted in structural damage to homes. Numerous trees and power lines were downed across these areas resulting in a loss of electricity for several weeks in some locations. The highest sustained wind speed recorded was 73 mph at Duck. The highest gusts recorded were 97 mph at Elizabeth City, 92 mph at Duck, and 74 mph at Elizabeth City. Mandatory evacuations were ordered for parts of Currituck county, with approximately several thousand persons evacuated and housed in numerous shelters across coastal northeast North

Carolina. The unusually large wind field uprooted many thousands of trees, downed many power lines, damaged hundreds of houses, and snapped thousands of telephone poles and cross arms. Hundreds of roads, including major highways, were blocked by fallen trees. Local power companies reported many thousands of customers were without power. Duck water levels peaked at 7.8 feet MLLW before data was lost. Abd the lowest sea level pressure recorded was 984 mb at Duck. Isabel will be remembered for the greatest wind and storm surge in the region since Hazel in 1954, and the 1933 Chesapeake-Potomac Hurricane. Also, Isabel will be remembered for the extensive power outages in northeast North Carolina, and permanent change to the landscape from all the fallen trees and storm surge.

According to the Dare County preliminary damage report from September 19, 2003, Dare County suffered significant property damage and erosion from wave action during the storm. The hardest hit area was Hatteras Village, which was initially inaccessible by road due to a breech on NC 12. An aerial survey, and brief ground assessment indicated extensive damage to properties. Numerous homes and businesses were moved off of their foundations, or totally destroyed. Some residents reported four feet of ocean water in homes located well off of the oceanfront.

November 11-14, 2009 – The nor'easter that lingered over the Outer Banks in November 2009 resulted in coastal property damage, flooding of roadways and ground elevation structures, and extensive beach erosion. Most of the oceanfront damage from Duck south to Buxton was caused by wave action and loss of protective dunes. Flooding of roadways and ground elevation structures was due to a combination of heavy rains, and ocean overwash. Portions of NC 12 north of Rodanthe buckled due to loss of protective dunes over the extended days of punishing high tides. Hatteras village experienced soundside flooding but fortunately was spared property damage. Some scouring of dunes occurred in the Frisco area but also without property loss

Three residences in Kill Devil Hills and Nags Head were destroyed in this storm and an additional 312 structures, mostly residences, were damaged. Most of the damaged residences were single family rental properties, with generally minor damage to heat pumps, decks, stairs, and pools. The residences with major damage include those that remained in the tide and those that sustained major structural damage. Seventy one of the structures with both minor and major damage were uninhabitable. Two motels in Buxton sustained major damage and several other businesses and town properties reported minor damage.

August 26-27, 2011 – Hurricane Irene made landfall during the morning of the 27th, near Cape Lookout, as a large category 1 hurricane on the Saffir/Simpson Hurricane Wind Scale. Due to the large size of the hurricane, strong damaging winds, major storm surge, and flooding rains were experienced across much of eastern North Carolina. Several destructive tornados occurred during the evening of the 26th associated with the hurricane.

Across Eastern Dare County, maximum wind gusts from 63 to 88 mph were recorded resulting in numerous trees and power-lines down with extensive power outages and structural damage. The highest surge was 7 to 10 feet on the sound-side from Buxton to Rodanthe and the highest ocean-side surge of 9.5 feet was recorded at Hatteras Village. In Currituck, a 3 to 4-foot surge was observed on the eastern shore of the county adjacent to the Currituck Sound. Surge resulted in extensive damage, flooding of structures, and caused many dune breaches and damage to Highway 12. Mandatory evacuations were ordered for all visitors and residents on the 24th and 25th.

Much of Dare County suffered significant soundside flooding from storm surge, with some areas reporting up to five feet of water in structures. Many vehicles were also flooded. Minor oceanfront and oceanside damage was reported, but no area of the county was spared from damage.

September 2, 2016 – Hurricane Hermine made landfall in the Big Bend area of Florida during the early morning hours on September 2nd, and moved northeast along the Southeastern United States on the 2nd. Hermine weakened slightly to Tropical Storm strength and crossed through Eastern North Carolina during the late evening on September 2nd, and exited off the North Carolina coast near Duck during the morning of September 3rd.

Tropical Storm Hermine produced significant impacts across the Outer Banks. Strong north winds developed during the morning and early afternoon of September 3rd as Hermine moved northeast of the region. Winds of 60 to 70 mph were common over Hatteras Island with a peak gust of 84 mph recorded at the Duck Pier. These strong winds led to structural damage to several homes and businesses as well as sporadic power outages across North Carolina. These strong winds also pushed water from the Pamlico sound onshore leading to moderate to major sound-side storm surge of 2 to 4 feet above ground level. This storm surge flooded many homes and businesses with significant damage to some. The highest surge values of 3 to 4 feet were observed between Buxton and Hatteras Village. On the ocean side moderate beach erosion and ocean over wash was observed damaging roads and a few homes. Very heavy rain led to some flash flooding over the Hatteras Village area and an EF0 tornado also damaged a couple cabins in the Hatteras Village community. Overall damage was estimated at 5.4 million dollars over the Outer Banks with most of this caused by storm surge flooding.

October 8, 2016 – Hurricane Matthew affected all areas of Dare County, causing significant and wide spread flooding -mostly from heavy rains, wide spread damage due to high winds, and wide spread power outages. Many areas that are not normally flooded experienced flooding due to the amount of rain brought by the storm. Roughly 13% of improved properties countywide suffered some level of property damage as a result of this storm. The areas with the highest concentration of properties suffering major damage were Frisco and Hatteras Village, where a significant number of properties suffered major damage from severe soundside flooding and flooding from excessive rainfall. Water levels in some living areas in Hatteras village were reported at 5 feet and above and most commercial properties suffered major flood damage. Some marinas also suffered damage to their infrastructure.

Damage throughout the rest of the county was attributed to wind, which included missing shingles and siding, and water, both surge and excessive rainfall. In the Town of Manteo, areas that typically do not see flooding were flooded due to the amount of rain that fell. In Nags Head, commercial businesses on NC 12 from Bonnett Street to Eighth Street and in the Gallery Row area were hit particularly hard. Portions of NC 12 were covered with over three feet of water. Water dependent structures such as piers, docks, and bulkheads experienced heavy damage and in some cases were completely destroyed.

August 4, 2020 – Tropical Storm Isaias caused limited, minor storm-related property damage as a result of high winds and soundside flooding from storm surge. Sustained tropical storm force winds over a period of approximately 6 hours caused water levels to rise in the sounds throughout the county. Damage was reported in only three districts. The storm surge caused minor flooding in soundside areas of the county. Most of the flooding that occurred did not reach residential properties and was limited to the flooding of yards. There was one instance where water did reach the ground level interior of a residential property in Stumpy Point. High winds caused limited damage to docks, siding, and shingles.

As noted in several of these event narratives, in addition to wind impacts, the Outer Banks region has experienced storm surge and flooding from hurricane and tropical storm events.

COASTAL EROSION

As DCM's shoreline change data shows, erosion is occurring along the coast of the Outer Banks. Per an examination of event narratives in NCEI records for hurricanes, tropical storms, storm surges, and coastal floods, many events that have occurred in the Outer Banks region between 1999 and 2023 caused erosion. Table 4.57 below summarizes these events.

Table 4.57 – NCEI Events with Erosion Effects, 1999-2023, Outer Banks Region

Location	Event Name	Start Date	Event Type	Reported Property Damage
Eastern/Western Dare (Zone)	Hurricane Dennis	8/30/1999	Hurricane	$0
Eastern Dare (Zone)	Hurricane Floyd	9/14/1999	Hurricane	$0
Eastern Dare (Zone), Eastern Currituck (Zone)	Hurricane Isabel	9/17/2003	Hurricane	$347,000,000
Western Dare (Zone)	Tropical Storm Ernesto	8/31/2006	Tropical Storm	$10,000
Eastern Dare (Zone)	--	11/22/2006	Coastal Flood	$2,100,000
Eastern Dare (Zone)	--	5/7/2007	Coastal Flood	$30,000
Eastern Dare (Zone)	Tropical Storm Gabrielle	9/9/2007	Storm Surge	$0
Eastern Dare (Zone)	--	11/3/2007	Coastal Flood	$72,000
Eastern Dare (Zone), Eastern/ Western Currituck (Zone)	Tropical Storm Hanna	9/5/2008	Tropical Storm	$30,000
Eastern Currituck (Zone)	Unnamed Nor'easter	11/12/2009	Coastal Flood	$5,000,000
Eastern/Western Dare (Zone)	Hurricane Earl	9/2/2010	Tropical Storm, Storm Surge	$547,000
Eastern Dare (Zone)	Hurricane Sandy	10/28/2012	Tropical Storm, Storm Surge	$14,000,000
Eastern/Western Dare (Zone)	Tropical Storm Andrea	6/6/2013	Tropical Storm, Storm Surge	$0
Eastern Dare (Zone)	--	10/4/2015	Coastal Flood	$590,000
Eastern Currituck (Zone), Eastern Dare (Zone)	Tropical Storm Hermine	9/2/2016	Tropical Storm	$5,410,000
Eastern Dare (Zone)	Hurricane Matthew	10/8/2016	Hurricane	$0
Northern Outer Banks (Zone), Hatteras Island (Zone)	--	11/6/2021	Coastal Flood	$0

Source: NCEI

Note: Damages are reported for the entire event and are not necessarily erosion related.

Recorded incidents of erosion in the Outer Banks region include the following:

August 30-September 1, 1999 – For most counties, Hurricane Dennis left relatively little in its wake, however on the Outer Banks, erosion and the storm tide effects were extreme. Unfortunately, the hurricane approached eastern North Carolina during one of the highest astronomical tides of the month. The dune structure on Hatteras Island was breeched in numerous locations.

September 19, 2003 – Hurricane Isabel made landfall early in the afternoon on September 19th as a category two hurricane. Major ocean overwash and beach erosion occurred along the Outer Banks, where waves of up to 20 feet accompanied a 6 to 8-foot storm surge.

November 22, 2006 – Strong low pressure developed off the southeast United States coast on November 20th. This low then slowly lifted north to the North Carolina coast on Wednesday November 22nd. The storm system produced heavy rain of 4 to 8 inches, very strong winds of 40 to 60 mph, and significant coastal flooding across eastern North Carolina as it approached the region. Significant coastal flooding was reported across Dare County, mainly for areas north of Buxton. Water levels of 4 to 6 feet above normal reported with significant beach erosion and ocean overwash.

November 12, 2009 – An intense Nor'easter produced moderate to severe coastal flooding across much of the Currituck Outer Banks. The peak tide height at Duck was 7.20 feet above MLLW, which was 3.22 feet above the astronomical tide. Numerous streets, homes and businesses were flooded in low lying areas of the county close or directly exposed to the Atlantic Ocean, especially in the Corolla and Carova Beach areas. There was also severe beach erosion and loss of protective dunes.

October 8, 2016 – Hurricane Matthew moved northeast offshore of the North Carolina coast late on October 8th through October 9th. Strong winds of 40 to 60 mph inland and 60 to 80 mph along the coast occurred as Matthew passed offshore mainly during the evening of October 8th through the morning of the 9th. Storm surge inundation on the ocean side was generally 1 to 3 feet above ground producing significant beach erosion.

November 6, 2021 – A coastal storm formed off the Southeastern U.S. coast during the weekend of November 6-8th, and in tandem with 'King' tides, or high astronomical tides, produced water level rises of up to 2 to 4 feet above ground level for areas of Eastern NC, along with ocean overwash and severe erosion on the Outer Banks. In addition to the coastal flooding, high winds were recorded over 60 mph in some locations, and storm force winds over the coastal waters.

In addition to storm events reported in NCEI, news reports in recent years have highlighted the vulnerability of the Outer Banks to erosion. Per the National Park Service, seven homes in Rodanthe have collapsed in the past four years. Per reporting in March 2024 by The Washington Post, Rodanthe has some of the most rapid rates of erosion and relative sea level rise on the East Coast, and at least a dozen more houses are at risk of collapsing into the ocean. Debris from collapsed houses can be carried long distances along the coast and present hazards to people and other structures.

RIP CURRENT

Rip currents are listed in NCEI's storm events database only when they cause a drowning, near-drowning, result in one or more rescues, or cause damage to watercraft. Table 4.58 lists all rip current events recorded by NCEI for the Outer Banks Region during the 25-year period between 1999-2023. In total, 30 rip current events and associated deaths were reported.

Table 4.58 – NCEI Records of Rip Currents, 1999-2023, Outer Banks Region

Location	Date	Time	Deaths	Injuries	Reported Property Damage
Rodanthe	6/22/2002	1733	1	0	$0
(Hat)Cape Hatteras	9/4/2003	1700	1	0	$0
Nags Head	8/5/2004	1500	1	0	$0
Corolla	9/22/2004	0815	1	0	$0
Corolla	9/23/2004	1100	1	0	$0
Kill Devil Hills	5/27/2005	1400	1	0	$0
Nags Head	6/22/2005	1430	1	0	$0
Rodanthe	9/22/2006	1130	1	0	$0
Hatteras Village	7/1/2007	1130	1	0	$0
Hatteras Village	7/24/2009	1600	1	0	$0
Rodanthe	9/18/2009	1350	1	0	$0
Nags Head	6/20/2012	1300	1	0	$0
Buxton	7/25/2012	1745	1	0	$0
Frisco	6/26/2013	1500	1	0	$0
Eastern Dare (Zone)	6/4/2016	1200	0	0	$0
Frisco	7/22/2016	1420	1	0	$0

Location	Date	Time	Deaths	Injuries	Reported Property Damage
Rodanthe	9/9/2016	1338	2	0	$0
Salvo	10/2/2016	1006	1	0	$0
Avon	10/13/2016	1600	1	0	$0
Buxton	10/19/2016	1630	1	0	$0
Frisco	6/6/2017	1230	1	0	$0
Buxton	9/9/2017	1700	1	0	$0
Frisco	6/6/2018	0900	1	0	$0
Eastern Dare (Zone)	6/28/2018	1628	1	0	$0
Rodanthe	10/1/2018	1000	1	0	$0
Hatteras Island (Zone)	9/1/2019	1625	1	0	$0
Hatteras Island (Zone)	9/28/2019	1350	1	0	$0
Duck	9/30/2019	1522	1	0	$0
Nags Head	10/3/2019	1400	1	0	$0
Northern Outer Banks (Zone)	7/3/2020	0200	1	0	$0
		Total	**30**	**0**	**$0**

Source: NCEI

The following narratives detail selected events reported in the table above:

September 4, 2003 – Dare County Emergency Management reported a rip current drowning of a Maryland man near Cape Hatteras. Swells generated from Hurricane Fabian, which was 875 miles southeast of the Outer Banks, caused heavy surf and rip currents across the entire North Carolina coast.

May 27, 2005 – Two swimmers at the Ramada Plaza in Kill Devil Hills were pulled away from the shore by a strong rip current during the mid afternoon. One man drowned.

July 25, 2012 – Two people swimming near the Cape Hatteras Light House were pulled out to sea by a rip current. They were found face down in the surf and rescued. One woman died.

June 6, 2017 – A 17 year old male died from a rip current off Frisco. The victim was last seen going into the water on a boogie board urging others to come back toward shore but succumbed to the rip current himself. His body was recovered the next morning, on June 7th.

October 1, 2018 – The initial call came in around 10:00 a.m. of two swimmers in trouble in Rodanthe. The victim's friend started CPR, which was continued by local paramedics. Efforts to revive the Baldwinsville, New York man were unsuccessful, and the victim died in the surf zone due to a rip current.

The National Weather Service has also tracked surf zone fatalities since 2010, including deaths caused by rip current, high surf, sneaker waves, and other causes. Data is available by location starting in 2010. Fatalities reported in the Outer Banks Region between 2010-2024 are listed below.

Table 4.59 – Surf Zone Fatalities, 2010-2024

Year	Cause	Count	Locations
2024	Rip Current	1	Nags Head
2022	Unknown	1	Kill Devil Hills
2020	Unknown	1	Duck
2020	Rip Current	1	Kitty Hawk
2019	Rip Current	3	Duck, Cape Hatteras
2019	Unknown	1	Nags Head
2018	High Surf	4	Kitty Hawk Beach, Kill Devil Hills, Duck, Southern Shores

Year	Cause	Count	Locations
2018	Rip Current	3	Frisco Day, Avon, Rodanthe
2018	Unknown	1	Buxton
2017	Rip Current	3	Corolla, Hatteras Point (Buxton)
2016	Rip Current	7	Corolla, Rodanthe, Salvo, Buxton, Frisco
2015	Unknown	1	Duck
2012	Rip Current	2	Nags Head, Buxton

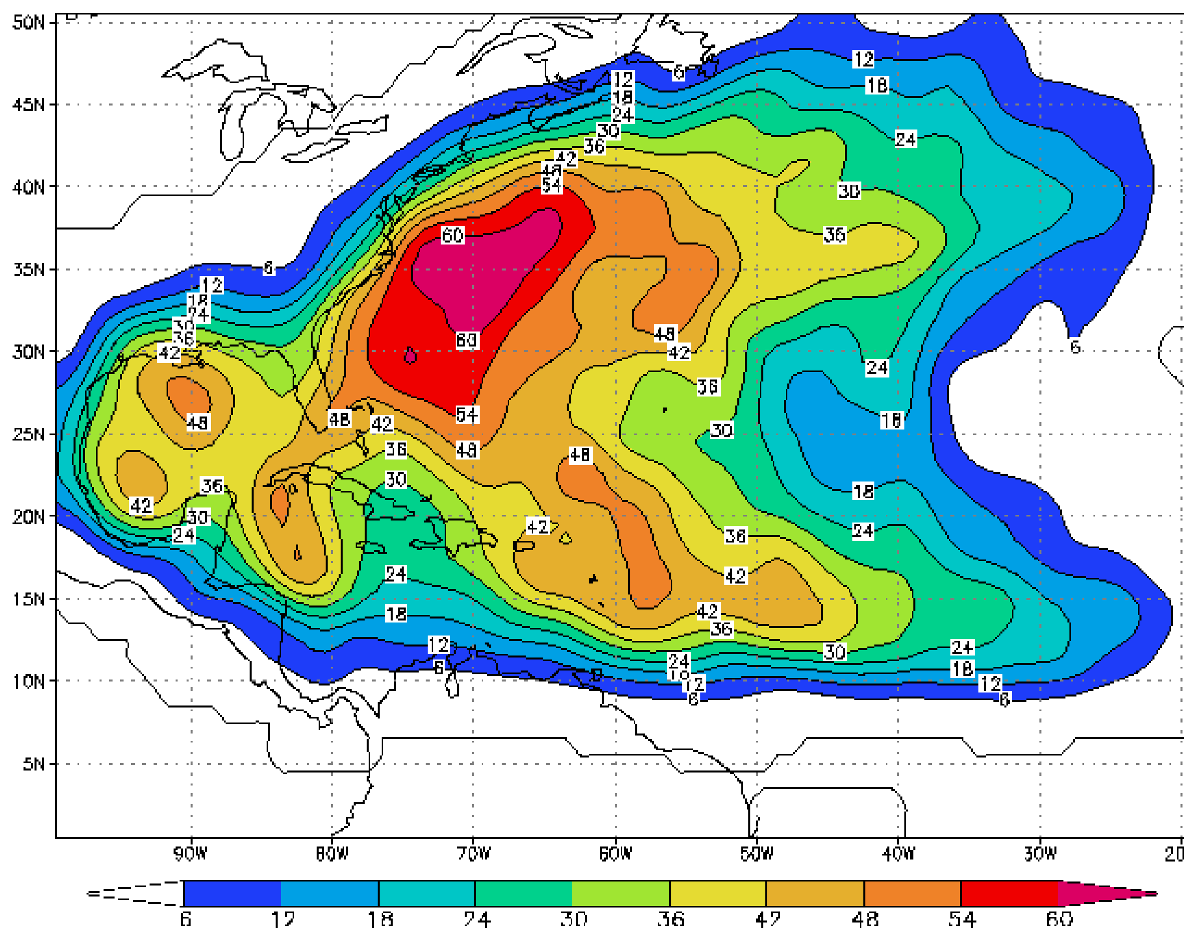
Source: National Weather Service

The Town of Nags Head started tracking statistics on drownings in 2014; since that time, 17 drowning deaths have occurred in Nags Head. While the specific cause of these deaths is not tracked, some are assumed to be attributed to rip currents.

PROBABILITY OF FUTURE OCCURRENCE

Figure 4.39 shows, for any particular 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 and shows the number of times a storm or hurricane was located within approximately 100 miles of a given spot in the Atlantic basin. Per this data, there has historically been approximately a 42-48% chance of a hurricane occurring near the Outer Banks Region in any given year.

Figure 4.39 – Empirical Probability of a Named Hurricane or Tropical Storm



Source: National Oceanic and Atmospheric Administration, Hurricane Research Division

On average, North Carolina experiences a hurricane approximately once every two years. Per historical records, in the 25-year period from 1999 through 2023, the Outer Banks Region was impacted by 25 separate hurricane and tropical storm events. Based on these historical data, it can be reasonably concluded that there is at least a 50 to 75 percent chance of a hurricane or tropical storm impacting the Region in any given year.

Hazards previously discussed, such as sea level rise, and coastal and estuarine erosion, can amplify impacts of hurricanes and related hazards, such as coastal and sound side storm surge.

Probability: 3 – Likely

Erosion and accretion are natural processes that are likely to continue to occur along both ocean and estuarine shorelines. 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, 17 events caused reported erosion in the region over the 25-year span between 1999-2023. This equates to a 68 percent annual chance of significant erosion. Additionally, drawing from the likelihood of hurricanes, tropical storms, and Nor'easters, erosion is likely to occur.

Probability: 3 – Likely

Rip currents are ongoing phenomena that are always occurring along ocean surf zones. Rip currents are guaranteed to continue occurring, however, of concern to the HMPC is the probability of rip currents resulting in death, injury, or property damages. NCEI and Town records indicate there have been at least 30 deaths due to rip currents over a 25-year period from 1999 through 2023. This equates over 100 percent annual probability of significant rip current impacts.

Probability: 4 – Highly Likely

CLIMATE CHANGE

North Carolina'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 in the near future.

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.

As a result of changes to the frequency and intensity of tropical storms and heavy rainfall events, erosion typically caused by these storms could be expected to occur more frequently. Coastal erosion is also expected to increase as a result of sea level rise.

Research on the impacts of climate change on rip currents are limited; however, the climate change factors that affect coastal erosion may also impact rip currents. Erosion and accretion result in changes to coastal bathymetry, which affects the location of rip currents. As large-scale erosion events occur more frequently, the location of rip currents may become more unpredictable.

VULNERABILITY ASSESSMENT

METHODOLOGIES AND ASSUMPTIONS

Property at risk to hurricanes was estimated using data from the NCEM IRISK database, which was compiled in NCEM's Risk Management Tool. The vulnerability data displayed below reflects loss estimates for wind-related damages. Hurricanes may also cause substantial damages from flooding related to heavy rains and storm surge, which is addressed in Section 4.5.4 Flood.

For more information on hurricane vulnerability, the South Atlantic Coastal Study from the U.S. Army Corps of Engineers (USACE) South Atlantic Division provides an assessment of coastal hazard risks and vulnerability. Back bay areas of Currituck County and areas along the Outer Banks and eastern peninsula in Dare County were identified as having high exposure, and Dare County has one of the highest projections of future risk in North Carolina, with economic damage projections nearly tripling between existing and future conditions. The SACS North Carolina Appendix report estimates future risk at nearly $125 million for Dare County and over $20 million for Currituck County.

PEOPLE

Children, elderly, individuals with disabilities, and others who may have difficulty evacuating 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.

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.

Rip currents pose a direct risk to human health and safety. Individuals who do not know how to recognize and avoid or escape rip currents are at risk of drowning. Since 1999, NCEI records 28 fatalities attributed to rip currents in the Region.

PROPERTY

General damages to property are both direct (what the winds associated with hurricanes physically destroy) and indirect, which focuses on additional costs, damages and losses attributed to secondary hazards spawned by the hurricane, or due to the damages caused by the storm. Depending on the size and strength of the hurricane, associated winds are capable of damaging and eventually destroying almost anything. Construction practices and building codes can help maximize structures' resistance to damage.

Secondary impacts of damage due to hurricane winds 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 impacts of a hurricane put tremendous strain on a community. In the immediate aftermath of a hurricane, the focus is on emergency services.

Table 4.60 through Table 4.64 detail buildings at risk and provide damage estimates across all jurisdictions for the 25-, 50-, 100-, 300-, and 700-year hurricane wind events. All scenarios impacted the same number of buildings but with varying severity of damage.

The damage estimates for the 100-year hurricane wind event totals $1,270,060,296, which equates to a loss ratio of 12.5 percent. The loss ratio is the damage estimate divided by the total potential exposure (i.e., total of improved and contents value for all buildings in the planning area), displayed as a percentage of value at risk. FEMA considers loss ratios greater than 10% to be significant and an indicator a community may have more difficulties recovering from an event.

Table 4.60 – Buildings at Risk from 25-Year Hurricane Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	14,980	84.7%	$24,126,742	1,449	8.2%	$5,472,658	179	1.0%	$425,659	16,608	93.9%	$30,025,059
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$38,424,921	644	4.6%	$2,175,194	152	1.1%	$807,710	13,247	94.5%	$41,407,825
Town of Duck	2,409	2,105	87.4%	$8,168,961	53	2.2%	$133,197	4	0.2%	$100,723	2,162	89.7%	$8,402,881
Town of Kill Devil Hills	6,033	5,380	89.2%	$5,983,774	309	5.1%	$2,767,233	18	0.3%	$82,608	5,707	94.6%	$8,833,615
Town of Kitty Hawk	2,862	2,501	87.4%	$4,262,277	179	6.3%	$804,446	11	0.4%	$17,983	2,691	94.0%	$5,084,707
Town of Manteo	943	764	81.0%	$8,879,098	124	13.1%	$816,719	29	3.1%	$145,431	917	97.2%	$9,841,248
Town of Nags Head	4,868	4,268	87.7%	$25,243,809	293	6.0%	$3,360,247	30	0.6%	$385,569	4,591	94.3%	$28,989,625
Town of Southern Shores	2,513	2,436	96.9%	$5,075,822	33	1.3%	$58,719	7	0.3%	$18,511	2,476	98.5%	$5,153,052
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$96,038,662**	**1,635**	**4.9%**	**$10,115,755**	**251**	**0.7%**	**$1,558,535**	**31,791**	**94.5%**	**$107,712,953**
Region Total	**51,332**	**44,885**	**87.4%**	**$120,165,404**	**3,084**	**6.0%**	**$15,588,413**	**430**	**0.8%**	**$1,984,194**	**48,399**	**94.3%**	**$137,738,012**

Source: NCEM Risk Management Tool

Table 4.61 – Buildings at Risk from 50-Year Hurricane Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	14,980	84.7%	$83,410,719	1,449	8.2%	$12,935,226	179	1.0%	$1,388,826	16,608	93.9%	$97,734,771
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$126,973,210	644	4.6%	$6,326,385	152	1.1%	$2,988,980	13,247	94.5%	$136,288,575
Town of Duck	2,409	2,105	87.4%	$28,665,690	53	2.2%	$408,190	4	0.2%	$246,813	2,162	89.7%	$29,320,693
Town of Kill Devil Hills	6,033	5,380	89.2%	$38,142,291	309	5.1%	$12,808,030	18	0.3%	$1,249,002	5,707	94.6%	$52,199,323
Town of Kitty Hawk	2,862	2,501	87.4%	$12,602,005	179	6.3%	$2,322,590	11	0.4%	$89,258	2,691	94.0%	$15,013,853
Town of Manteo	943	764	81.0%	$26,080,846	124	13.1%	$2,373,358	29	3.1%	$890,598	917	97.2%	$29,344,801
Town of Nags Head	4,868	4,268	87.7%	$100,729,126	293	6.0%	$9,752,559	30	0.6%	$1,673,623	4,591	94.3%	$112,155,307
Town of Southern Shores	2,513	2,436	96.9%	$15,720,752	33	1.3%	$191,748	7	0.3%	$63,707	2,476	98.5%	$15,976,208
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$348,913,920**	**1,635**	**4.9%**	**$34,182,860**	**251**	**0.7%**	**$7,201,981**	**31,791**	**94.5%**	**$390,298,760**
Region Total	**51,332**	**44,885**	**87.4%**	**$432,324,639**	**3,084**	**6.0%**	**$47,118,086**	**430**	**0.8%**	**$8,590,807**	**48,399**	**94.3%**	**$488,033,531**

Source: NCEM Risk Management Tool

Table 4.62 – Buildings at Risk from 100-Year Hurricane Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck County	17,685	14,980	84.7%	$244,543,000	1,449	8.2%	$27,737,666	179	1.0%	$3,742,511	16,608	93.9%	$276,023,177
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$324,260,588	644	4.6%	$15,512,965	152	1.1%	$8,346,279	13,247	94.5%	$348,119,832
Town of Duck	2,409	2,105	87.4%	$84,678,939	53	2.2%	$1,095,113	4	0.2%	$577,554	2,162	89.7%	$86,351,606
Town of Kill Devil Hills	6,033	5,380	89.2%	$115,328,828	309	5.1%	$27,436,454	18	0.3%	$3,753,387	5,707	94.6%	$146,518,669
Town of Kitty Hawk	2,862	2,501	87.4%	$36,496,835	179	6.3%	$6,325,484	11	0.4%	$356,819	2,691	94.0%	$43,179,138
Town of Manteo	943	764	81.0%	$58,902,065	124	13.1%	$5,733,864	29	3.1%	$2,953,744	917	97.2%	$67,589,673
Town of Nags Head	4,868	4,268	87.7%	$226,733,723	293	6.0%	$21,903,999	30	0.6%	$4,083,163	4,591	94.3%	$252,720,885
Town of Southern Shores	2,513	2,436	96.9%	$48,811,042	33	1.3%	$538,045	7	0.3%	$208,230	2,476	98.5%	$49,557,316
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$895,212,020**	**1,635**	**4.9%**	**$78,545,924**	**251**	**0.7%**	**$20,279,176**	**31,791**	**94.5%**	**$994,037,119**
Region Total	**51,332**	**44,885**	**87.4%**	**$1,139,755,020**	**3,084**	**6.0%**	**$106,283,590**	**430**	**0.8%**	**$24,021,687**	**48,399**	**94.3%**	**$1,270,060,296**

Source: NCEM Risk Management Tool

Table 4.63 – Buildings at Risk from 300-Year Hurricane Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	14,980	84.7%	$791,808,918	1,449	8.2%	$82,663,684	179	1.0%	$15,340,136	16,608	93.9%	$889,812,738

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$1,001,827,399	644	4.6%	$51,780,725	152	1.1%	$25,673,814	13,247	94.5%	$1,079,281,938
Town of Duck	2,409	2,105	87.4%	$343,595,786	53	2.2%	$5,289,417	4	0.2%	$2,827,816	2,162	89.7%	$351,713,019
Town of Kill Devil Hills	6,033	5,380	89.2%	$266,254,175	309	5.1%	$53,016,434	18	0.3%	$9,160,033	5,707	94.6%	$328,430,642
Town of Kitty Hawk	2,862	2,501	87.4%	$168,995,934	179	6.3%	$30,552,660	11	0.4%	$2,152,067	2,691	94.0%	$201,700,661
Town of Manteo	943	764	81.0%	$103,944,053	124	13.1%	$12,263,497	29	3.1%	$7,546,875	917	97.2%	$123,754,426
Town of Nags Head	4,868	4,268	87.7%	$415,761,393	293	6.0%	$41,947,287	30	0.6%	$8,415,759	4,591	94.3%	$466,124,439
Town of Southern Shores	2,513	2,436	96.9%	$246,181,529	33	1.3%	$3,374,636	7	0.3%	$1,620,540	2,476	98.5%	$251,176,705
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$2,546,560,269**	**1,635**	**4.9%**	**$198,224,656**	**251**	**0.7%**	**$57,396,904**	**31,791**	**94.5%**	**$2,802,181,830**
Region Total	**51,332**	**44,885**	**87.4%**	**$3,338,369,187**	**3,084**	**6.0%**	**$280,888,340**	**430**	**0.8%**	**$72,737,040**	**48,399**	**94.3%**	**$3,691,994,568**

Source: NCEM Risk Management Tool

Table 4.64 – Buildings at Risk from 700-Year Hurricane Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	14,980	84.7%	$1,222,437,283	1,449	8.2%	$140,776,361	179	1.0%	$28,259,247	16,608	93.9%	$1,391,472,891
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$1,328,472,789	644	4.6%	$75,657,812	152	1.1%	$39,750,650	13,247	94.5%	$1,443,881,251
Town of Duck	2,409	2,105	87.4%	$484,691,776	53	2.2%	$8,674,606	4	0.2%	$4,433,713	2,162	89.7%	$497,800,096
Town of Kill Devil Hills	6,033	5,380	89.2%	$414,250,034	309	5.1%	$82,053,054	18	0.3%	$16,232,324	5,707	94.6%	$512,535,411
Town of Kitty Hawk	2,862	2,501	87.4%	$261,402,873	179	6.3%	$50,096,193	11	0.4%	$3,572,443	2,691	94.0%	$315,071,509
Town of Manteo	943	764	81.0%	$143,774,461	124	13.1%	$20,915,288	29	3.1%	$13,656,593	917	97.2%	$178,346,343
Town of Nags Head	4,868	4,268	87.7%	$605,997,629	293	6.0%	$64,700,017	30	0.6%	$13,691,971	4,591	94.3%	$684,389,616
Town of Southern Shores	2,513	2,436	96.9%	$383,344,077	33	1.3%	$6,178,715	7	0.3%	$3,278,484	2,476	98.5%	$392,801,277
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$3,621,933,639**	**1,635**	**4.9%**	**$308,275,685**	**251**	**0.7%**	**$94,616,178**	**31,791**	**94.5%**	**$4,024,825,503**
Region Total	**51,332**	**44,885**	**87.4%**	**$4,844,370,922**	**3,084**	**6.0%**	**$449,052,046**	**430**	**0.8%**	**$122,875,425**	**48,399**	**94.3%**	**$5,416,298,394**

Source: NCEM Risk Management Tool

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. Buildings collapsing into the ocean as a result of erosion and other coastal forces cause not only property damages associated with the loss of the building, but also clean up costs and potential damages to other structures. An interagency work group co-led by the North Carolina Department of Environmental Quality and the National Park Service's Cape Hatteras National Seashore has developed ideas to address the vulnerability of oceanfront structures along eroding beaches. Ideas from the interagency work group are discussed in the Capability Assessment in Section 5.

Erosion impacts on infrastructure are also a major concern in the Outer Banks Region, particularly along N.C. 12 through Dare County. Efforts by the N.C. 12 Task Force to develop short- and long-term solutions for hot spot areas are discussed in the Capability Assessment in Section 5.

Rip current is unlikely to result in any property damages, though it may result in indirect damages to watercrafts by pushing them into jetties or sandbars.

ENVIRONMENT

Hurricane winds can cause massive damage to the natural environment, uprooting trees and other debris within the storm's path. Animals can either be killed directly by the storm or impacted indirectly through changes in habitat and food availability caused by high winds, storm surge and intense rainfall. Endangered species can be dramatically impacted. Forests can be completely defoliated by strong winds.

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 4.65 summarizes the potential consequences of hurricane winds and coastal hazards.

Table 4.65 – Consequence Analysis - Hurricane and Coastal Hazards

Category	Consequences
Public	Impacts from hurricane winds include injury or death, loss of property, outbreak of diseases, mental trauma and loss of livelihoods. 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. Erosion is unlikely to impact public health and safety. Rip currents may cause injuries or fatalities.
Responders	Impacts to responders and response capabilities may occur during severe storms. If properly trained, responders are unlikely to be impacted by rip currents. Erosion is unlikely to require immediate response or rescue operations.
Continuity of Operations (including Continued Delivery of Services)	Damage to facilities/personnel from 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. Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries. Erosion and rip tides would not impact public continuity of operations.

Category	Consequences
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. Erosion can result in property damage if it is severe enough or if scour occurs that undermines the integrity of structural foundations. Rip current is unlikely to damage property.
Environment	Hurricanes can devastate wooded ecosystems and remove the foliage from tree canopies, and they can drastically change habitats such that the indigenous animal populations suffer. 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 damage an above-ground fuel tank, resulting in a chemical spill. Erosion can increase sediment loads in waterbodies and change riverine and coastal topography. Rip current will not have severe environmental consequences.
Economic Condition of the Jurisdiction	Local economy and finances may be adversely affected, possibly for an extended period of time, depending on damages. Intangible impacts, including business interruption and additional living expenses, may also occur. Rip current and severe erosion can negatively impact tourist economies. Beach nourishment projects to counter erosion are extremely costly.
Public Confidence in the Jurisdiction's Governance	Public confidence may be affected by a major storm event requiring substantial response and long-term recovery effort. Erosion and rip current are unlikely to affect public confidence.

HAZARD SUMMARY BY JURISDICTION

The following tables summarizes hurricane and coastal hazard risk by jurisdiction.

HURRICANES AND NOR'EASTERS

Due to its coastal geography, the entire Outer Banks region is uniformly likely to experience winds from hurricanes and nor'easters. Certain areas may be particularly vulnerable to winds. For example, Currituck County and unincorporated areas of Dare County have higher proportion of mobile homes, which are more susceptible to damages from wind. However, coastal storms have the potential to be catastrophic across all jurisdictions. Other components of risk are uniform across the planning area.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Currituck County	3	4	4	1	3	3.3	H
Dare County	3	4	4	1	3	3.3	H
Duck	3	4	4	1	3	3.3	H
Kill Devil Hills	3	4	4	1	3	3.3	H
Kitty Hawk	3	4	4	1	3	3.3	H
Manteo	3	4	4	1	3	3.3	H
Nags Head	3	4	4	1	3	3.3	H
Southern Shores	3	4	4	1	3	3.3	H

COASTAL EROSION

Risk to coastal erosion is uniform across most of the region. Jurisdictions with more frequented beaches could currently be experiencing a slower rate of erosion due to mitigation efforts. Still, severe erosion that causes building damages can occur in any jurisdiction with oceanfront property. Less is known about estuarine erosion rates and impacts.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Currituck County	3	3	3	2	3	2.9	M
Dare County	3	3	3	2	3	2.9	M
Duck	3	3	3	2	3	2.9	M
Kill Devil Hills	3	3	3	2	3	2.9	M
Kitty Hawk	3	3	3	2	3	2.9	M
Manteo	3	2	3	2	3	2.6	M
Nags Head	3	3	3	2	3	2.9	M
Southern Shores	3	3	3	2	3	2.9	M

RIP CURRENT

Rip current risk is largely uniform across the region, except for Manteo, which does not have any oceanfront and therefore has no rip current risk. Due to the geography and tourist-based economy of the region, all other jurisdictions have similar risk. Jurisdictions with more frequented beaches may have more population at risk. However, other components of risk are uniform for all areas.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Currituck County	4	3	3	4	2	3.3	H
Dare County	4	3	3	4	2	3.3	H
Duck	4	3	3	4	2	3.3	H
Kill Devil Hills	4	3	3	4	2	3.3	H
Kitty Hawk	4	3	3	4	2	3.3	H
Manteo	0	0	0	0	0	0.0	N/A
Nags Head	4	3	3	4	2	3.3	H
Southern Shores	4	3	3	4	2	3.3	H

4.5.6 TORNADOES & THUNDERSTORMS

HAZARD BACKGROUND

TORNADOES

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." Tornados can appear from any direction. Most move from southwest to northeast, or west to east. Some tornados have changed direction or even backtracked.

Tornados are commonly produced by land falling tropical cyclones. Those making landfall along the Gulf coast traditionally produce more tornados than those making landfall along the Atlantic coast. Tornados 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 tornados. Tornados are more likely to be spawned within 24 hours of landfall and are usually within 30 miles of the tropical cyclone’s center.

Tornados 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. Tornados 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. Figure 4.40 provides a description and breakdown of tornadoes by severity. Violent tornadoes, as described below, are unlikely in the Outer Banks region.

Figure 4.40 – Tornadoes by Severity

Weak Tornadoes

- 88% of all tornadoes
- Less than 5% of tornado deaths
- Lifetime 1 – 10+ minutes
- Winds less than 110 mph
- Produces EF0 or EF1 damage

Strong Tornadoes

- 11% of all tornadoes
- Nearly 30% of all tornado deaths
- May last 20 minutes or longer
- Winds 111-165 mph
- Produces EF2 or EF3 damage

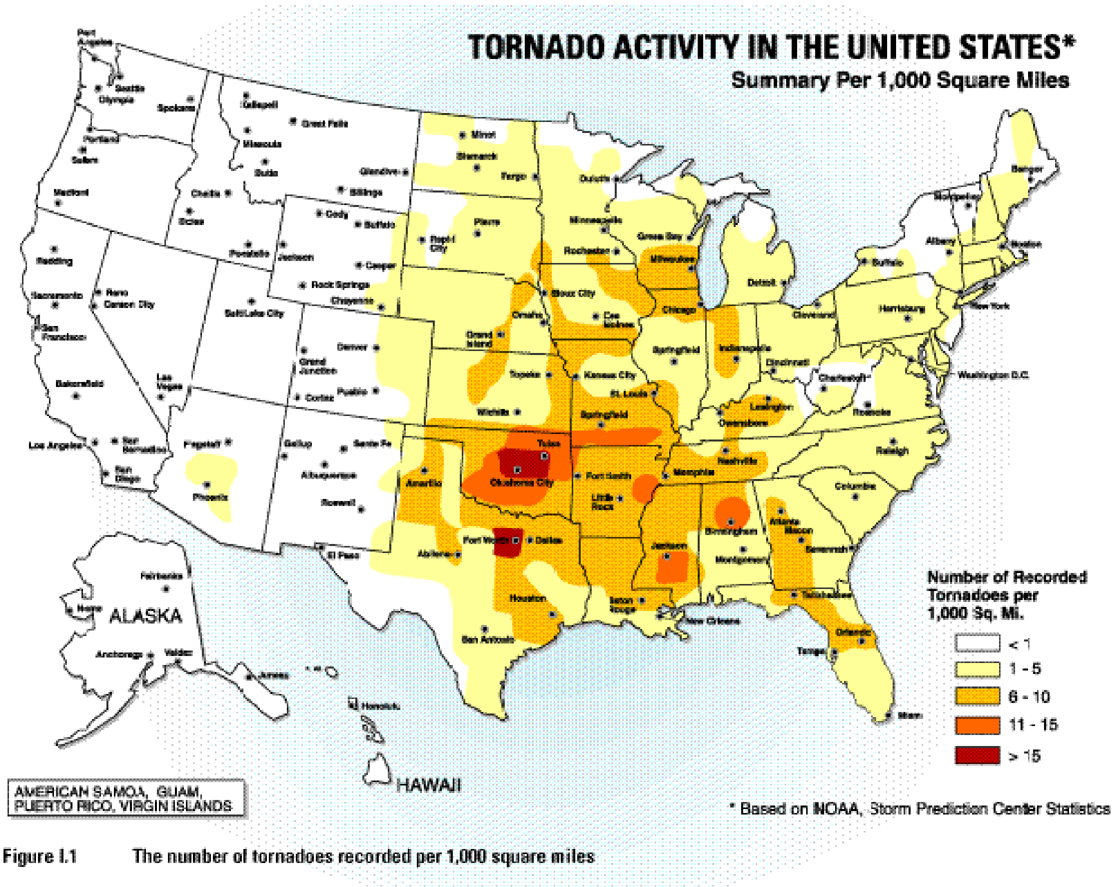
Violent Tornadoes

- Less than 1% of all tornadoes
- 70% of all tornado deaths
- Can exceed 1 hour
- Winds greater than 166 mph
- Produces EF4 or EF5 damage

Source: NOAA National Weather Service

Figure 4.41 shows tornado activity in the United States based on the number of recorded tornados per 1,000 square miles. North Carolina has averaged 1 to 5 tornados per 1,000 square miles.

Figure 4.41 – Tornado Activity in the U.S.



Source: American Society of Civil Engineers

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. Supercell thunderstorms are most frequently associated with severe weather phenomena, but thunderstorms most frequently organize into clusters or lines. Warm, humid conditions are favorable for the development of thunderstorms.

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; flood risk is discussed in Section 4.5.4. Stronger thunderstorms can produce tornados and waterspouts.

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.

HAIL

According to the 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 come into contact with super-cooled water which will freeze on contact with the frozen rain droplet. This frozen rain droplet can continue to grow and form hail. As long as 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 down 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 North Carolina 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.

While conditions for thunderstorms, lightning, hail, and tornadoes may be anticipated within a few hours, the severity of conditions is difficult to predict. The onset of thunderstorms with hail is generally rapid. The watch or warning time for a given storm is usually a few hours. There is no warning time for any given lightning strike. Regardless of severity, storms generally pass within a few hours.

Warning Time: 4 – Less than six hours

Duration: 1 – Less than six hours

LOCATION

TORNADOES

Tornados and thunderstorms can occur anywhere in the region. Tornados 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. Tornados can be spawned by tropical cyclones; however, these tornados typically occur up to 2 days before and as many as 3 days after landfall of the tropical cyclone.

Spatial Extent: 2 – Small

THUNDERSTORM WINDS

Thunderstorm winds, lightning, and hail events do not have a defined vulnerability zone. The average single cell thunderstorm is approximately 15 miles in diameter and lasts less than 30 minutes at a single location. However, thunderstorms can travel intact for distances exceeding 600 miles, especially when organized into clusters or lines. Any given thunderstorm event may be expected to impact a large portion of the Outer Banks region.

Spatial Extent: 3 – Moderate

LIGHTNING AND HAIL

The scope of lightning and hail is generally defined to the footprint of its associated thunderstorm. However, large-scale hail tends to occur in a more localized area within the storm, and lightning strikes and associated damages are highly localized. 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. The entire Outer Banks region is uniformly exposed to each of these hazards.

Spatial Extent: 1 – Negligible

EXTENT

TORNADOES

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 EF scale provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis with 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 4.5 shows the wind speeds associated with the Enhanced Fujita scale ratings and the damage that could result at different levels of intensity.

Table 4.66 – 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 completely 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.

EF Number	3 Second Gust (mph)	Damage
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 through the air in excess of 100 m; high-rise buildings have significant structural deformation; incredible phenomena will occur.

The most intense tornado to pass through the Outer Banks Region was an F3 in September 1952. However, the most damaging tornados on record for the region were an F2 in July 1978, which caused a fatality, four injuries, and an estimated $250,000 in damages, and an F2 in March 1987, which caused seven injuries and an estimated $2.5 million in damages. Most tornadoes that occur in the region are EF1 or lesser magnitude, causing limited damages.

Impact: 3 – Critical

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. Tornado is discussed above, and Hurricane Wind is addressed as a separate hazard. 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 region occurred on March 8, 2005 in Dare County with an estimated gust of 109 mph. The event caused $200,000 in recorded property damage.

Impact: 2 – Limited

LIGHTNING

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

Table 4.67 – 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

Lightning Activity Level Scale	
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 small area, very few injuries or fatalities, and minimal disruption to quality of life.

Impact: 1 – Minor

HAIL

The NWS classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 4.68 indicates the hailstone measurements utilized by the NWS.

Table 4.68 – 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 4.69 describes typical intensity and damage impacts of the various sizes of hail.

Table 4.69 – 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

Intensity Category	Diameter (mm)	Diameter (inches)	Size Description	Typical Damage Impacts
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 1999 and 2023 in the Outer Banks Region was a little under 1" in diameter; the largest hailstones recorded were 1.75", recorded on six separated occasions, none of which caused any damage, injuries, or fatalities.

Impact: 1 – Minor

HISTORICAL OCCURRENCES

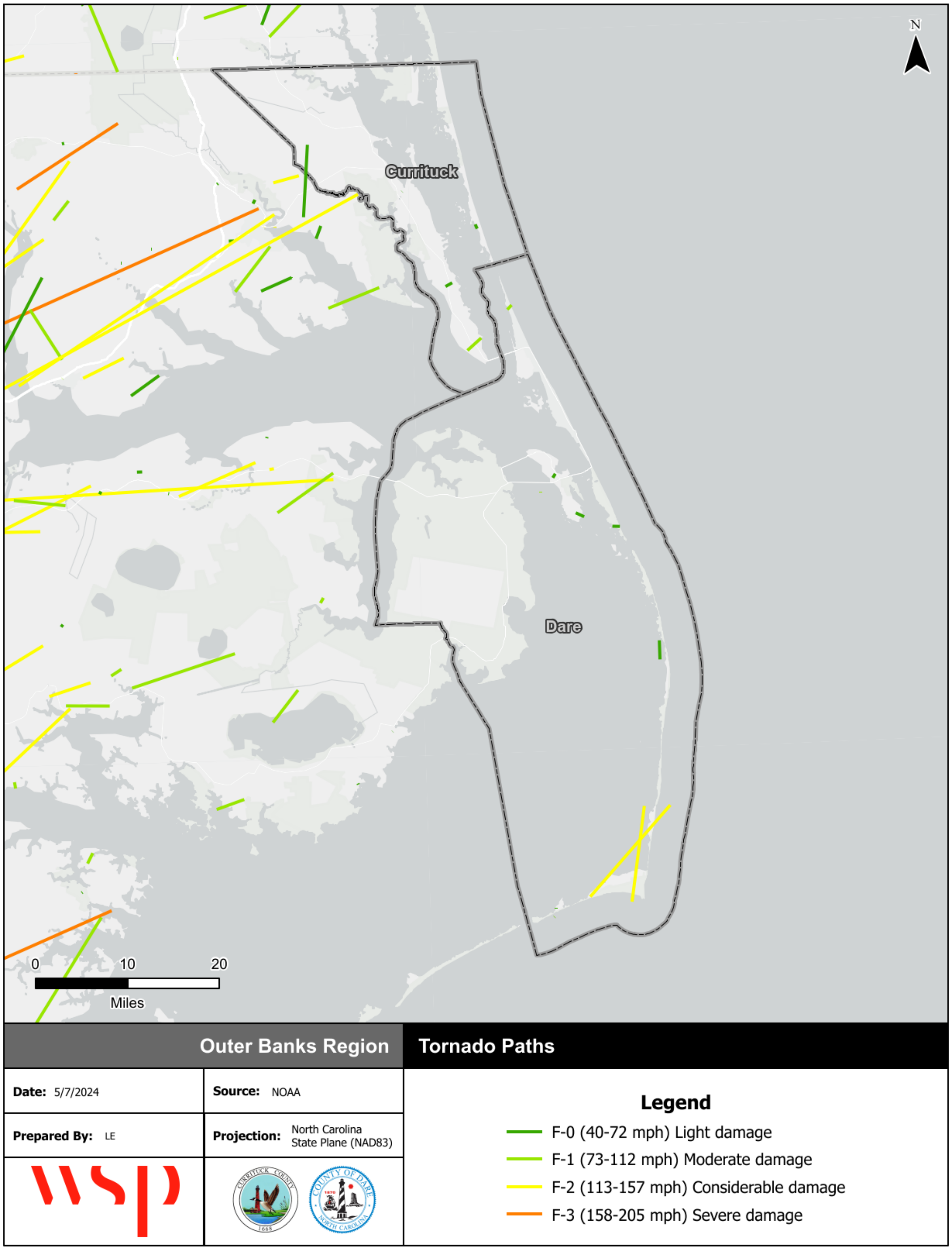
TORNADOES

Figure 4.42 reflects the tracks of past tornadoes that passed through the Outer Banks Region from 1950 through 2023 according to data from the NOAA/NWS Storm Prediction Center. There were 50 tornadoes that tracked through the region during this time. These tornadoes caused 24 injuries and 1 fatality. Table 4.70 summarizes these past tornadoes by magnitude.

Table 4.70 – Past Tornadoes in the Outer Banks Region, 1950-2023

Magnitude	Count	Related Injuries and Fatalities
F0/EF0	31	7
F1/EF1	14	3
F2/EF2	4	14
F3/EF3	1	0
Total	**50**	**24**

Figure 4.42 – Tornado Paths Through the Outer Banks Region, 1950-2023



NCEI storm reports were reviewed from 1996 through 2023 to assess whether recent trends vary from the longer historical record. No variation was found. According to NCEI, the Outer Banks region experienced 20 tornado incidents between 1996 and 2023, causing 6 injuries and $1,397,000 in property damage. Table 4.71 details past tornados in the Outer Banks region during this period.

Table 4.71 – Recorded Tornados in the Outer Banks Region, 1996-2023

Location	Date	Time	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
Buxton	1/19/1996	1316	F0	0	0	$30,000	$0
Nags Head	9/17/1996	0255	F0	0	1	$0	$0
Frisco	10/8/1996	0720	F0	0	0	$10,000	$0
Corolla	7/24/2000	1257	F0	0	0	$0	$0
Rodanthe	5/28/2001	1233	F0	0	0	$5,000	$0
Avon	8/26/2002	0805	F0	0	0	$10,000	$0
Moyock	6/7/2003	1955	F0	0	2	$25,000	$0
Nags Head	8/14/2004	1715	F1	0	0	$225,000	$0
Frisco	6/14/2006	1340	F0	0	0	$0	$0
Rodanthe	7/15/2007	0706	EF0	0	0	$0	$0
Harbinger	4/16/2011	2030	EF1	0	0	$40,000	$0
Duck	4/16/2011	2035	EF1	0	0	$767,000	$0
Wanchese	7/30/2012	0940	EF0	0	0	$0	$0
Wanchese	7/30/2012	1001	EF0	0	0	$0	$0
Rodanthe	8/19/2012	1319	EF0	0	0	$0	$0
Jarvisburg	4/25/2014	1928	EF0	0	0	$15,000	$0
Manteo	5/11/2015	1610	EF0	0	0	$5,000	$0
Cape Hatteras	9/3/2016	0002	EF0	0	3	$250,000	$0
Gregory	5/5/2017	0708	EF0	0	0	$5,000	$0
Poplar Branch	8/1/2021	1114	EF0	0	0	$10,000	$0
Total				**0**	**6**	**$1,397,000**	**$0**

Source: NCEI

Specific incidents with some noted impact are summarized below according to records in NCEI:

June 7, 2003 – An F0 tornado downed numerous trees and stripped some siding off houses. Any structural damage was from falling trees and debris. Two injuries occurred when a large tree fell on a house and collapsed the roof of the one-story building.

August 14, 2004 – Tropical Storm Charley moved northeast across the Coastal Plains of Eastern North Carolina during the afternoon hours on August 14th. Five weak tornados were reported across the area associated with Charley with damage reported. The most significant damage related to a tornado occurred along the Outer Banks in Nags Head, where an F1 tornado damaged 20 structures and caused $225,000 in damages.

April 16, 2011 – One of the largest tornado outbreaks ever observed across eastern North Carolina occurred during the afternoon and evening. Several powerful super-cell thunderstorms developed ahead of an approaching cold front. Conditions ahead of the front were favorable for tornados with a moderately unstable atmosphere combined with strong winds that veered with height. In Duck, the tornado developed near the sound in the Four Seasons subdivision, then moved northeast across the community of Duck before exiting into the ocean. The tornado was estimated to be an EF1 with winds around 90 mph. About 75 structures were damaged mostly minor to roofs and siding. Several large pines were toppled and damaged homes.

September 3, 2016 – Hurricane Hermine weakened slightly to Tropical Storm strength and crossed through Eastern North Carolina during the late evening on September 2nd and exited off the North Carolina coast near Duck during the morning of September 3rd. Rain-bands associated with Hermine produced three tornados. In Cape Hatteras, a weak tornado briefly touched down at the Hatteras Sands RV resort near Hatteras Village in Dare County, North Carolina, The EF0 tornado had winds estimated at 80 mph, a path width of 25 yards and path length of 100 yards. The tornado damaged or destroyed approximately 5 travel trailers and camping cabins, some which were not attached to the ground. Three injuries were reported from this tornado.

August 1, 2021 – A tornado touched down along the intersection of the Currituck Sound adjacent to the Currituck Club golf course. The tornado tracked south southeast along the 7th and 8th holes of the golf course and uprooted large trees and snapped numerous limbs. The tornado lifted shortly before crossing the intersection of Hunt Club Drive and Trumpeter Swan Court, but not before knocking down several large trees and ripping some shingles off of a house on Trumpeter Swan Court.

THUNDERSTORM WINDS

Between January 1, 1996 and December 31, 2023, the NCEI recorded 238 separate incidents of high winds, strong winds, and thunderstorm winds, occurring on 144 separate days. Of these events, 85 caused property damage. Wind gusts with property damage recorded averaged $16,565 in damage. These events caused $1,408,000 in recorded property damage, 9 injuries and no fatalities or crop damage. The recorded gusts averaged 61.48 mph, with the highest gusts recorded at 109 mph. Gusts of this speed were recorded only once in the Region, during a storm on March 8, 2005. Only two of these wind events caused injuries. One occurred in July 1997 in when thunderstorm wind blew off a section of roof from waterfront shops causing one minor injury. The second occurred during a storm in April 1999 when a circus tent was blown over, injuring eight circus workers.

Incidents with recorded damages are detailed in Table 4.72.

Table 4.72 – Recorded Wind Events with Property Damages in the Outer Banks, 1996-2023

Location	Date	Time	Wind Speed (mph)	Deaths/ Injuries	Property Damage
Coinjock	5/11/1996	1900	-	0/0	$10,000
Maple	5/3/1997	1115	-	0/0	$2,000
Maple	7/18/1997	1540	-	0/0	$1,000
Western Currituck (Zone)	7/24/1997	1400	-	0/0	$3,000
Duck	7/24/1997	1420	58	0/1	$50,000
Rodanthe	8/18/1997	1545	-	0/0	$10,000
Moyock	6/3/1998	2045	-	0/0	$5,000
Manteo Airport	4/11/1999	1415	104	0/8	$230,000
Currituck	7/24/1999	1620	-	0/0	$2,000
Rodanthe	5/27/2000	2330	-	0/0	$100,000
Eastern Currituck (Zone)	5/29/2000	900	69	0/0	$20,000
Eastern Dare (Zone)	3/13/2001	330	63	0/0	$10,000
Moyock	5/13/2002	2100	-	0/0	$2,000

Location	Date	Time	Wind Speed (mph)	Deaths/ Injuries	Property Damage
Grandy	6/14/2002	1627	-	0/0	$2,000
Corolla	8/24/2002	1623	-	0/0	$2,000
Eastern Currituck (Zone)	4/10/2003	400	46	0/0	$5,000
Western Currituck (Zone)	4/10/2003	400	46	0/0	$5,000
Moyock	8/17/2003	1540	58	0/0	$2,000
Currituck	8/17/2003	1610	58	0/0	$1,000
Moyock	8/18/2003	1415	58	0/0	$2,000
Jarvisburg	6/25/2004	1543	58	0/0	$2,000
Poplar Branch	10/15/2004	1045	60	0/0	$5,000
Countywide	3/8/2005	1226	109	0/0	$200,000
Point Harbor	3/8/2005	1235	58	0/0	$2,000
Coinjock	7/28/2006	2007	58	0/0	$2,000
Moyock	8/4/2006	1740	58	0/0	$2,000
Aydlett	8/8/2006	1330	58	0/0	$2,000
Eastern Currituck (Zone)	11/3/2007	430	54	0/0	$1,000
Currituck Co Airport	5/11/2008	1853	58	0/0	$3,000
Grandy	5/11/2008	1905	58	0/0	$2,000
Snowden	1/7/2009	1105	58	0/0	$2,000
Snowden	9/28/2009	1955	58	0/0	$2,000
Knotts Is	9/28/2009	2010	58	0/0	$2,000
Aydlett	7/20/2010	1640	58	0/0	$2,000
Grandy	7/20/2010	1645	58	0/0	$2,000
Knotts Is	4/28/2011	1636	58	0/0	$2,000
Aydlett	6/25/2012	1800	58	0/0	$2,000
Currituck	6/29/2012	2340	58	0/0	$2,000
Snowden	6/30/2012	2230	58	0/0	$2,000
Snowden	7/1/2012	10	58	0/0	$2,000
Snowden	8/15/2012	1600	58	0/0	$3,000
Waterlily	4/25/2014	1937	58	0/0	$2,000
Snowden	6/19/2014	1745	58	0/0	$10,000
Buffalo City	2/16/2016	1006	77	0/0	$10,000
Eastern Currituck (Zone)	10/8/2016	1800	70	0/0	$250,000
Western Currituck (Zone)	10/8/2016	1800	62	0/0	$250,000
Snowden	5/5/2017	715	58	0/0	$2,000
Jarvisburg	5/22/2017	1530	58	0/0	$2,000
Snowden	5/27/2017	2110	58	0/0	$5,000
Eastern Currituck (Zone)	3/2/2018	400	58	0/0	$25,000
Western Currituck (Zone)	3/2/2018	400	58	0/0	$25,000
Mayock	6/23/2018	1827	58	0/0	$2,000
Eastern Currituck (Zone)	10/11/2018	1830	63	0/0	$10,000
Western Currituck (Zone)	10/11/2018	1830	58	0/0	$5,000
Currituck	4/15/2019	402	58	0/0	$2,000
Mayock	4/19/2019	2015	58	0/0	$5,000

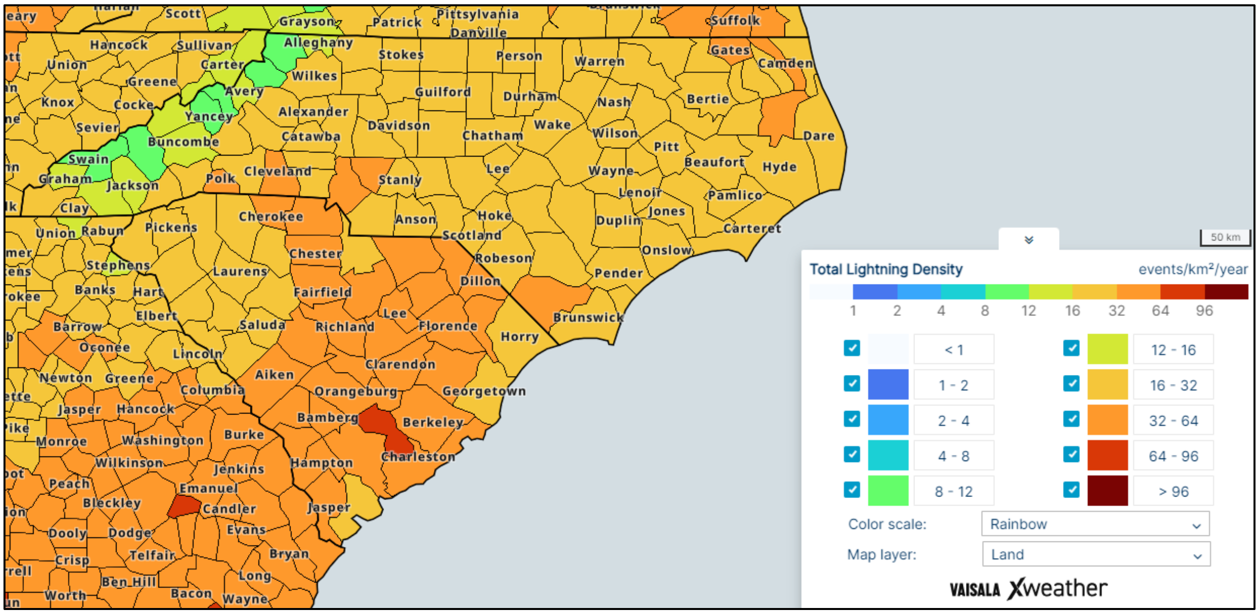
Location	Date	Time	Wind Speed (mph)	Deaths/ Injuries	Property Damage
Poplar Branch	5/31/2019	1230	58	0/0	$1,000
Shawboro	6/20/2019	1639	58	0/0	$2,000
Knotts Is	6/20/2019	1658	58	0/0	$3,000
Jarvisburg	6/20/2019	1700	58	0/0	$2,000
Mayock	7/23/2019	1238	58	0/0	$1,000
Tulls	7/23/2019	1345	58	0/0	$2,000
Snowden	8/9/2019	1710	58	0/0	$2,000
Mayock	8/15/2019	1630	58	0/0	$1,000
Mayock	8/20/2019	1800	58	0/0	$3,000
Mayock	11/1/2019	11	58	0/0	$3,000
Western Currituck (Zone)	4/13/2020	1016	58	0/0	$2,000
Western Currituck (Zone)	4/13/2020	1030	64	0/0	$1,000
Snowden	4/18/2020	1010	58	0/0	$10,000
Point Harbor	4/30/2020	1440	58	0/0	$5,000
Waterlily	6/22/2020	1640	58	0/0	$1,000
Jarvisburg	3/28/2021	1645	58	0/0	$2,000
Snowden	4/9/2021	1814	58	0/0	$1,000
Mayock	5/4/2021	1845	58	0/0	$2,000
Grandy	5/4/2021	1920	58	0/0	$2,000
Tulls	8/1/2021	1000	58	0/0	$2,000
Waterlily	8/1/2021	1055	58	0/0	$1,000
Corolla	8/1/2021	1119	58	0/0	$2,000
Powells PT	8/1/2021	1207	58	0/0	$2,000
Grandy	8/4/2021	620	64	0/0	$20,000
Mamie	5/4/2022	1755	58	0/0	$1,000
Maple	4/30/2023	1630	58	0/0	$3,000
Knotts Is	4/30/2023	1650	59	0/0	$1,000
Tulls	7/3/2023	1445	58	0/0	$2,000
Poplar Branch	7/19/2023	1614	58	0/0	$15,000
Total				**0/9**	**$1,408,000**

Source: NCEI

LIGHTNING

According to the Vaisala Interactive Global Lightning Density Map, shown in Figure 4.43, the Outer Banks Region is located in an area that experiences 16 to 32 lightning flashes per square kilometer per year. Future lightning occurrences may exceed these figures.

Figure 4.43 - Total Lightning Density (2016-2023)



Source: Vaisala Interactive Global Lightning Density Map

NCEI maintains records of lightning strikes that cause injuries, deaths, or property damage. NCEI records 15 lightning strikes reported between 1996 and 2023 in the Outer Banks region. Of these, 10 strikes caused property damage totaling over $614,000. Of this total, $500,000 of property damage is from a single event in August 2023 when lightning struck a house in Duck causing a major fire. Four lightning strikes directly caused fatalities, and two caused injuries. As these are only the events with reported impacts on people and property, it is certain that additional lightning incidents have occurred in the Outer Banks region. Table 4.73 details NCEI-recorded lightning strikes from 1996 through 2023.

Table 4.73 – Recorded Lightning Strikes in the Outer Banks Region, 1996-2023

Location	Date	Time	Fatalities	Injuries	Property Damage
Moyock	5/6/1996	200	0	0	$30,000
Manteo	4/3/2002	2115	0	0	$10,000
Colington	8/24/2002	1800	0	0	$12,000
Hatteras	8/24/2002	2000	1	4	$0
Buxton	9/5/2002	1510	0	0	$20,000
Moyock	8/18/2003	1415	0	0	$2,000
Rodanthe	6/20/2008	1430	0	2	$0
Duck	7/27/2009	1600	1	0	$0
Currituck	8/6/2009	1230	0	0	$2,000
Kitty Hawk	7/21/2012	1910	0	0	$10,000
Corolla	7/10/2014	630	0	0	$25,000
Knotts Is	7/31/2016	1510	1	0	$0
Mayock	7/23/2017	1931	0	0	$3,000
Kitty Hawk	8/23/2019	1350	1	0	$0
Duck	8/10/2023	1705	0	0	$500,000
		Total	**4**	**6**	**$614,000**

Source: NCEI

The following are a selection of narrative descriptions recorded in NCEI for lightning events that occurred in the Outer Banks Region:

August 24, 2002 – Lightning struck 5 people attempting to dig a vehicle out of the sand. One woman was killed, and 4 others were injured, one seriously. Another lightning strike on the same day caused $12,000 in property damages.

September 5, 2002 – Five homes here struck by lightning in and around Buxton as well as near Kitty Hawk. Property damage from fires occurred with several of the buildings.

June 20, 2008 – Scattered thunderstorms developed over eastern North Carolina during the afternoon hours north of a stalled frontal boundary. A few of the storms became severe producing large hail. Two people struck by lightning just south of Rodanthe. One person had to be revived by emergency medical technicians.

July 27, 2009 – Thunderstorms crossing the northern Outer Banks produced a lightning strike that killed a man in Southern Shores.

July 21, 2012 – Very unstable air developed over eastern North Carolina as a front was stalled to the north. Scattered to numerous showers and thunderstorms developed in the afternoon as an upper level disturbance approached from the northwest. A few of these storms became severe producing damaging winds into the early evening hours. Dare county 911 reported several homes struck by lightning in Duck and Kitty Hawk, actual damage estimates unknown.

July 31, 2016 – Scattered severe thunderstorms in advance of a frontal boundary produced damaging winds and a lightning death across portions of northeast North Carolina. A five-year-old boy was struck by lightning and killed near a vehicle at Carova Beach.

August 23, 2019 – The police in Kitty Hawk, NC said that on August 23rd, 2019 around 1:50 PM LST in the 3800 block of North Virginia Dare Trail, in Kitty Hawk, a man was struck by lightning while near shore in the water, throwing a frisbee with friends. After the strike he was face down in the water, and his friends brought him in and performed CPR until a lifeguard arrived. The man was transported to a hospital and died several weeks later.

August 10, 2023 – Lightning struck a home in Duck, resulting in a major house fire.

Ten of the 15 incidents recorded by the NCEI included property damage, which was mostly recorded as fire damage ignited by lightning. The highest rate of property damage recorded for a single incident was $500,000.

In addition to these events, the Town of Nags Head Fire Department has tracked losses related lightning strikes back to 2013, summarized in Table 4.74 below.

Table 4.74 – Property Damages Caused by Lightning Strikes, Tracked by Town of Nags Head

Year	Damages Caused by Lightning Strikes
2022	$140,000.00
2021	$30,000.00
2018	$20,000.00
2015	$400.00
2014	$2,500.00
2013	$3,500.00

HAIL

NCEI records 70 separate hail incidents across 48 days between January 1, 1999 and December 31, 2023 in the Outer Banks Region. None of these events were reported to have caused property damage, fatality, injury, or crop damage. The largest diameter hail recorded in the region was 1.75" and was recorded on six separate occasions; the average hail size across all reported events was a little under one inch in diameter.

Table 4.75 – Summary of Hail Occurrences by County

Location	Number of Occurrences	Average Hail Diameter
Currituck	28	1.0104"
Dare	42	0.8993"

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

May 25, 2004 – Dare County 911 Center reported half dollar size hail at the intersection of Routes 64 and 264 near Mann's Harbor.

March 28, 2005 – Several severe thunderstorms produced large hail across northeastern portions of the area during the morning hours of March 28th.

April 22, 2009 – A cold front crossed eastern North Carolina during the morning of April 22, 2009. A strong upper level disturbance was also crossing the region, and this combined with the front to produce isolated severe thunderstorms along the immediate coast.

May 11, 2016 – Scattered thunderstorms develop south of a front across eastern North Carolina during the evening of May 11, 2016. Some of the storms became strong producing dime sized hail. Dime sized hail reported in Manteo.

May 4, 2022 – Public estimated one inch hail at a business in Grandy.

PROBABILITY OF FUTURE OCCURRENCE

TORNADOES

In the 25-year span from 1999 through 2023, the Outer Banks region experienced 17 separate tornado incidents over 15 separate days. This correlates to a 68 percent annual probability that the region will experience a tornado somewhere in its boundaries. None of these past tornado events were a magnitude EF2 or greater; the probability of a stronger tornado is much lower. Probability is assumed to be uniform across the county.

Probability: 3 – Likely

THUNDERSTORMS

Based on historical occurrences recorded by NCEI for the 28-year period from 1996 through 2023, the Outer Banks Region averages 8.5 thunderstorm wind events per year. Over this same period, 15 lightning events were reported as having caused death, injury, or property damage, which equates to an average of 0.5 damaging lightning strikes per year.

The average hailstorm in the Outer Banks region occurs in the afternoon and has a hail stone with a diameter of just under one inch. Over the 28-year period from 1996 through 2023, the region experienced 70 reported hail incidents, averaging 1.5 reported incidents per year somewhere in the planning area. This equates to a 100% chance that the region will experience a hail incident in any given year.

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

Probability: 4 – Highly Likely

CLIMATE CHANGE

According to the National Aeronautics and Space Administration (NASA), thunderstorm events in the future are likely to become more frequent in the southeast as a result of weather extremes. Thunderstorm potential is measured by an index that NASA created called the Convective Available Potential Energy (CAPE) index. This measures how warm and moist the air is, which is a major contributing factor in thunderstorm/tornado formation. NASA projects that by the period of 2072-2099, the CAPE in the southeastern United States will increase dramatically. Parts of North Carolina are in an area that will likely experience the greatest increase in CAPE in the United States and all of the state is likely to experience at least some increase. This indicates that there will potentially be even more frequent thunderstorms in the state going forward.

According to NOAA and NWS, the number of annual tornado days is decreasing, but the number of tornadoes that occur on tornado days is increasing. Research suggests there is a greater risk of more off-season tornadoes in a warmer future climate, which could mean more tornadic activity at a time of year when people are least expecting it. Results are inconclusive for whether tornadoes frequency could change during the traditional severe weather season. Based on studies from NASA's Earth Observatory, meteorologists are unsure why some thunderstorms generate tornados and others don't, beyond knowing that they require a certain type of wind shear. Tornadoes spawn from approximately one percent of thunderstorms, usually supercell thunderstorms that are in a wind shear environment that promotes rotation. Some studies show a potential for a decrease in wind shear in mid-latitude areas. Many tornadoes along the coast are spawned by tropical cyclones; therefore, climate change impacts on tropical cyclones may affect tornado activity in the Outer Banks region. The potential influence of climate change on tornadoes will continue to be revisited over time.

VULNERABILITY ASSESSMENT

PEOPLE

People and populations exposed to the elements are most vulnerable to tornadoes and thunderstorms. 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 wind- and hail-resistant materials and methods, and public storm shelters, all reduce the exposure of the population. Individuals who work outdoors may face increased risk during severe weather events.

Individuals living in mobile homes are also more vulnerable to tornado and thunderstorm events due to the lack of shelter locations and the vulnerability of the housing unit to damages. According to the 2022 American Community Survey (ACS), 2,909 occupied housing units (4%) in the Outer Banks region are classified as "mobile homes or other types of housing." Based on an estimated average of 2.4 persons per household from the 2022 ACS, there are approximately 6,982 people in the Outer Banks region living in mobile homes. Table 4.76 summarizes estimates of mobile home units in the Outer Banks region by county as of 2022.

Table 4.76 – Mobile Home Units in the Outer Banks Region, 2022

County	Occupied Mobile Home Units	Total Occupied Housing Units	Percent of Occupied Housing
Currituck County	1,636	16,219	10.1%
Dare County (unincorporated)*	909	12,186	7.5%
Duck	0	2,985	0.0%
Kill Devil Hills	34	7,008	0.5%
Kitty Hawk	61	3,316	1.8%
Manteo	35	1,476	2.4%
Nags Head	41	5,174	0.8%
Southern Shores	11	2,348	0.5%
Total	**2,909**	**73,019**	**4.0%**

Source: American Community Survey 2018-2022 5-Year Estimates

*Estimated as the total Dare County estimate less the incorporated community estimates.

Since 1996, the NCEI records four fatalities and six injuries attributed to lightning in the Outer Banks. NCEI records 9 injures and no fatalities attributed to wind events in the Outer Banks. There are no injuries or fatalities attributed to hail.

Since 1950, one fatality and 24 injuries are attributed to tornados in the Outer Banks Region; these injuries were the result of tornados rated as low as EF0, illustrating the destructive power of tornados and the dangers they pose to exposed populations without proper shelter.

PROPERTY

Damages to property from tornadoes can be both direct (what the tornado physically destroys) and indirect (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 1950, damaging tornados in the Outer Banks region are directly responsible for $5.78 million worth of damage to property, according to NCEI data. This equates to an annualized loss of $79,178.

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 the Outer Banks, the majority of recorded property damage was due to structure or vehicle fires. During the 28-year span between 1996 to 2023, NCEI reported $614,000 in property damage caused by lightning, including one event with $500,000 in damages. Therefore, annualized property losses from lightning are approximately $40,933; or, $8,143, not including the outlier.

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 the 28-year span between January 1, 1996 and December 31, 2023 in the Outer Banks Region, NCEI reported no property damage due to hail, however this does not mean damage is not possible in the future. 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 the Region, thus the NCEI is still used to form a baseline.

When strong enough, wind events can cause significant direct damage to buildings and infrastructure. NCEM's IRISK database estimates damages from tornadoes and thunderstorms by storm magnitude. Table 4.77 through Table 4.80 detail the estimated buildings impacted and losses incurred from tornado events of magnitudes ranging from EF0 to EF3. Damages from increasing magnitudes of thunderstorm wind events are detailed in Table 4.81 through Table 4.84. Note that all of these tables provide an estimate of building damages should all exposed property be impacted by an event of the stated magnitude. Actual damages resulting from a tornado or thunderstorm event of each magnitude would be lower because any one event would impact only a portion of the region. These tables should only be used to understand the range of damage potential relative to storms of varying degrees of severity.

Table 4.77 – Estimated Buildings Impacted by EF0 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	15,377	86.9%	$178,328,825	1,468	8.3%	$36,511,676	183	1.0%	$7,533,903	17,028	96.3%	$222,374,403
Dare													
Unincorporated Dare County	14,019	12,795	91.3%	$139,889,481	667	4.8%	$11,067,229	153	1.1%	$4,046,015	13,615	97.1%	$155,002,725
Town of Duck	2,409	2,316	96.1%	$43,149,006	76	3.2%	$1,657,168	7	0.3%	$228,052	2,399	99.6%	$45,034,226
Town of Kill Devil Hills	6,033	5,634	93.4%	$50,505,590	312	5.2%	$10,353,998	18	0.3%	$2,554,498	5,964	98.9%	$63,414,086
Town of Kitty Hawk	2,862	2,597	90.7%	$29,105,180	188	6.6%	$7,001,890	11	0.4%	$304,849	2,796	97.7%	$36,411,919
Town of Manteo	943	764	81.0%	$11,900,936	125	13.3%	$3,480,108	29	3.1%	$2,514,397	918	97.3%	$17,895,440
Town of Nags Head	4,868	4,484	92.1%	$59,191,744	302	6.2%	$8,324,261	32	0.7%	$1,183,249	4,818	99.0%	$68,699,253
Town of Southern Shores	2,513	2,454	97.7%	$40,866,617	33	1.3%	$1,049,745	7	0.3%	$814,833	2,494	99.2%	$42,731,194
Subtotal Dare	**33,647**	**31,044**	**92.3%**	**$374,608,554**	**1,703**	**5.1%**	**$42,934,399**	**257**	**0.8%**	**$11,645,893**	**33,004**	**98.1%**	**$429,188,843**
Region Total	**51,332**	**46,421**	**90.4%**	**$552,937,379**	**3,171**	**6.2%**	**$79,446,075**	**440**	**0.9%**	**$19,179,796**	**50,032**	**97.5%**	**$651,563,246**

Source: NCEM Risk Management Tool

Table 4.78 – Estimated Buildings Impacted by EF1 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	15,377	86.9%	$1,292,316,655	1,468	8.3%	$243,208,378	183	1.0%	$40,426,085	17,028	96.3%	$1,575,951,118
Dare													
Unincorporated Dare County	14,019	12,795	91.3%	$1,027,084,972	667	4.8%	$78,375,396	153	1.1%	$24,026,165	13,615	97.1%	$1,129,486,533
Town of Duck	2,409	2,316	96.1%	$317,562,334	76	3.2%	$11,865,765	7	0.3%	$1,835,961	2,399	99.6%	$331,264,060
Town of Kill Devil Hills	6,033	5,634	93.4%	$370,626,461	312	5.2%	$69,834,686	18	0.3%	$11,200,656	5,964	98.9%	$451,661,802
Town of Kitty Hawk	2,862	2,597	90.7%	$212,152,299	188	6.6%	$41,305,118	11	0.4%	$2,138,419	2,796	97.7%	$255,595,835
Town of Manteo	943	764	81.0%	$86,142,861	125	13.3%	$21,985,706	29	3.1%	$11,392,412	918	97.3%	$119,520,979
Town of Nags Head	4,868	4,484	92.1%	$435,123,981	302	6.2%	$53,306,444	32	0.7%	$7,236,560	4,818	99.0%	$495,666,985
Town of Southern Shores	2,513	2,454	97.7%	$301,659,057	33	1.3%	$6,669,086	7	0.3%	$3,682,626	2,494	99.2%	$312,010,769
Subtotal Dare	**33,647**	**31,044**	**92.3%**	**$2,750,351,965**	**1,703**	**5.1%**	**$283,342,201**	**257**	**0.8%**	**$61,512,799**	**33,004**	**98.1%**	**$3,095,206,963**
Region Total	**51,332**	**46,421**	**90.4%**	**$4,042,668,620**	**3,171**	**6.2%**	**$526,550,579**	**440**	**0.9%**	**$101,938,884**	**50,032**	**97.5%**	**$4,671,158,081**

Source: NCEM Risk Management Tool

Table 4.79 – Estimated Buildings Impacted by EF2 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	15,377	86.9%	$2,390,736,487	1,468	8.3%	$563,343,807	183	1.0%	$123,144,538	17,028	96.3%	$3,077,224,832
Dare													
Unincorporated Dare County	14,019	12,795	91.3%	$1,933,863,610	667	4.8%	$173,664,046	153	1.1%	$78,094,463	13,615	97.1%	$2,185,622,120
Town of Duck	2,409	2,316	96.1%	$607,121,528	76	3.2%	$27,817,938	7	0.3%	$6,643,547	2,399	99.6%	$641,583,013
Town of Kill Devil Hills	6,033	5,634	93.4%	$710,188,520	312	5.2%	$156,638,264	18	0.3%	$30,837,989	5,964	98.9%	$897,664,772
Town of Kitty Hawk	2,862	2,597	90.7%	$407,496,528	188	6.6%	$96,647,759	11	0.4%	$7,411,157	2,796	97.7%	$511,555,444
Town of Manteo	943	764	81.0%	$167,975,354	125	13.3%	$50,300,235	29	3.1%	$32,064,479	918	97.3%	$250,340,068
Town of Nags Head	4,868	4,484	92.1%	$832,241,445	302	6.2%	$129,336,445	32	0.7%	$23,816,549	4,818	99.0%	$985,394,439
Town of Southern Shores	2,513	2,454	97.7%	$573,033,653	33	1.3%	$16,056,059	7	0.3%	$10,347,862	2,494	99.2%	$599,437,574
Subtotal Dare	**33,647**	**31,044**	**92.3%**	**$5,231,920,638**	**1,703**	**5.1%**	**$650,460,746**	**257**	**0.8%**	**$189,216,046**	**33,004**	**98.1%**	**$6,071,597,430**
Region Total	**51,332**	**46,421**	**90.4%**	**$7,622,657,125**	**3,171**	**6.2%**	**$1,213,804,553**	**440**	**0.9%**	**$312,360,584**	**50,032**	**97.5%**	**$9,148,822,262**

Source: NCEM Risk Management Tool

Table 4.80 – Estimated Buildings Impacted by EF3 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	15,377	86.9%	$2,814,159,063	1,468	8.3%	$724,529,993	183	1.0%	$189,883,453	17,028	96.3%	$3,728,572,509
Dare													
Unincorporated Dare County	14,019	12,795	91.3%	$2,270,104,490	667	4.8%	$218,082,364	153	1.1%	$122,238,478	13,615	97.1%	$2,610,425,332
Town of Duck	2,409	2,316	96.1%	$721,001,621	76	3.2%	$36,033,844	7	0.3%	$10,567,300	2,399	99.6%	$767,602,764
Town of Kill Devil Hills	6,033	5,634	93.4%	$850,694,604	312	5.2%	$215,082,091	18	0.3%	$46,882,379	5,964	98.9%	$1,112,659,074
Town of Kitty Hawk	2,862	2,597	90.7%	$496,294,655	188	6.6%	$129,497,373	11	0.4%	$11,715,128	2,796	97.7%	$637,507,157
Town of Manteo	943	764	81.0%	$210,696,505	125	13.3%	$68,806,093	29	3.1%	$48,952,430	918	97.3%	$328,455,027
Town of Nags Head	4,868	4,484	92.1%	$991,268,446	302	6.2%	$177,368,492	32	0.7%	$37,352,657	4,818	99.0%	$1,205,989,595
Town of Southern Shores	2,513	2,454	97.7%	$671,448,277	33	1.3%	$21,189,330	7	0.3%	$15,793,040	2,494	99.2%	$708,430,647
Subtotal Dare	**33,647**	**31,044**	**92.3%**	**$6,211,508,598**	**1,703**	**5.1%**	**$866,059,587**	**257**	**0.8%**	**$293,501,412**	**33,004**	**98.1%**	**$7,371,069,596**
Region Total	**51,332**	**46,421**	**90.4%**	**$9,025,667,661**	**3,171**	**6.2%**	**$1,590,589,580**	**440**	**0.9%**	**$483,384,865**	**50,032**	**97.5%**	**$11,099,642,105**

Source: NCEM Risk Management Tool

Table 4.81 – Estimated Buildings Impacted by 25-Year Thunderstorm Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	14,980	84.7%	$28,559,500	1,449	8.2%	$6,213,483	179	1.0%	$785,705	16,608	93.9%	$35,558,688
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$15,978,310	644	4.6%	$742,749	152	1.1%	$275,938	13,247	94.5%	$16,996,997
Town of Duck	2,409	2,105	87.4%	$8,168,961	53	2.2%	$133,197	4	0.2%	$100,723	2,162	89.7%	$8,402,881
Town of Kill Devil Hills	6,033	5,380	89.2%	$5,983,774	309	5.1%	$2,767,233	18	0.3%	$82,608	5,707	94.6%	$8,833,615
Town of Kitty Hawk	2,862	2,501	87.4%	$4,262,277	179	6.3%	$804,446	11	0.4%	$17,983	2,691	94.0%	$5,084,707
Town of Manteo	943	764	81.0%	$2,497,101	124	13.1%	$281,108	29	3.1%	$48,114	917	97.2%	$2,826,323
Town of Nags Head	4,868	4,268	87.7%	$10,678,506	293	6.0%	$1,514,948	30	0.6%	$173,338	4,591	94.3%	$12,366,792
Town of Southern Shores	2,513	2,436	96.9%	$5,064,713	33	1.3%	$58,317	7	0.3%	$18,511	2,476	98.5%	$5,141,541
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$52,633,642**	**1,635**	**4.9%**	**$6,301,998**	**251**	**0.7%**	**$717,215**	**31,791**	**94.5%**	**$59,652,856**
Region Total	**51,332**	**44,885**	**87.4%**	**$81,193,142**	**3,084**	**6.0%**	**$12,515,481**	**430**	**0.8%**	**$1,502,920**	**48,399**	**94.3%**	**$95,211,544**

Source: NCEM Risk Management Tool

Table 4.82 – Estimated Buildings Impacted by 50-Year Thunderstorm Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	14,980	84.7%	$93,390,220	1,449	8.2%	$14,691,987	179	1.0%	$2,083,974	16,608	93.9%	$110,166,180
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$45,084,223	644	4.6%	$2,139,366	152	1.1%	$897,345	13,247	94.5%	$48,120,934
Town of Duck	2,409	2,105	87.4%	$28,665,690	53	2.2%	$408,190	4	0.2%	$246,813	2,162	89.7%	$29,320,693
Town of Kill Devil Hills	6,033	5,380	89.2%	$17,848,780	309	5.1%	$6,239,803	18	0.3%	$331,816	5,707	94.6%	$24,420,400
Town of Kitty Hawk	2,862	2,501	87.4%	$12,602,005	179	6.3%	$2,322,590	11	0.4%	$89,258	2,691	94.0%	$15,013,853
Town of Manteo	943	764	81.0%	$8,937,422	124	13.1%	$858,031	29	3.1%	$204,241	917	97.2%	$9,999,694
Town of Nags Head	4,868	4,268	87.7%	$34,666,456	293	6.0%	$3,845,713	30	0.6%	$579,709	4,591	94.3%	$39,091,878
Town of Southern Shores	2,513	2,436	96.9%	$15,720,752	33	1.3%	$191,748	7	0.3%	$63,707	2,476	98.5%	$15,976,208
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$163,525,328**	**1,635**	**4.9%**	**$16,005,441**	**251**	**0.7%**	**$2,412,889**	**31,791**	**94.5%**	**$181,943,660**
Region Total	**51,332**	**44,885**	**87.4%**	**$256,915,548**	**3,084**	**6.0%**	**$30,697,428**	**430**	**0.8%**	**$4,496,863**	**48,399**	**94.3%**	**$292,109,840**

Source: NCEM Risk Management Tool

Table 4.83 – Estimated Buildings Impacted by 100-Year Thunderstorm Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	14,980	84.7%	$164,375,188	1,449	8.2%	$22,516,196	179	1.0%	$3,449,195	16,608	93.9%	$190,340,579
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$87,840,960	644	4.6%	$4,082,396	152	1.1%	$1,757,250	13,247	94.5%	$93,680,606
Town of Duck	2,409	2,105	87.4%	$50,974,888	53	2.2%	$693,494	4	0.2%	$380,711	2,162	89.7%	$52,049,093
Town of Kill Devil Hills	6,033	5,380	89.2%	$31,894,645	309	5.1%	$9,359,791	18	0.3%	$699,873	5,707	94.6%	$41,954,309
Town of Kitty Hawk	2,862	2,501	87.4%	$22,042,279	179	6.3%	$3,957,036	11	0.4%	$195,491	2,691	94.0%	$26,194,806
Town of Manteo	943	764	81.0%	$15,822,249	124	13.1%	$1,478,199	29	3.1%	$461,130	917	97.2%	$17,761,578
Town of Nags Head	4,868	4,268	87.7%	$61,324,644	293	6.0%	$6,287,267	30	0.6%	$1,023,940	4,591	94.3%	$68,635,851
Town of Southern Shores	2,513	2,436	96.9%	$28,468,529	33	1.3%	$331,719	7	0.3%	$119,938	2,476	98.5%	$28,920,185
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$298,368,194**	**1,635**	**4.9%**	**$26,189,902**	**251**	**0.7%**	**$4,638,333**	**31,791**	**94.5%**	**$329,196,428**
Region Total	**51,332**	**44,885**	**87.4%**	**$462,743,382**	**3,084**	**6.0%**	**$48,706,098**	**430**	**0.8%**	**$8,087,528**	**48,399**	**94.3%**	**$519,537,007**

Source: NCEM Risk Management Tool

Table 4.84 – Estimated Buildings Impacted by 300-Year Thunderstorm Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	14,980	84.7%	$439,618,421	1,449	8.2%	$50,027,365	179	1.0%	$8,789,621	16,608	93.9%	$498,435,407
Dare													
Unincorporated Dare County	14,019	12,451	88.8%	$254,863,428	644	4.6%	$10,900,046	152	1.1%	$5,619,385	13,247	94.5%	$271,382,858
Town of Duck	2,409	2,105	87.4%	$135,414,635	53	2.2%	$1,759,488	4	0.2%	$908,427	2,162	89.7%	$138,082,550
Town of Kill Devil Hills	6,033	5,380	89.2%	$90,538,050	309	5.1%	$20,215,931	18	0.3%	$2,444,415	5,707	94.6%	$113,198,396
Town of Kitty Hawk	2,862	2,501	87.4%	$59,387,565	179	6.3%	$10,249,480	11	0.4%	$665,500	2,691	94.0%	$70,302,545
Town of Manteo	943	764	81.0%	$41,515,662	124	13.1%	$3,897,650	29	3.1%	$1,847,770	917	97.2%	$47,261,082
Town of Nags Head	4,868	4,268	87.7%	$160,403,250	293	6.0%	$15,339,069	30	0.6%	$2,747,355	4,591	94.3%	$178,489,675
Town of Southern Shores	2,513	2,436	96.9%	$82,268,987	33	1.3%	$904,338	7	0.3%	$381,963	2,476	98.5%	$83,555,288
Subtotal Dare	**33,647**	**29,905**	**88.9%**	**$824,391,577**	**1,635**	**4.9%**	**$63,266,002**	**251**	**0.7%**	**$14,614,815**	**31,791**	**94.5%**	**$902,272,394**
Region Total	**51,332**	**44,885**	**87.4%**	**$1,264,009,998**	**3,084**	**6.0%**	**$113,293,367**	**430**	**0.8%**	**$23,404,436**	**48,399**	**94.3%**	**$1,400,707,801**

Source: NCEM Risk Management Tool

ENVIRONMENT

Tornados 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. The main environmental impact from thunderstorm 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 result in the ignition of wildfires. This is often 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. In some cases, melting hail can increase flash flood risk.

CONSEQUENCE ANALYSIS

Table 4.85 summarizes the potential negative consequences of tornadoes and thunderstorms.

Table 4.85 – Consequence Analysis – Tornadoes and Thunderstorms

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	Thunderstorms, lightning, and hail present the possibility of structure fire ignition; potential for disruptions in power and communications infrastructure; and destruction and/or damage to any exposed property, especially windows, cars and siding. The weakest tornados, EF0, can cause minor roof damage, while strong tornados can destroy frame buildings and even damage steel reinforced concrete structures. Buildings are vulnerable to direct impact from tornados and also from wind borne debris. Mobile homes are particularly susceptible to damage during tornados and thunderstorms.
Environment	Potential fire ignition from lightning; hail and wind damage to wildlife and foliage
Economic Condition of the Jurisdiction	Temporary business interruptions are possible, but thunderstorms and tornadoes are unlikely to causes any sustained impact on the local economy.
Public Confidence in the Jurisdiction's Governance	Public confidence is not likely to be affected by thunderstorms and tornadoes.

HAZARD SUMMARY BY JURISDICTION

The following tables summarize tornado and thunderstorm hazard risk by jurisdiction. The impact of these severe weather hazards may vary by jurisdiction based on each community's property exposure. Communities with a higher proportion of mobile homes may be disproportionately impacted by thunderstorm winds and tornadoes. While mobile home units do not comprise a significant proportion of any jurisdiction's housing mix, mobiles homes make up 10 percent of occupied housing in Currituck

County and 7 percent in unincorporated Dare County. Therefore, these communities may face more severe impacts from wind. Other elements of severe weather risk do not vary by jurisdiction.

TORNADO

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Currituck County	3	3	1	4	1	2.5	M
Dare County	3	3	1	4	1	2.5	M
Duck	3	2	1	4	1	2.2	M
Kill Devil Hills	3	2	1	4	1	2.2	M
Kitty Hawk	3	2	1	4	1	2.2	M
Manteo	3	2	1	4	1	2.2	M
Nags Head	3	2	1	4	1	2.2	M
Southern Shores	3	2	1	4	1	2.2	M

THUNDERSTORM WIND

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Currituck County	4	3	3	4	1	3.2	H
Dare County	4	3	3	4	1	3.2	H
Duck	4	2	3	4	1	2.9	M
Kill Devil Hills	4	2	3	4	1	2.9	M
Kitty Hawk	4	2	3	4	1	2.9	M
Manteo	4	2	3	4	1	2.9	M
Nags Head	4	2	3	4	1	2.9	M
Southern Shores	4	2	3	4	1	2.9	M

LIGHTNING

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
All jurisdictions	4	1	1	4	1	2.2	M

HAIL

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
All jurisdictions	4	1	1	4	1	2.2	M

4.5.7 SEVERE WINTER WEATHER

HAZARD BACKGROUND

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 of 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. Furthermore, communication and power may be disrupted 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 one 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 the region.

Spatial Extent: 4 – Large

EXTENT

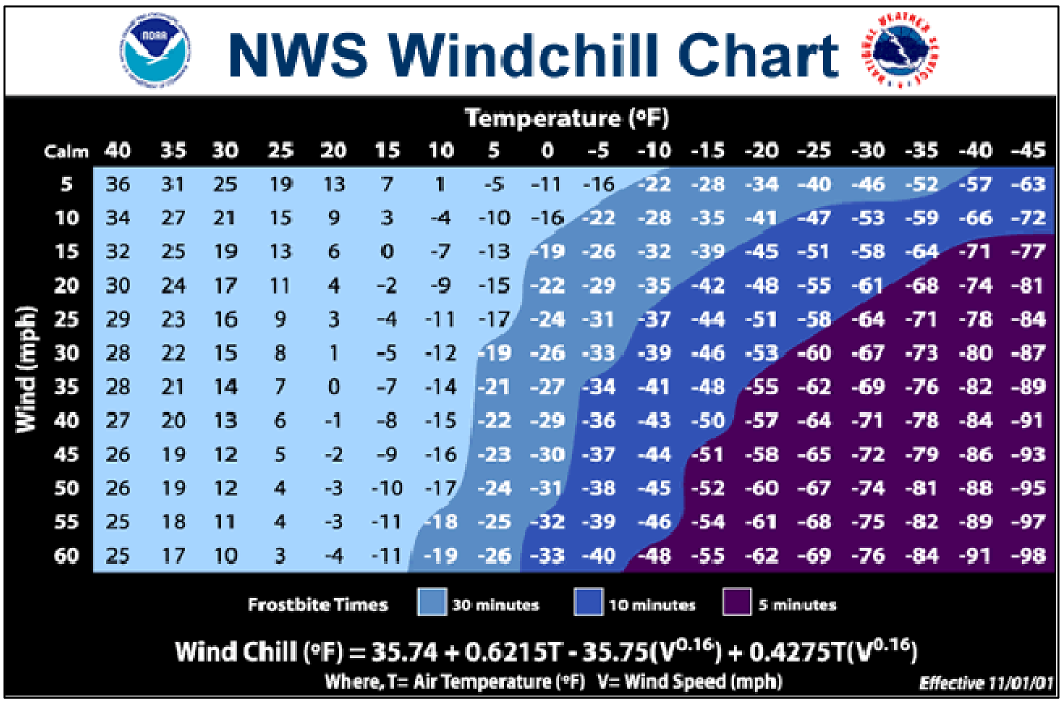
The National Oceanic and Atmospheric Administration (NOAA) uses the Regional Snowfall Index (RSI) to assess the societal impact of winter storms in the six easternmost regions in the United States. The index makes use of population and regional differences to assess the impact of snowfall. For example, areas which receive very little snowfall on average may be more adversely affected than other regions, resulting in a higher severity.

Table 4.86 – 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

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 4.44, provides a formula for calculating the dangers of winter winds and freezing temperatures.

Figure 4.44 – NWS Wind Chill Temperature Index



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

Per the National Centers for Environmental Information, the greatest snowfall amount recorded in Dare County was 13.7 inches, recorded on March 3, 1980 at the Hatteras weather station. The greatest snowfall for Currituck County was 7.5 inches, recorded on December 27, 2010.

Impact: 1 – Minor

The entirety of North Carolina 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. The Outer Banks generally receives smaller scale severe winter weather conditions 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) Raleigh Forecast Office 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 of time 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 4.87 summarizes winter storm related events by type as reported in NCEI for 1993 through 2023. Severe winter weather did not cause any reported damage, injuries, or fatalities, though these types of impacts are possible in future events. No cold/wind chill, extreme cold/wind chill, or sleet events were recorded. Table 4.88 details all reported events.

Table 4.87 – Reported Severe Winter Storm Events in the Outer Banks Region, 1999-2023

Event Type	Number of Recorded Incidents	Total Deaths	Total Injuries	Reported Property Damage	Reported Crop Damage
Currituck County					
Winter Storm	17	0	0	$0	$0
Winter Weather	15	0	0	$0	$0

Event Type	Number of Recorded Incidents	Total Deaths	Total Injuries	Reported Property Damage	Reported Crop Damage
Frost/Freeze	3	0	0	$0	$0
Blizzard	1	0	0	$0	$0
Dare County					
Winter Storm	9	0	0	$0	$0
Winter Weather	4	0	0	$0	$0
Frost/Freeze	1	0	0	$0	$0
Heavy Snow	4	0	0	$0	$0
Region Total	**54**	**0**	**0**	**$0**	**$0**

Source: NCEI

Table 4.88 – Severe Winter Storm Incidents in the Outer Banks, 1999-2023

Date	Event Type	Deaths	Injuries	Property Damage	Crop Damage
12/3/2000	Winter Storm	0	0	$0	$0
1/2/2002	Winter Storm	0	0	$0	$0
1/3/2002	Winter Storm	0	0	$0	$0
1/23/2003	Winter Storm	0	0	$0	$0
1/23/2003	Winter Storm	0	0	$0	$0
11/30/2003	Frost/Freeze	0	0	$0	$0
1/9/2004	Winter Storm	0	0	$0	$0
1/9/2004	Winter Weather	0	0	$0	$0
1/25/2004	Winter Storm	0	0	$0	$0
1/25/2004	Winter Storm	0	0	$0	$0
2/15/2004	Winter Storm	0	0	$0	$0
2/16/2004	Winter Weather	0	0	$0	$0
3/23/2004	Frost/Freeze	0	0	$0	$0
4/6/2004	Frost/Freeze	0	0	$0	$0
12/19/2004	Winter Weather	0	0	$0	$0
12/20/2004	Winter Weather	0	0	$0	$0
12/26/2004	Winter Storm	0	0	$0	$0
1/19/2005	Winter Weather	0	0	$0	$0
2/20/2006	Winter Weather	0	0	$0	$0
1/28/2007	Winter Weather	0	0	$0	$0
11/21/2008	Winter Weather	0	0	$0	$0
1/20/2009	Winter Weather	0	0	$0	$0
1/20/2009	Heavy Snow	0	0	$0	$0
1/30/2010	Winter Storm	0	0	$0	$0
12/16/2010	Winter Weather	0	0	$0	$0
12/25/2010	Winter Storm	0	0	$0	$0
12/26/2010	Heavy Snow	0	0	$0	$0
1/22/2011	Heavy Snow	0	0	$0	$0
2/9/2011	Winter Storm	0	0	$0	$0
2/10/2011	Heavy Snow	0	0	$0	$0
1/25/2013	Winter Weather	0	0	$0	$0
1/21/2014	Winter Storm	0	0	$0	$0

Date	Event Type	Deaths	Injuries	Property Damage	Crop Damage
1/28/2014	Winter Storm	0	0	$0	$0
1/28/2014	Winter Storm	0	0	$0	$0
2/11/2014	Winter Storm	0	0	$0	$0
3/3/2014	Winter Weather	0	0	$0	$0
2/16/2015	Winter Storm	0	0	$0	$0
2/24/2015	Winter Storm	0	0	$0	$0
2/25/2015	Winter Weather	0	0	$0	$0
1/22/2016	Winter Weather	0	0	$0	$0
2/12/2016	Winter Weather	0	0	$0	$0
2/12/2016	Winter Storm	0	0	$0	$0
4/5/2016	Frost/Freeze	0	0	$0	$0
1/7/2017	Winter Storm	0	0	$0	$0
1/3/2018	Blizzard	0	0	$0	$0
1/4/2018	Winter Storm	0	0	$0	$0
1/17/2018	Winter Storm	0	0	$0	$0
1/17/2018	Winter Storm	0	0	$0	$0
2/20/2020	Winter Weather	0	0	$0	$0
1/28/2021	Winter Weather	0	0	$0	$0
1/21/2022	Winter Storm	0	0	$0	$0
1/28/2022	Winter Weather	0	0	$0	$0
	Total	**0**	**0**	**$0**	**$0**

Source: NCEI

Narratives from selected winter storm related events as reported in NCEI are summarized below:

January 23, 2003 - The storm dumped the highest amounts of snow east of highway 17 across the area known as the Outer Banks, where 8 to 12 inches of snow fell with isolated amounts up to 14 inches, including the counties of eastern Carteret, Dare and, and Hyde counties. This was the largest one-day snowfall on the Outer Banks in over a decade. Corolla received 4" of snow. Local law enforcement agencies reported numerous accidents and most, if not all, schools were closed due to road conditions.

December 26, 2004 – A winter storm produced one to as much as five inches of snow across the coastal areas of northeast North Carolina. The snow caused hazardous driving conditions, which resulted in numerous accidents. 4.5” of snow were reported in Moyock.

January 20, 2009 – Rain developed over eastern North Carolina after midnight on Jan 20th and changed to snow around 9 am over the northern part of the county and continue into the late evening hours. Over the southern half of the county the rain changed to snow during the late morning hours and continued into the late evening. Snow accumulated 2 to 5 inches across Dare County, and up to 2 inches in Currituck County.

December 25-26, 2010 – Strong low pressure moved northeast just offshore of the North Carolina coast. As the low approached the region areas of rain developed and as cold air spread the rain gradually turned to snow. Snowfall amounts were generally between five and eleven inches across Currituck County, where Moyock reported 10.0 inches of snow. In Dare County, widespread snow developed during the morning hours and continued into the early evening. Total snow accumulations across the county ranged from 2 to 4 inches north of Oregon Inlet to less than 1 inch south of Oregon Inlet.

January 28, 2014 – Sleet and freezing rain began during the early afternoon of January 28th over southern Dare County. As the precipitation spread north it became all snow north of Oregon Inlet toward evening.

The precipitation ended during the late morning of January 29th. Total snow accumulations ranged from 5 to 8 inches north to around 1 inch of sleet and snow south. There was also up to 0.25 inches of freezing rain over the southern sections. Roads were icy during and several days after the event.

January 3-4, 2018 - Strong low pressure tracking northward just off the East Coast produced between three inches and twelve inches of snow across northeast North Carolina. In addition to the winter weather very strong winds occurred along the coast with minor coastal flooding along the Outer Banks. Snowfall totals ranged between three inches and eight inches across the county. Very strong north to northwest winds of 35 to 50 mph affected the area, producing blowing snow and poor visibilities. Knotts Island reported 7.5 inches of snow.

February 20, 2020 - Low pressure tracking from the Gulf Coast States east northeast and off the Southeast Coast produced snowfall totals between one half inch and three inches across northeast North Carolina.

January 28, 2022 - Rapidly intensifying low pressure lifting northward just off the Mid Atlantic coast produced snowfall totals between one half inch and three inches across portions of northeast North Carolina.

Dare County has received one emergency declaration since 1968 for an incident related to severe winter storms, and Currituck County received none. As a state, North Carolina received eight disaster declarations related to severe winter storms during this timeframe.

Table 4.89 – Emergency & Disaster Declarations in Dare County due to Severe Winter Storms

Disaster Number	Date	Disaster Type	Incident Start	Incident End
3110	1993	Severe Snow and Winter Storm	3/13/1993	3/17/1993

Source: FEMA, August 7, 2024

PROBABILITY OF FUTURE OCCURRENCE

NCEI records 54 severe winter storm related events during the 25-year period from 1999 through 2023, which equates to an average of 2.1 events per year or more than 100 percent likelihood of an occurrence in any given year.

Probability: 4 – Highly Likely

CLIMATE CHANGE

According to the 2023 North Carolina Hazard Mitigation Plan, there is uncertainty associated with climate change impacts on future severe winter storms. Global temperature rise could cause shorter and warmer winters in many areas; however, the likelihood of dangerously low temperatures may increase due to continuing trends of temperature extremes. Warmer winters, however, mean that precipitation that would normally fall as snow may begin to fall as rain or freezing rain instead

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

According to reported data of storm impacts recorded by the NCEI, between 1999 and 2023 the Outer Banks Region did not experience any reported property damage as a result of severe winter weather.

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 4.90 summarizes the potential negative consequences of severe winter storm.

Table 4.90 – 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, 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 and there are no characteristics of the jurisdictions that cause significant variation in risk.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
All jurisdictions	4	1	4	1	3	2.7	M

4.5.8 WILDFIRE

HAZARD BACKGROUND

A wildfire is an uncontained fire that spreads through the environment. Wildfires have the ability to 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.

Warning Time: 4 – Less than six hours

Duration: 3 – Less than one week

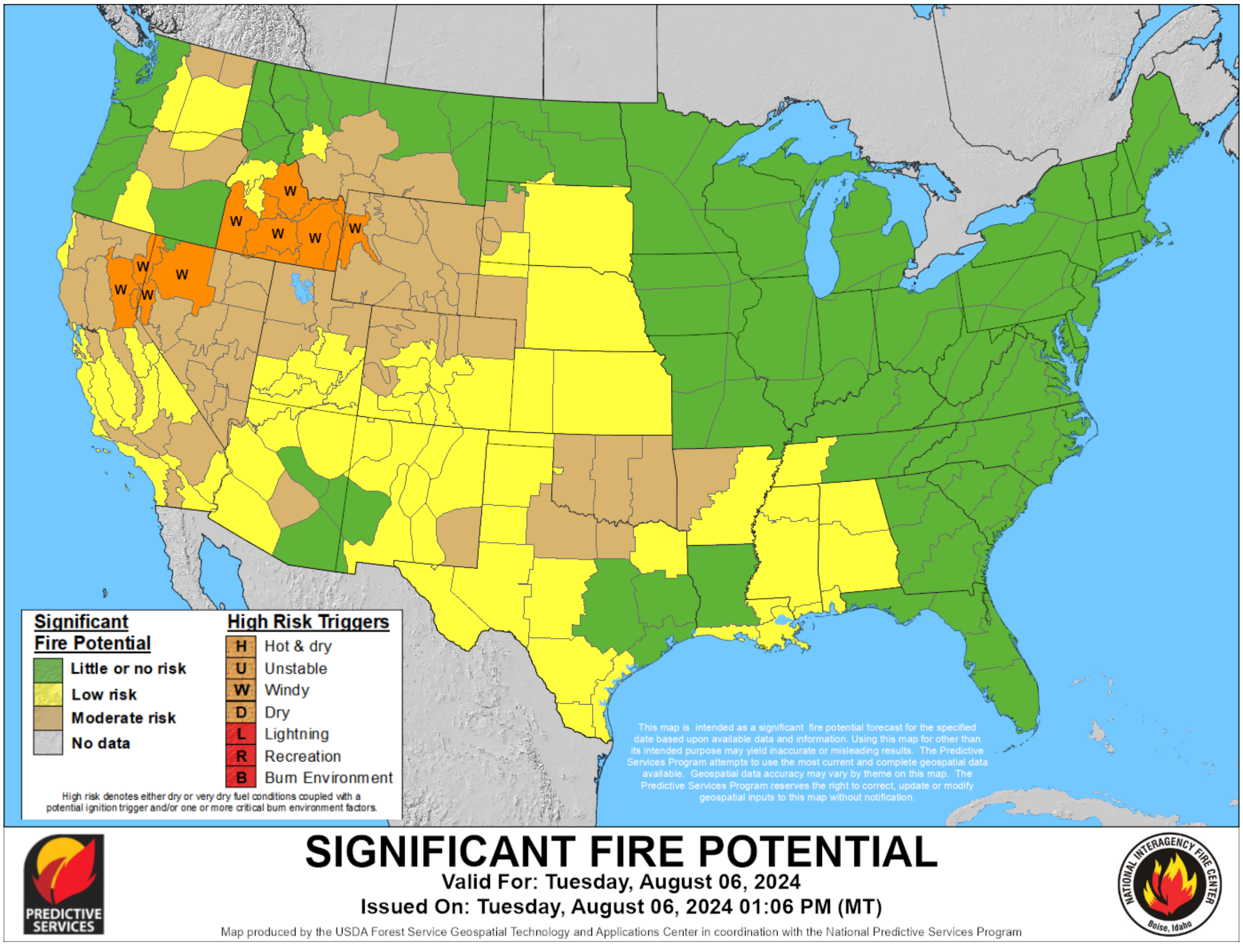
Weather plays a major role in the birth, growth and death of a wildfire. Weather conditions favorable to wildfire include drought, which increases flammability of surface fuels, and winds, which aid a wildfire's progress. The combination of wind, temperature, and humidity affects how fast wildland fires can spread. Rapid response can contain wildfires and limit their threat to property. The Outer Banks Region experiences a variety of wildfire conditions found in the Keetch-Byram Drought Index, which is described in Table 4.91.

Table 4.91 – 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 sufficient 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.

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 4.45 on the following page, the NWS Wildland Fire Potential for August 6th, 2024 shows the state of North Carolina at "little or no risk" for fire potential based on weather conditions at the time.

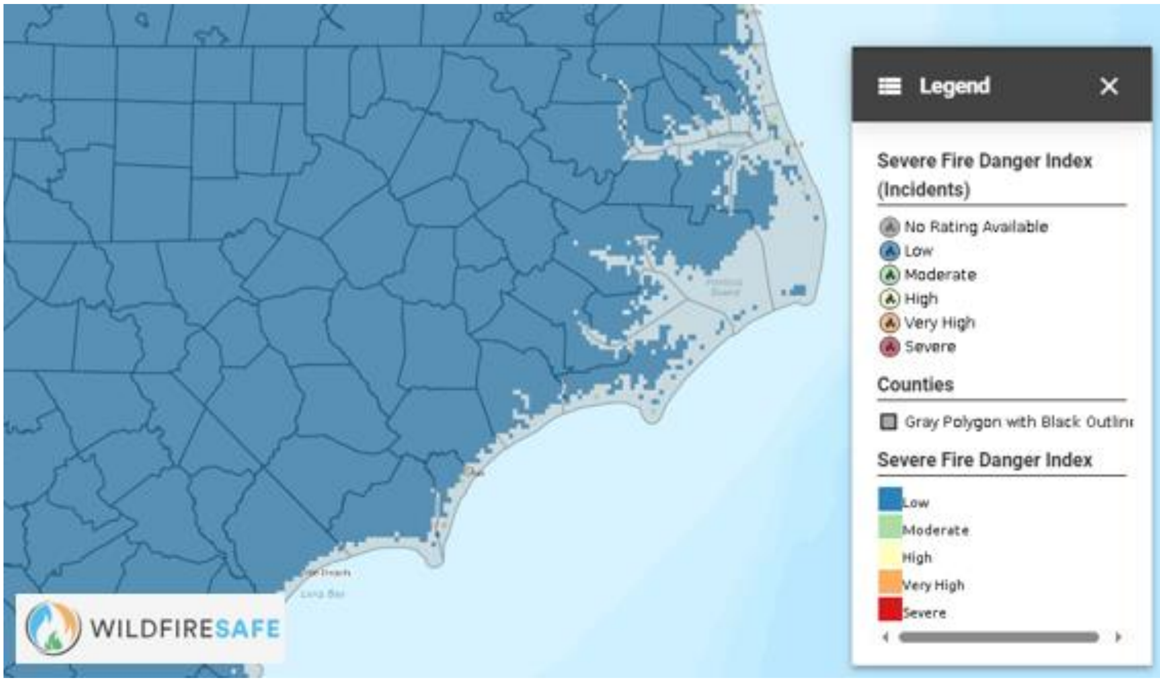
Figure 4.45 – U.S. Wildland Fire Outlook



Source: National Weather Service

The WildfireSAFE platform was created through the United States Forest Service and pulls directly from the Wildland Fire Assessment System. The severe fire danger index for August 7th, 2024 is shown in Figure 4.46 along with current fire incidents. The severe fire weather potential forecast for Currituck County and Dare County at this time was low with no fire incidents being reported in the area.

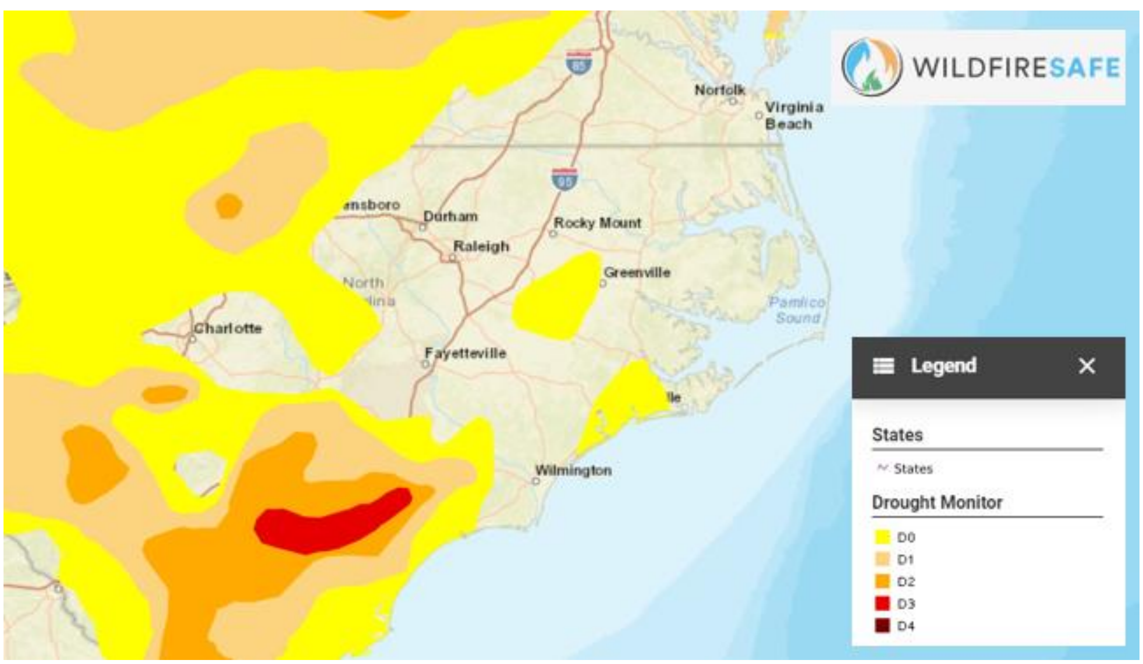
Figure 4.46 – Severe Fire Danger Index, August 2024



Source: USFS WildfireSAFE

The WildfireSAFE platform collects data from the U.S. Drought Monitor and maps parts of the U.S. that are currently in drought. As shown in Figure 4.47, neither Currituck County nor Dare County were experiencing any level of drought on August 7th, 2024 while other regions within the state of North Carolina were experiencing low to moderate degrees of drought making them more susceptible to wildfires.

Figure 4.47 - Drought Monitor, August 2024



Source: USFS WildfireSAFE

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 region that is not heavily urbanized. 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.

Based on data from The Southern Wildfire Risk Assessment (SWRA) and the 2020 U.S. Census, it is estimated that 71.7% of the Region's population lives within the WUI. A GIS analysis overlayed the population density within each census block with the different WUI categories to determine the extent of the WUI in the Outer Banks as shown in Table 4.92. Figure 4.48 maps the WUI. Note, maps for each local jurisdiction are provided in the jurisdictional annexes.

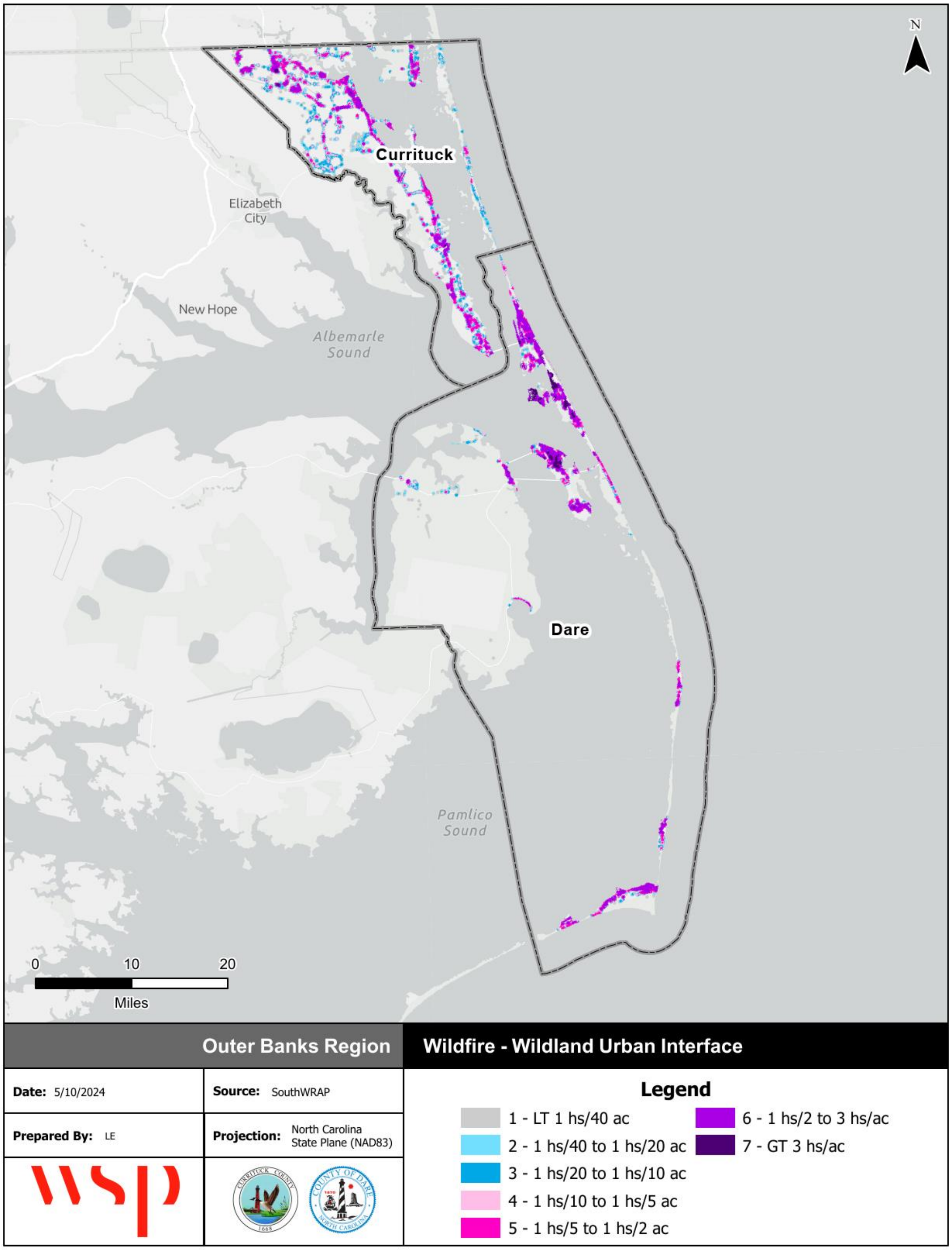
Table 4.92 – Wildland Urban Interface, Population and Acres

	Housing Density	WUI Population	Percent of WUI Population	WUI Acres	Percent of WUI Acres
	LT 1hs/40ac	1,945	4.24%	14,013.60	15.97%
	1hs/40ac to 1hs/20ac	1,479	3.23%	8,388.50	9.56%
	1hs/20ac to 1hs/10ac	2,753	6.01%	12,676.50	14.45%
	1hs/10ac to 1hs/5ac	3,227	7.04%	12,612.60	14.37%
	1hs/5ac to 1hs/2ac	6,852	14.95%	17,318.40	19.74%
	1hs/2ac to 3hs/1ac	20,796	45.37%	20,368.90	23.21%
	GT 3hs/1ac	8,784	19.16%	2,367.40	2.70%
	Total	**45,836**	**100.00%**	**87,745.90**	**100.00%**

Source: Southern Wildfire Risk Assessment, 2020 US Census

Spatial Extent: 3 – Moderate

Figure 4.48 – Wildland Urban Interface, Outer Banks Region



Source: Southern Wildfire Risk Assessment

EXTENT

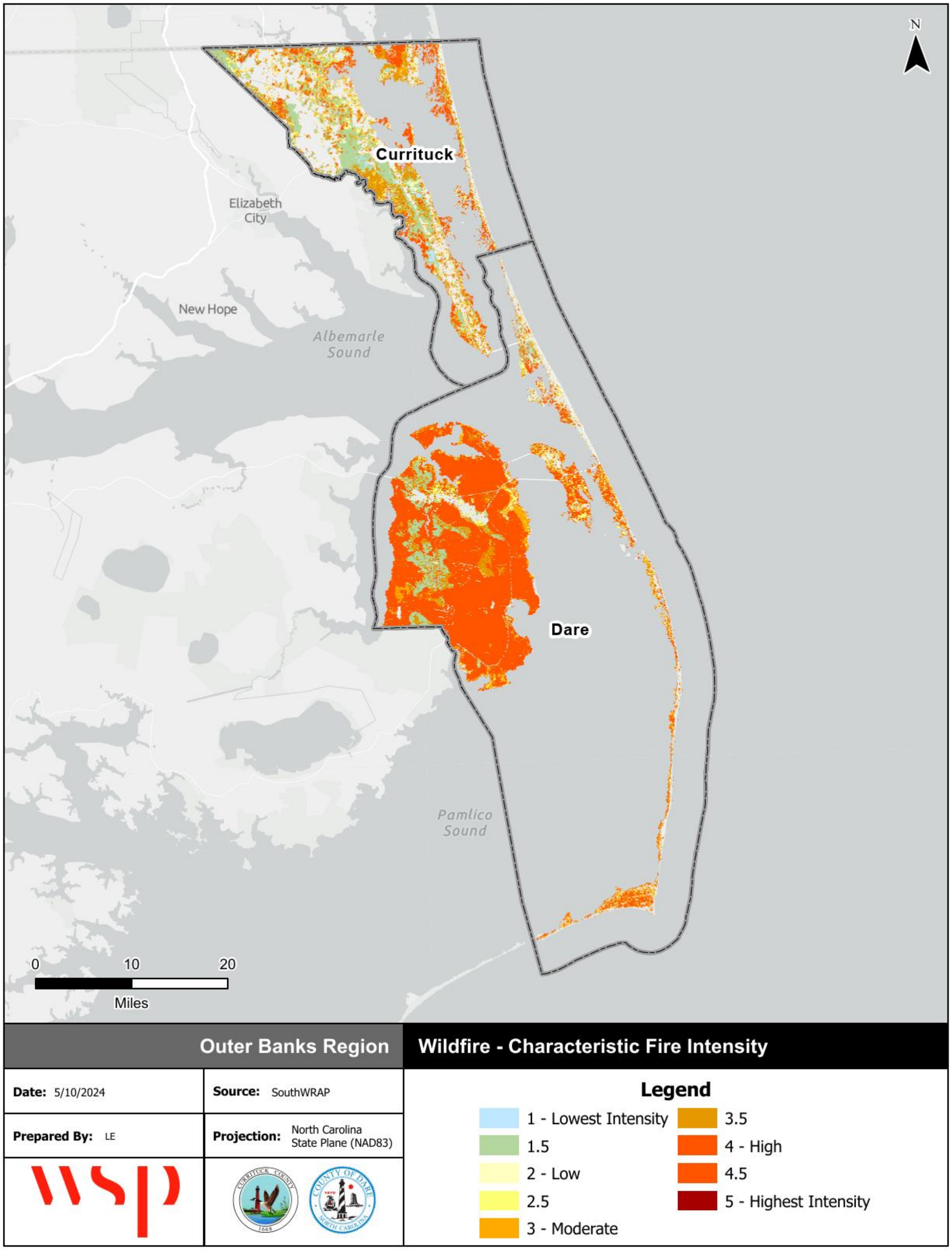
Wildfire extent can be defined by the fire's intensity and measured by the Characteristic Fire Intensity Scale, which identifies areas where significant fuel hazards which could produce dangerous fires exist. Fire Intensity ratings identify where significant fuel hazards and dangerous fire behavior potential 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. Figure 4.49 shows the potential fire intensity within the WUI across the Region. Note, maps for each local jurisdiction are provided in the jurisdictional annexes.

Table 4.93 – 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 4.49 – Characteristic Fire Intensity, Outer Banks Region



Source: Southern Wildfire Risk Assessment

Table 4.94 shows the amount and percentage of land area susceptible to each level of the fire intensity scale by acre. Over 32% of the Region is susceptible to Class 4 and 4.5 high intensity fires, which pose significant harm or damage to life and property. Another 11.6 percent of the Region may experience Class 3 fire intensities, which have potential for harm to life and property but are easier to suppress with dozer and plows. The remainder of the Region is either non-burnable (41.6%) or would face a Class 1 or Class 2 Fire Intensity, which are easily suppressed.

Impact: 2 – Limited

Table 4.94 – Fire Intensity Scale

	Class	Acres	Percent
	Non-Burnable	232,371.37	41.68%
	1 Lowest Intensity	3,394.85	0.61%
	1.5	49,148.53	8.82%
	2 Low	8,185.78	1.47%
	2.5	18,159.64	3.26%
	3 Moderate	28,402.52	5.09%
	3.5	36,432.99	6.53%
	4 High	116,802.17	20.95%
	4.5	64,638.68	11.59%
	5 Highest Intensity	0.00	0.00%
	Total	**557,536.54**	**100.00%**

Source: Southern Wildfire Risk Assessment & GIS analysis

Note: This data was adjusted from SWRA estimates to exclude 922,098 acres of water area from the non-burnable area estimate.

HISTORICAL OCCURRENCES

The North Carolina Forest Service (NCFS) began keeping records of fire occurrence on private and state-owned lands in 1928. Within the last 10 years, North Carolina has averaged nearly 4,300 fires per year and 14,000 acres burned annually.

Table 4.95 lists past occurrences of wildfire in the Outer Banks Region since 2009 as provided by the North Carolina Forest Service (NCFS) in September 2024. This data only accounts for occurrences within unincorporated areas of Currituck and Dare Counties, which fall under the NCFS jurisdiction, as well as larger events in incorporated areas where local fire departments requested NCFS support for fire suppression.

Table 4.95 – Records for Wildfire in Outer Banks, 2009-2023

Year	Number of Fires			Acreage Burned		
	Dare	Currituck	Region Total	Dare	Currituck	Region Total
2009	52	46	98	72.80	196.60	269.40
2010	43	36	79	15.10	18.20	33.30
2011	45	60	105	11.40	42.30	53.70
2012	22	24	46	315.10	6.80	321.90
2013	25	31	56	22.60	27.90	50.50
2014	9	18	27	1.90	6.40	8.30

Year	Number of Fires			Acreage Burned		
	Dare	Currituck	Region Total	Dare	Currituck	Region Total
2015	14	39	53	1.78	10.59	12.37
2016	9	31	40	255.62	15.08	270.70
2017	4	24	28	34.74	34.42	69.16
2018	3	24	27	0.05	5.38	5.43
2019	5	28	33	0.64	11.06	11.7
2020	13	27	40	3.38	39.82	43.2
2021	8	18	26	0.86	7.5	8.36
2022	10	32	42	1.37	14.16	15.53
2023	3	21	24	7.59	528.45	536.04
Total	**265**	**459**	**724**	**744.93**	**964.66**	**1,709.59**

Source: NC Forest Service

The Outer Banks Region averages 48.3 fires and 114 acres burned annually from fires that require the NCFS to respond. These numbers have changed in the last five years, with fewer fires on average but slightly more acres burned. Actual number of fires and acreage burned is likely higher because smaller fires within jurisdictional boundaries are managed by local fire departments.

The Outer Banks experienced prolonged periods of severe to extreme drought in 2011, as well as severe drought in 2008. These droughts may explain some of the annual variation in fires and acreage burned.

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 the Outer Banks Region is presented in Table 4.96 and illustrated in Figure 4.50. Note, maps for each local jurisdiction are provided in the jurisdictional annexes.

Table 4.96 – Burn Probability, Outer Banks Region

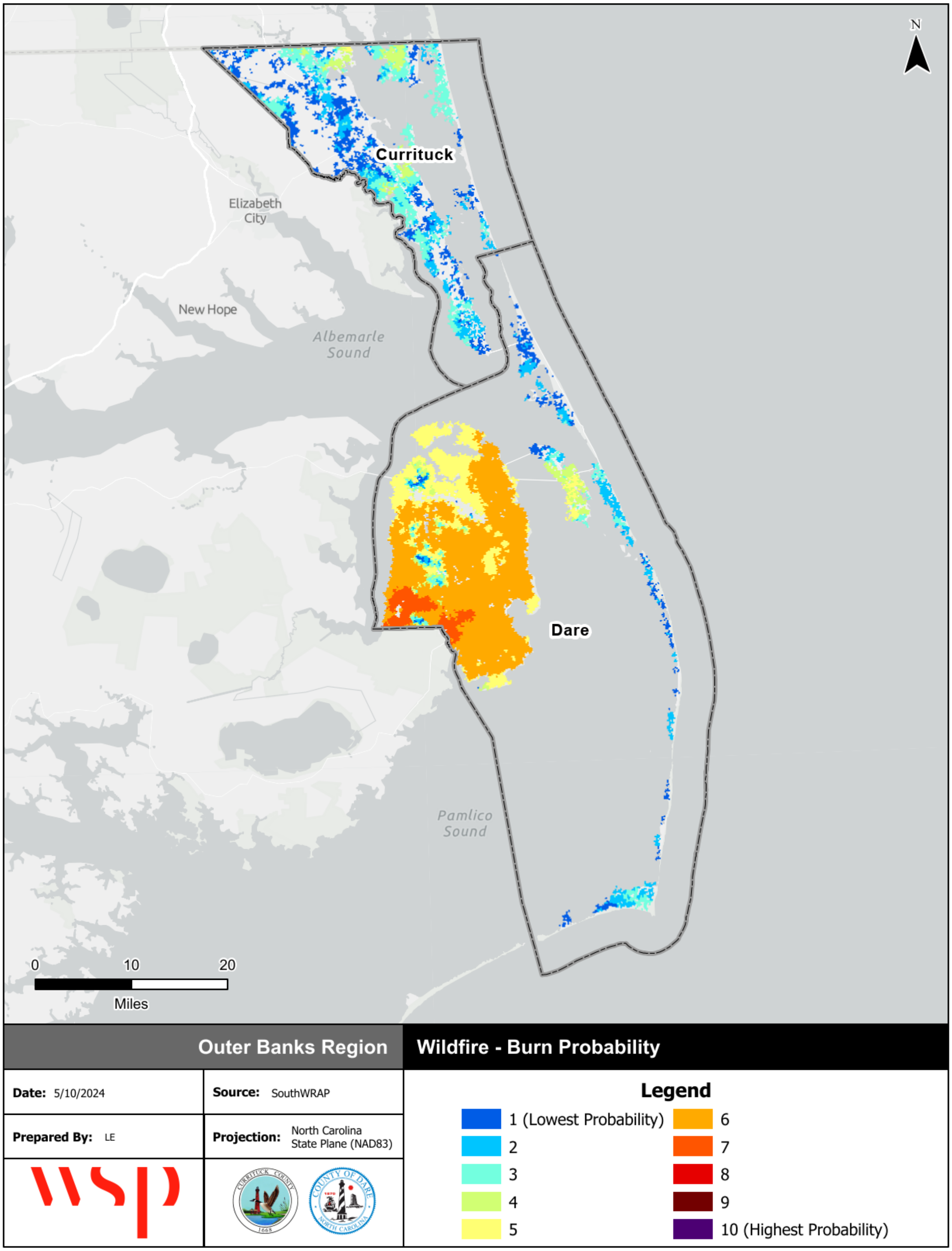
	Class	Acres	Percent
	1	38,039	12.7%
	2	33,901	11.4%
	3	37,115	12.4%
	4	16,466	5.5%
	5	43,380	14.5%
	6	117,198	39.3%
	7	12,386	4.1%
	8	0	0.0 %
	9	0	0.0%
	10	0	0.0%
	Total	**298,487**	**100.0%**

Source: Southern Wildfire Risk Assessment

Most of the Outer Banks region has a relatively low burn probability of 5 or less, however approximately 43 percent of the Region has a burn probability of 6 or 7. These areas of moderate to high moderate burn probability are located primarily in mainland Dare County. The probability of wildfire across the Region county is considered possible, defined as between a 1% and 10% annual chance of occurrence. While the whole area falls within this threshold, the communities containing moderate burn probability, noted above, have a comparatively higher probability of occurrence.

Probability: 2 – Possible

Figure 4.50 – Burn Probability, Outer Banks Region



Source: Southern Wildfire Risk Assessment

CLIMATE CHANGE

Wildfires are usually prevalent with a combination of high temperatures and dry conditions, combustible fuels and an ignition source. Climate change has been linked to longer, warmer and drier conditions in the southeast, exacerbating key potential conditions for a wildfire to spread. According to the Fifth National Climate Assessment, fire activity is projected to increase with further warming and reductions in precipitation creating a longer fire season across the United States.

VULNERABILITY ASSESSMENT

METHODOLOGIES AND ASSUMPTIONS

Population and property at risk to wildfire were estimated using data from the North Carolina Emergency Management (NCEM) IRISK database, which was compiled in NCEM's Risk Management Tool.

Within IRISK, wildfire hazard areas were determined using the Wildland Fire Susceptibility Index (WFSI). The following parameters were applied:

- Areas with a WFSI value of 0.01 – 0.05 were considered to be at moderate risk.
- Areas with a WFSI value greater than 0.05 were considered to be at high risk.
- Areas with a WFSI value less than 0.01 were considered to not be at risk.

The WFSI integrates the probability of an acre igniting and the expected final fire size based on the rate of spread in four weather percentile categories into a single measure of wildland fire susceptibility. Due to some necessary assumptions, mainly fuel homogeneity, it is not the true probability. But since all areas of the state have this value determined consistently, it allows for comparison and ordination of areas of the state as to the likelihood of an acre burning.

Critical facility exposure to wildfire was estimated using SWRA's Wildland Urban Interface Risk Index (WUIRI). The WUIRI provides a rating of the potential impact of a wildfire on people and properties. To calculate the WUIRI, SWRA combines WUI housing density data with flame length data and response functions to represent potential impacts. The range of values is from -1 to -9, with -1 representing the least negative impact and -9 representing the most negative impact.

PEOPLE

Wildfire can cause fatalities and human health hazards. Ensuring procedures are in place for rapid warning and evacuation are essential to reducing vulnerability. Table 4.97 details the population estimated to be at risk to wildfire according to the NCEM IRISK database.

Table 4.97 – Estimated Population Impacted by Wildfire

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Currituck									
Unincorporated Currituck County	31,343	16,468	53	5,390	2,832	53	1,596	839	53

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Dare									
Unincorporated Dare County	24,369	12,567	52%	4,752	2,451	52%	1,150	593	52%
Town of Duck	1,722	441	26%	582	149	26%	53	14	26%
Town of Kill Devil Hills	7,588	1,416	19%	1,298	242	19%	260	49	19%
Town of Kitty Hawk	3,903	1,267	32%	861	280	33%	137	44	32%
Town of Manteo	1,360	799	59%	220	129	59%	80	47	59%
Town of Nags Head	3,178	777	24%	1,084	265	24%	70	17	24%
Town of Southern Shores	2,536	1,011	40%	858	342	40%	78	31	40%
Subtotal Dare	**44,656**	**18,278**	**41%**	**9655**	**3858**	**40%**	**1828**	**795**	**43%**
Region Total	**75,999**	**34,746**	**46%**	**15045**	**6690**	**44%**	**3424**	**1634**	**48%**

Source: NCEM Risk Management Tool

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.

Table 4.98**Error! Reference source not found.** summarizes the number of parcels and their total value that fall within areas with moderate to high risk for wildfire impacts, defined as ratings of -5 to -9 on the WUIRI.

Table 4.98 – Critical Facility Exposure to Moderate to High Risk of Wildfire Impacts

FEMA Lifeline	Critical Facility Count	Total Structure Value
Communications	11	$2,024,450
Energy	3	$1,337,100
Food, Hydration, Shelter	53	$204,757,569
Health and Medical	11	$24,101,680
Safety and Security	56	$75,698,140
Transportation	4	$9,114,260
Water Systems	34	$11,812,020
Total	**172**	**$328,845,219**

Table 4.99 details the buildings at risk to wildfire in the Outer Banks Region.

Table 4.99 – Estimated Buildings Impacted by Wildfire

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Currituck													
Currituck County	17,685	8,394	47%	$1,202,443,436	905	5%	$477,787,006	114	1%	$113,569,325	9,413	53%	$1,793,799,767
Dare													
Unincorporated Dare County	14,019	6,791	48%	$1,065,573,744	325	2%	$98,327,901	89	1%	$91,146,105	7,205	51%	$1,255,047,750
Town of Duck	2,409	594	25%	$208,013,816	27	1%	$14,783,889	2	0%	$2,375,605	623	26%	$225,173,310
Town of Kill Devil Hills	6,033	1,071	18%	$172,524,391	71	1%	$48,033,306	10	0%	$39,129,320	1,152	19%	$259,687,017
Town of Kitty Hawk	2,862	863	30%	$169,526,300	47	2%	$32,352,996	5	0%	$4,654,834	915	32%	$206,534,131
Town of Manteo	2,862	863	30%	$169,526,300	47	2%	$32,352,996	5	0%	$4,654,834	915	32%	$206,534,131
Town of Nags Head	2,862	863	30%	$169,526,300	47	2%	$32,352,996	5	0%	$4,654,834	915	32%	$206,534,131
Town of Southern Shores	943	458	49%	$114,321,743	83	9%	$49,400,268	17	2%	$49,456,777	558	59%	$213,178,787
Subtotal Dare	**54,133**	**17,794**	**33%**	**$3,636,462,218**	**986**	**2%**	**$521,205,840**	**190**	**0%**	**$320,001,028**	**18,970**	**35%**	**$4,477,669,091**
Region Total	**71,818**	**26,188**	**36%**	**$4,838,905,654**	**1,891**	**3%**	**$998,992,846**	**304**	**0%**	**$433,570,353**	**28,383**	**40%**	**$6,271,468,858**

Source: NCEM Risk Management Tool

The sectors facing the greatest risk to wildfire in the Outer Banks Region are commercial facilities, critical manufacturing, food and agriculture, government facilities, and transportation systems.

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 4.100 summarizes the potential detrimental consequences of wildfire.

Table 4.100 – Consequence Analysis - Wildfire

Category	Consequences
Public	In addition to the potential for fatalities, wildfire and the resulting diminished air quality pose health risks, 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 priority in all wildland fire management activities. Wildfires are a 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 can damage community infrastructure, including roadways, communication networks and facilities, power lines, and water distribution systems. Restoring basic services is critical. 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.

Category	Consequences
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. Local property values can decline. Extensive fire damage to trees can significantly alter the timber supply through a short-term surplus from timber salvage and a longer-term decline while 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; actions taken to respond to the event; and actions taken to recover from the impacts.

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 based on the proportion of area within the WUI; all jurisdictions have at least 50% of their area in the WUI and were assigned a rating of 3. 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 were assigned a rating of 3; all other jurisdictions were assigned a probability of 2.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Currituck County	2	2	3	4	3	2.5	M
Dare County	3	3	3	4	3	3.1	H
Duck	2	2	3	4	3	2.5	M
Kill Devil Hills	2	2	3	4	3	2.5	M
Kitty Hawk	2	2	3	4	3	2.5	M
Manteo	2	3	3	4	3	2.8	M
Nags Head	2	2	3	4	3	2.5	M
Southern Shores	2	2	4	4	3	2.7	M

4.5.9 HAZARDOUS MATERIALS INCIDENT

HAZARD BACKGROUND

Generally, a hazardous material is a substance or combination of substances which, because of quantity, concentration, or physical, chemical, or infectious characteristics, may either cause or significantly contribute to an increase in mortality or serious illness. Hazardous materials may also pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Hazardous material incidents can occur while a hazardous substance is stored at a fixed facility, or while the substance is being transported along a road corridor or railroad line or via an enclosed pipeline or other linear infrastructure.

The U.S. Department of Transportation (DOT), U.S. Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) all have responsibilities relating to the transportation, storage, and use of hazardous materials and waste. The EPA's Toxic Release Inventory (TRI), is a primary source of information on the use and storage of hazardous materials, as well as data regarding spills and releases.

Hazardous materials are typically divided into the following classes:

- Explosives
- Compressed gases: flammable, non-flammable compressed, poisonous
- Flammable or combustible liquids
- Flammable solids: spontaneously combustible, dangerous when wet
- Oxidizers and organic peroxides
- Toxic materials: poisonous material, infectious agents
- Radioactive material
- Corrosive material: destruction of human skin, corrodes steel

It is common to see hazardous materials releases as escalating incidents resulting from other hazards such as floods, wildfires, and earthquakes that may cause containment systems to fail or affect transportation infrastructure. The release of hazardous materials can greatly complicate or even eclipse the response to the natural hazards disaster that caused the spill.

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. While these incidents can sometimes involve large quantities of materials, their locations can be more easily predicted and monitored.

TRANSPORTATION HAZARDOUS MATERIALS INCIDENT

A transportation hazardous materials incident is the accidental release of chemical substances or mixtures during transport. Transportation hazardous materials incidents 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 Score: 4 – Less than six hours

Duration Score: 2 – Less than 24 hours

LOCATION

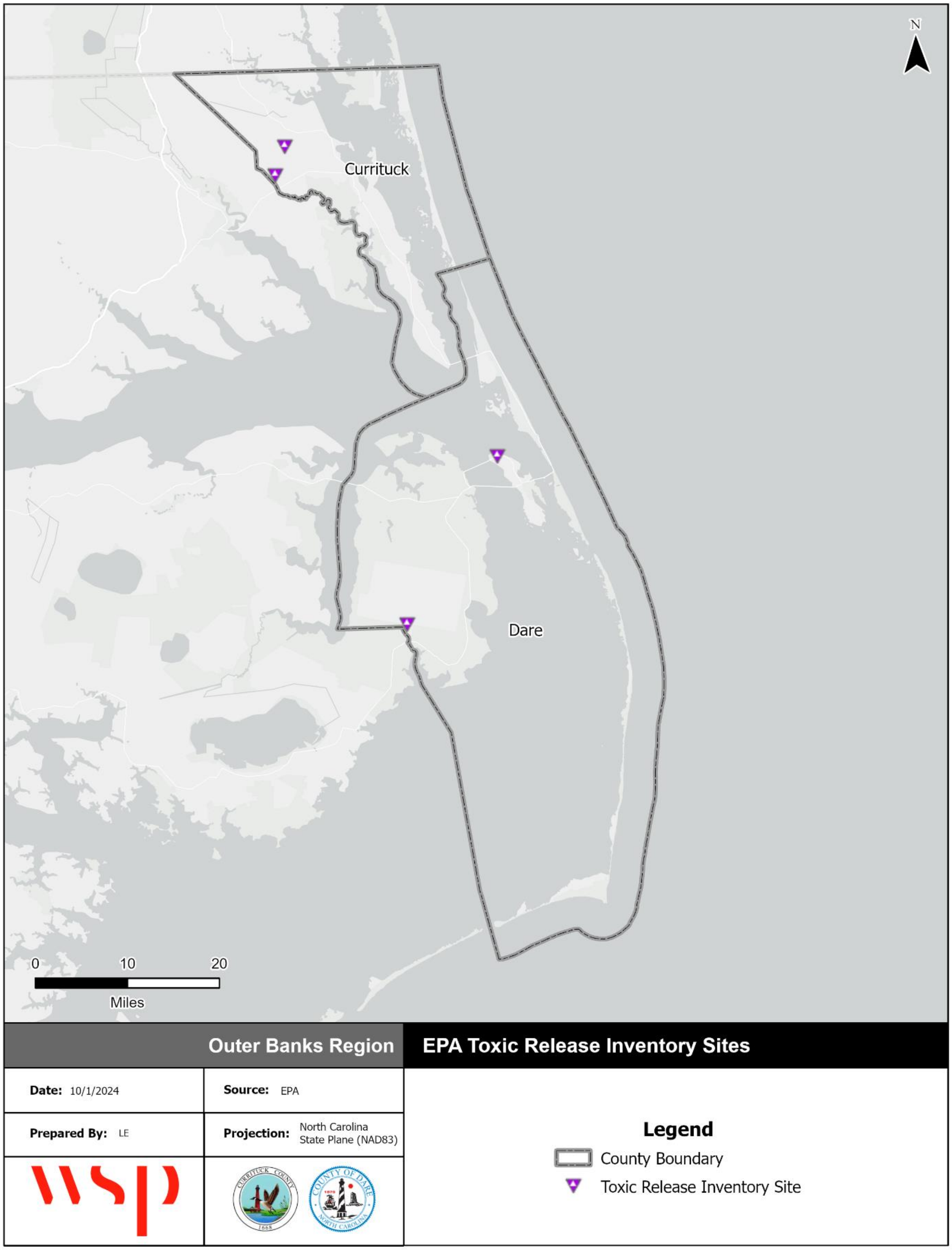
The Toxic Release Inventory (TRI) Program run by the U.S. Environmental Protection Agency (EPA) maintains a database of industrial facilities across the country and the type and quantity of toxic chemicals they release. The program also tracks pollution prevention activities and which facilities are reducing toxic releases. The Toxic Release Inventory reports four sites with hazardous materials in the planning area, two in Currituck County and two in Dare County. These sites are shown in Figure 4.51 and detailed in Table 4.101 below.

Table 4.101 – Toxic Release Inventory Sites

Facility Name	County	Chemicals Reported	Most Recent Release
Tidewater Agricorp Central Fertilizer	Currituck	Ammonium Sulfate, Ammonia, Phosphoric Acid	1988
W S Clark & Sons Inc	Currituck	Ammonia, Phosphoric Acid	1990
Us Air Force Dare County Bomb Range	Dare	Lead	2023
Us Natl Park Service Cape Hatteras Natl Seashore (Caha)	Dare	Lead	2018

Source: US EPA

Figure 4.51 – Toxic Release Inventory Sites in the Planning Area



Source: EPA Toxic Release Inventory

In transit, hazardous materials generally follow major transportation routes, including road, rail and pipelines, creating a risk area immediately adjacent to these routes. In 2021, the Outer Banks Local Emergency Planning Committee (LEPC) commissioned a Joint Hazardous Materials Commodity Flow Study to better understand and plan for exposure risks associated with the transport of hazardous materials. There are no designated or restricted hazardous materials routes in the planning area; all the area's roads have the potential for hazardous material incidents, particularly state and U.S. highways. The 2021 Hazardous Materials Commodity Flow Study identified these primary transportation routes as planning priorities:

- US 158 At NC 12
- US 158 at NC 168
- NC 168 at NC 34
- NC 168 at VA Border
- US 64 at US 264
- US 64 at NC 12

Railroad lines may also transport hazardous materials. Rail is limited in the planning area, with only one freight line, a segment of the Chesapeake & Albemarle Railway, that passes through northwestern Currituck County from Virginia to Camden County, running mostly parallel to NC 168. Per the 2021 Hazardous Materials Commodity Flow Study, the Chesapeake & Albemarle Railway does not transport hazardous materials.

Figure 4.52 shows the major transportation routes through the planning area.

Both Dare and Currituck County also have regional airports, which have Jet A fuel and 100LL fuel stored in large quantities.

Additionally, waterway traffic poses a risk for hazardous materials release. Commodity transport may occur in the Intracoastal Waterway, but no data is available. The Hatteras to Ocracoke ferry transports tanker trucks and vessels carrying large quantities of gasoline, diesel fuel, LP gas, and similar substances. Other near-shore or off-shore shipping accidents could result in hazardous materials releases affecting the region.

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. The location of pipelines, pipeline infrastructure, and past pipeline incidents in the planning area are shown by county in Figure 4.53 and Figure 4.54, as reported in the public viewer of the National Pipeline Mapping System.

Spatial Extent: 1 – Negligible

Figure 4.52 – Key Transportation Routes in the Planning Area

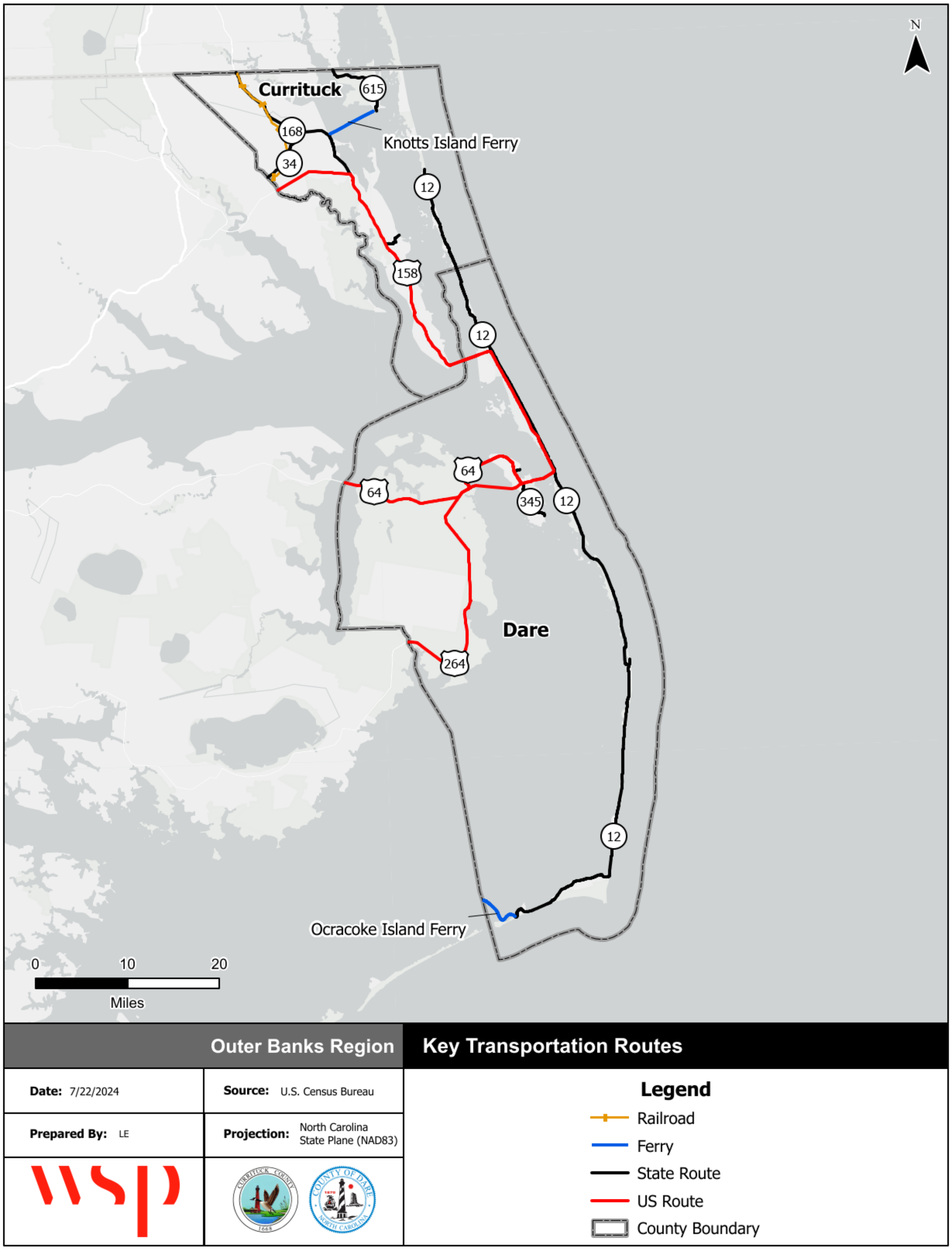
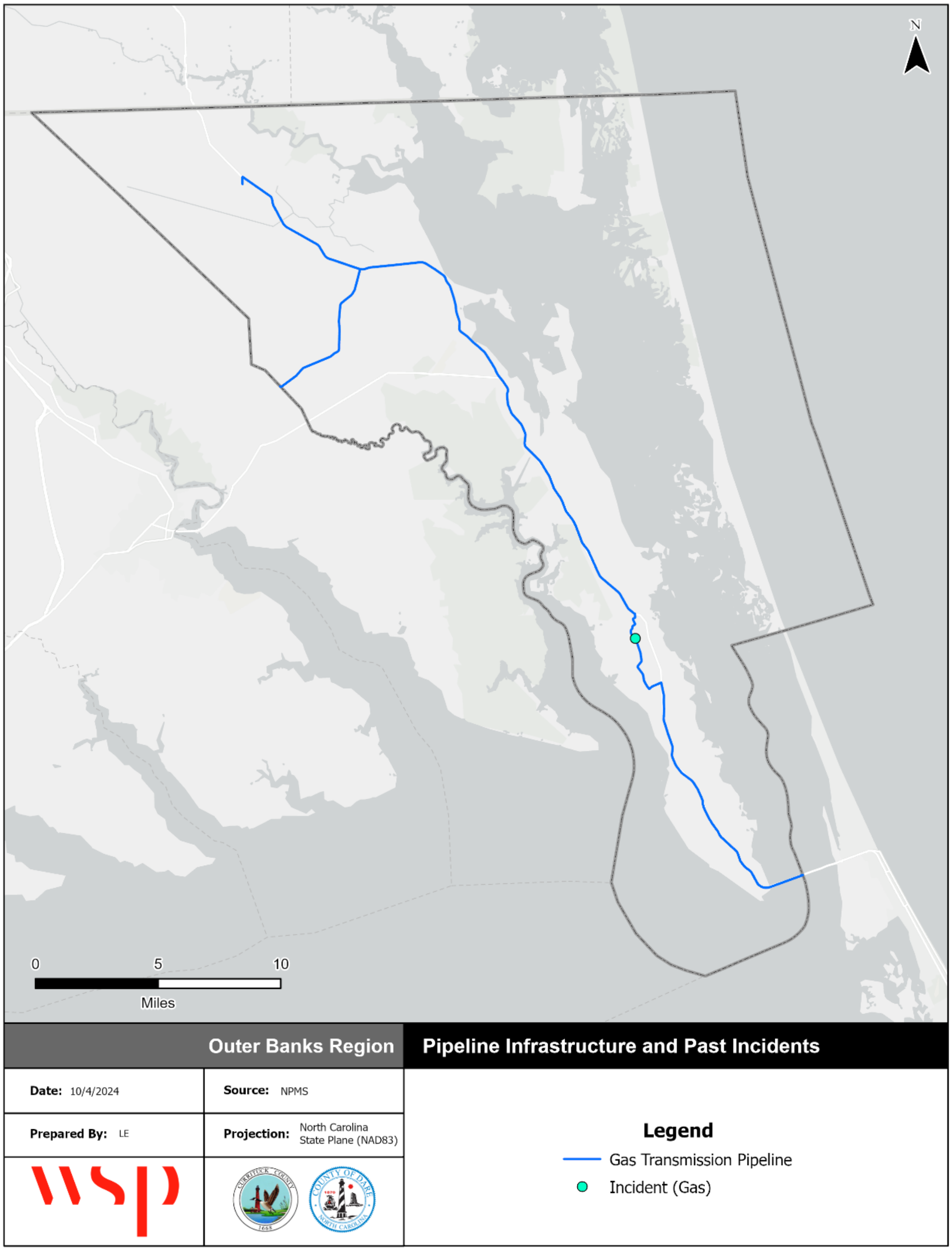
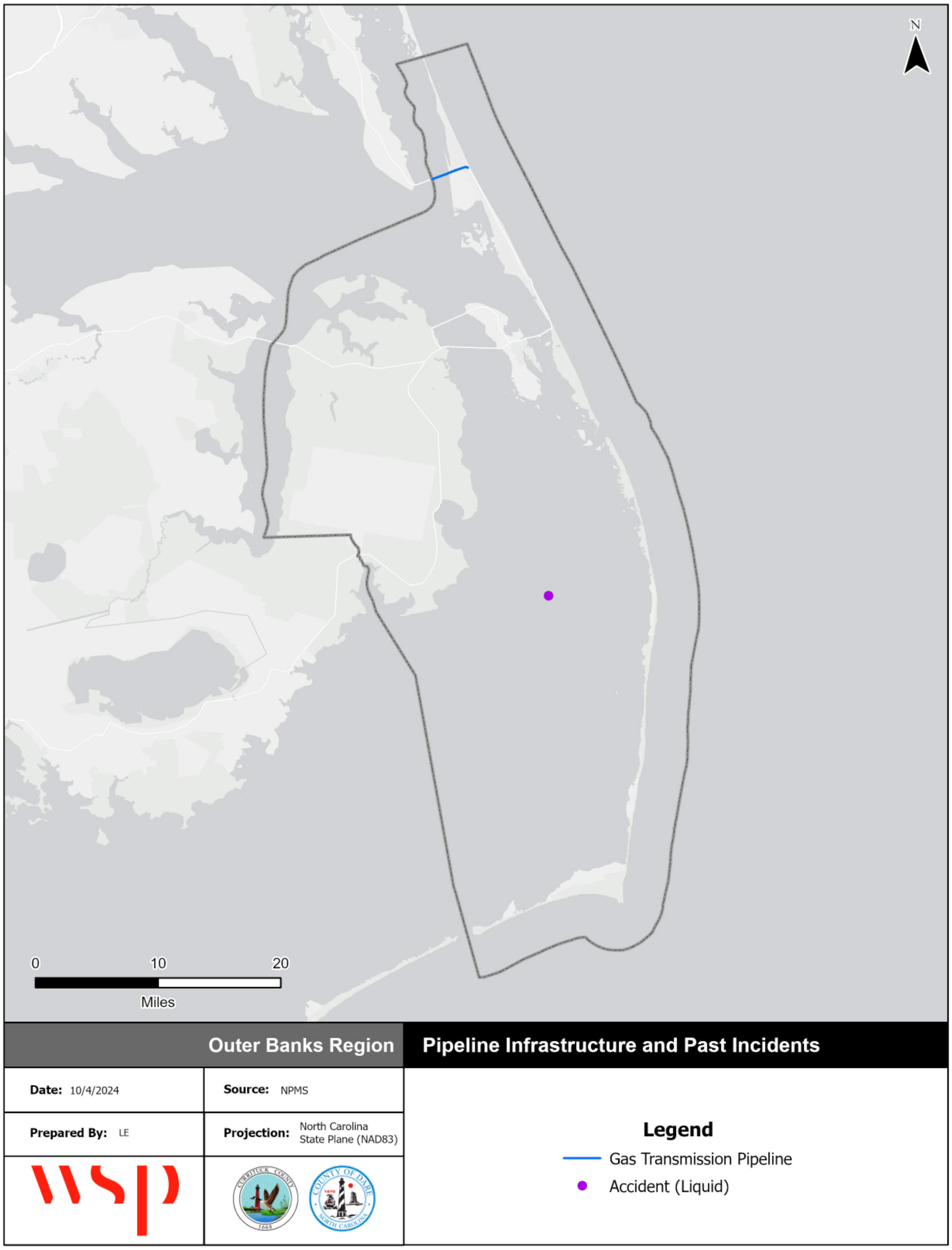


Figure 4.53 – Pipelines, Pipeline Infrastructure, and Past Incident Locations in Currituck County



Source: US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, National Pipeline Mapping System

Figure 4.54 – Pipelines, Pipeline Infrastructure, and Past Incident Locations in Dare County



Source: US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, National Pipeline Mapping System

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 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.

The release or spill of hazardous materials can also require different emergency responses depending on the amount, type, and location of the spill incident. Potential losses can vary greatly for hazardous material incidents. For even a small incident, there are cleanup and disposal costs. In a larger scale incident, cleanup can be extensive and protracted. There can be deaths or injuries requiring doctor’s visits and hospitalization, disabling chronic injuries, soil and water contamination can occur, necessitating costly remediation. Evacuations can disrupt home and business activities. Large-scale incidents can easily reach $1 million or more in direct damages, with clean-ups that can last for years.

Impact: 1 – Minor

HISTORICAL OCCURRENCES

The USDOT’s PHMSA maintains a database of reported hazardous materials incidents since 1989. According to PHSMA records, there were 8 recorded releases in the Outer Banks Region from 1990 to 2023. These releases are listed in Table 4.102. Of these events, two were flagged as serious incidents. In total, these events caused an estimated $316,891 in damages.

Table 4.102 - PHMSA Recorded Hazardous Materials Incidents, 1990-2023

Report Number	Date	Hazard Class	Mode of Transportation	Causes of Failure	Total Damages	Serious?
I-1991060964	6/9/1991	2	Highway		$950	No
I-1998010879	12/13/1997	2	Highway	Loose Closure, Component, or Device	$10	No
I-2000050259	4/28/2000	3	Highway	Loose Closure, Component, or Device	$100	No
I-2003060990	5/22/2003	3	Highway	Rollover Accident; Vehicular Crash or Accident Damage	$311,625	Yes
I-2004041265	4/14/2004	3	Highway		$206	No
E-2009060055	5/6/2009	2.1	Highway	Corrosion - Exterior	$4,000	No
I-2011060083	5/24/2011		Air	Valve Open	$0	No
E-2016100250	9/26/2016	2.1	Highway	Corrosion - Exterior	$0	Yes

Source: PHMSA Incident Reports, Office of Hazardous Materials Safety, Incident Reports Database Search

The most common materials spilled in the planning area are Class 2 (Gases) and Class 3 (Flammable Combustible Liquids). Figure 4.55 describes all nine hazard classes.

Figure 4.55 - Hazardous Materials Classes

Source: U.S. Department of Transportation

The incidents and accidents mapped by PHMSA include a spill of 0.95 bbls of diesel fuel in 2004 in Dare County and a natural gas release in 2010 in Currituck County. Neither event caused any injuries or fatalities.

In addition to these events, in September 2023 Cape Hatteras National Seashore closed beach areas in Buxton after erosion uncovered a Formerly Used Defense Sites (FUDS) used by the Navy and Coast Guard, which resulted in the release of unknown hazardous materials. Cape Hatteras National Seashore staff reported petroleum odors and sheen on the ocean water. Samples from the area tested positive for petroleum-contaminated soils. The beach remains closed until it can be remediated.

The HMPC noted that there are several other FUDS in the region which could pose similar risks.

PROBABILITY OF FUTURE OCCURRENCE

Based on historical occurrences, there have been two serious incidents of hazardous materials releases in the 34-year period from 1990 through 2023. Based on this historical data, there is a 6% annual chance of the planning area experiencing a damaging hazardous materials incident.

Probability: 2 – Possible

VULNERABILITY ASSESSMENT

The impacts of a hazardous materials incident vary based on the type and quantity of material released, as well as the location, time of day, and weather conditions.

METHODOLOGIES AND ASSUMPTIONS

Vulnerability to hazardous materials incidents was assessed based on past occurrences in the region and nationally and the known behavior of these materials.

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 sufficient 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 4.103 summarizes the potential detrimental consequences of hazardous materials incident.

Table 4.103 – 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.

Category	Consequences
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.

4.5.10 RADIOLOGICAL EMERGENCY

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 North Carolina 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 of 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 4.104 shows these classifications, as well as descriptions of each.

Table 4.104 – 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 six hours

Duration: 4 – More than one week

LOCATION

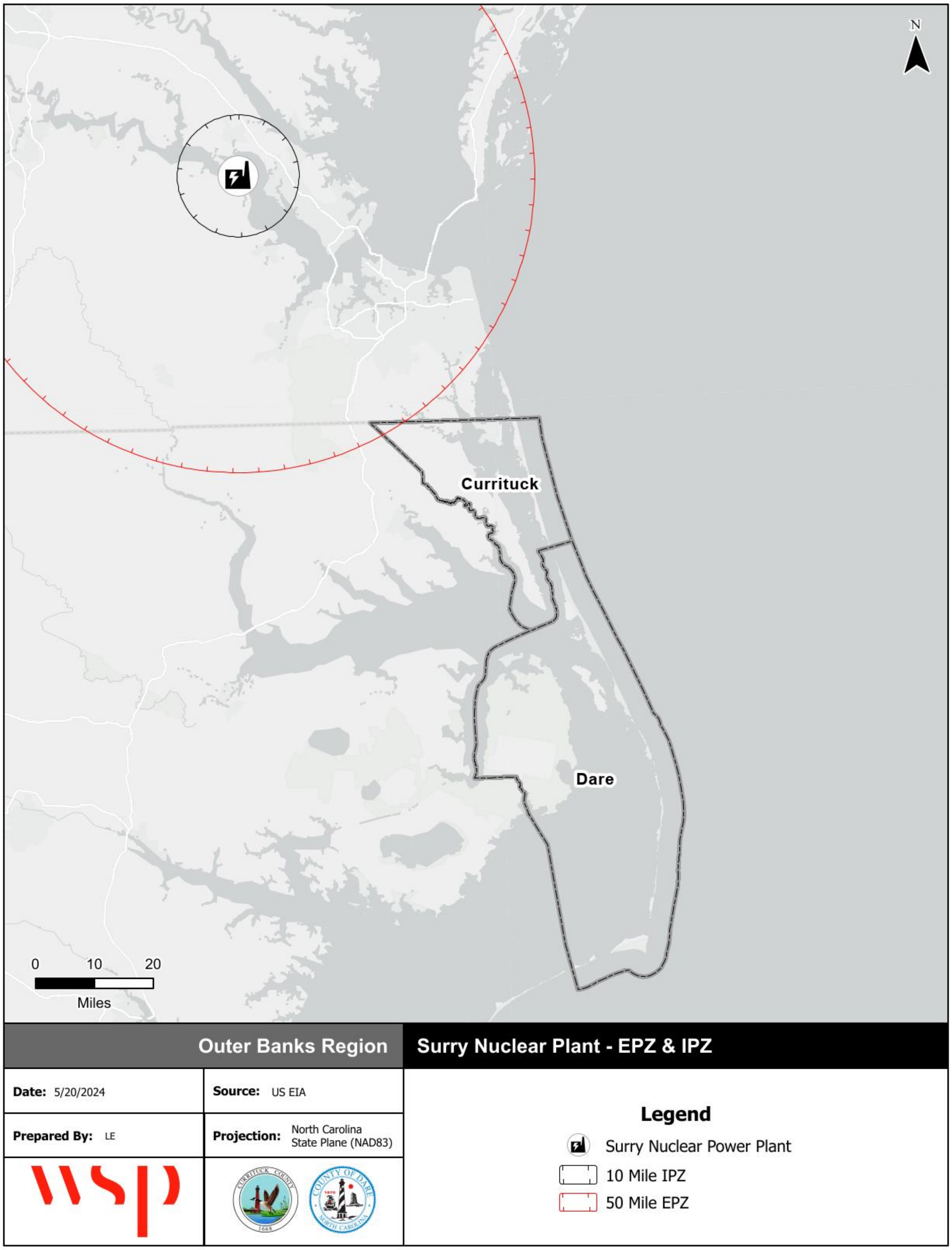
The Nuclear Regulatory Commission defines two emergency planning zones around nuclear plants:

- **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 considered to be 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 products may occur when radionuclides are deposited on surfaces.

The Surry Power Station is located in Surry, Virginia, about 17 miles away from Newport News. Its license of operation was issued in 1972 and is currently operating under a renewed license until 2032. The plant generates enough power for 420,000 homes. Northern Currituck County is located within the IPZ for this plant and could see impacts if there were a failure at the plant. Figure 4.56 shows the location of Surry Power Station and the area that falls within the EPZ and IPZ of the plant.

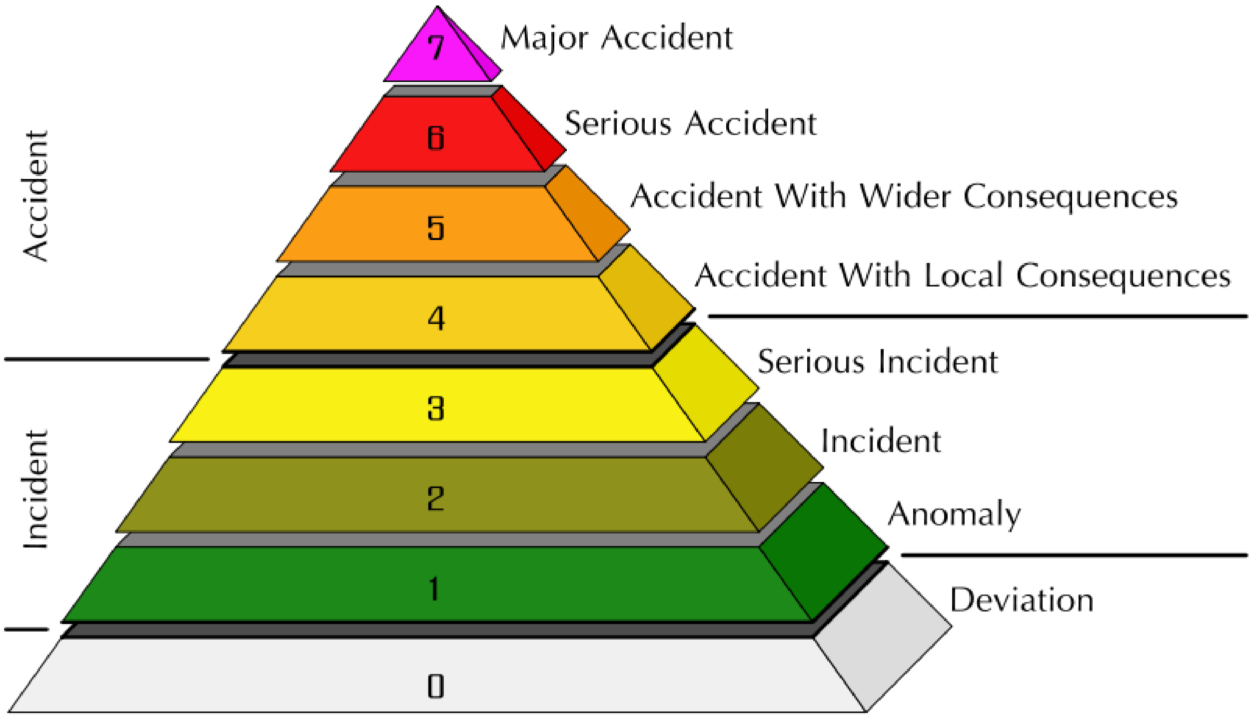
Spatial Extent: 1 – Negligible

Figure 4.56– Surry Power Station Location



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: 2 – Limited

HISTORICAL OCCURRENCES

As reported in the 2018 State Hazard Mitigation Plan, there have been no major release events in North Carolina nuclear facilities; there was one situation in 2008 where the nuclear material was being monitored for criticality that occurred within the fuel rod fabrication facility.

On April 16, 2011, a tornado touched down in the switchyard of the Surry Nuclear Power Plant, cutting off external power to the plant. Both units of Surry NPP automatically shut down after losing offsite power. Because of loss of offsite power diesel generators started to supply units emergency loads for shutdown and cooling of the plant. Soon after loss of offsite power, the Surry NPP operator notified NRC of the situation and NRC declared an unusual event, the lowest of the four NRC emergency classification levels.

On August 23rd, 2011, an earthquake occurred in central Virginia. Dominion Energy's North Anna reactors automatically shut down. The earthquake was felt at the Surry Power Station, but not as strongly. Dominion Energy declared a Notification of Unusual Event but exited it later the same day. The station was built to seismic standards appropriate for the region.

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 radiological incident.

VULNERABILITY ASSESSMENT

PEOPLE

People within the 50-mile IPZ are at risk of exposure through ingestion of contaminated food and water. Part of northwestern Currituck County is located within a 50-mile radius, or within the Ingestion Pathway Zone (IPZ), of Surry Power Station. High exposure to radiation can cause serious illness or death, but such exposure is unlikely in Currituck County.

PROPERTY

A radiological incident could cause severe damage to the power station itself but would not cause direct property damage outside the station. 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.

CONSEQUENCE ANALYSIS

Table 4.105 summarizes the potential detrimental consequences of radiological incident.

Table 4.105 – Consequence Analysis - Radiological Incident

Category	Consequences
Public	People living in Currituck County could be exposed to contaminated food or water after a major incident, but such an incident is unlikely.
Responders	Responders could 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 station could interrupt power generation and cause power shortages. Regular operations would likely be affected by the response effort an event would require.
Property, Facilities and Infrastructure	Property and facilities in the Outer Banks would not be directly affected by contamination.
Environment	Water supply, crops, and livestock within 50 miles of the nuclear station 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 tourism could decline.
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.

4.5.11 CYBER THREAT

HAZARD BACKGROUND

The State of North Carolina Hazard Mitigation Plan defines cyber-attacks 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.

Cyber-crime 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.

The North Carolina State Bureau of investigation’ Computer Crime Unit helps law enforcement across North Carolina solve sophisticated crimes involving digital evidence.

Warning Time: 4 – Less than six hours

Duration: 4 – More than one week

LOCATION

Cyber disruption events can occur and/or impact virtually any location in the state 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.

Spatial Extent: 2 – Small

EXTENT

The extent or magnitude/severity of a cyber disruption event is variable depending on the nature of the event. 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.

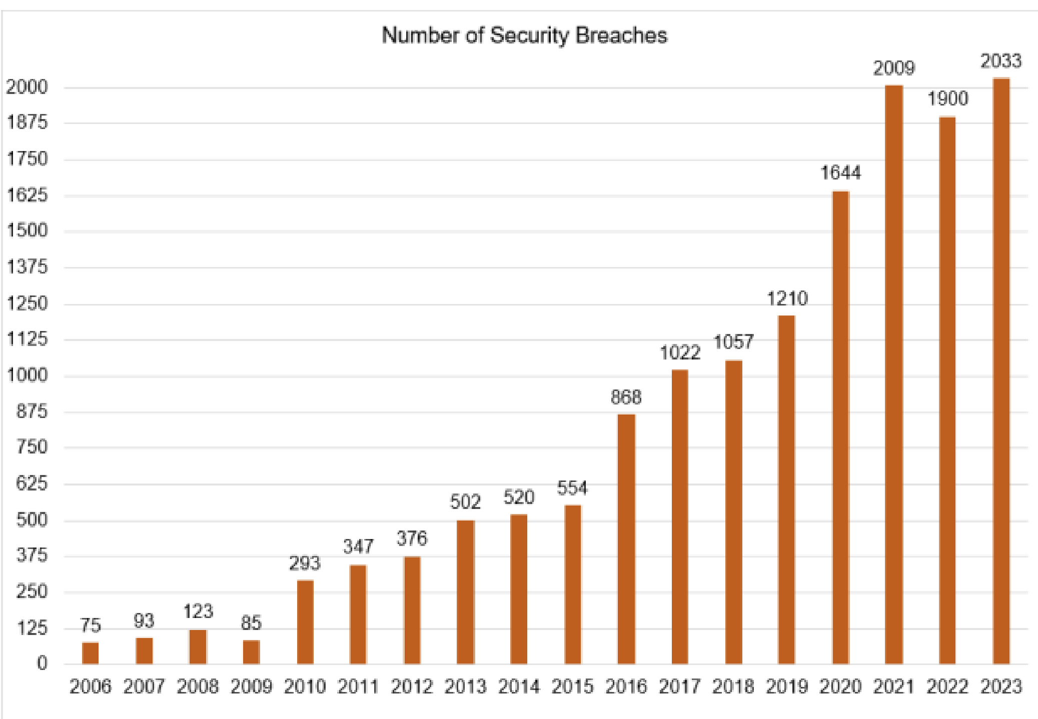
A disruption affecting a small, isolated system could impact only a few functions/processes. Disruptions of large, integrated systems could impact many functions/processes, as well as many individuals that rely on those systems. Ransomware attacks are a particular concern as they can shut down government operations for long periods of time and can interrupt delivery of critical services. For that reason, the HMPC assigned cyber attack an impact rating of critical.

Impact: 3 – Critical

HISTORICAL OCCURRENCES

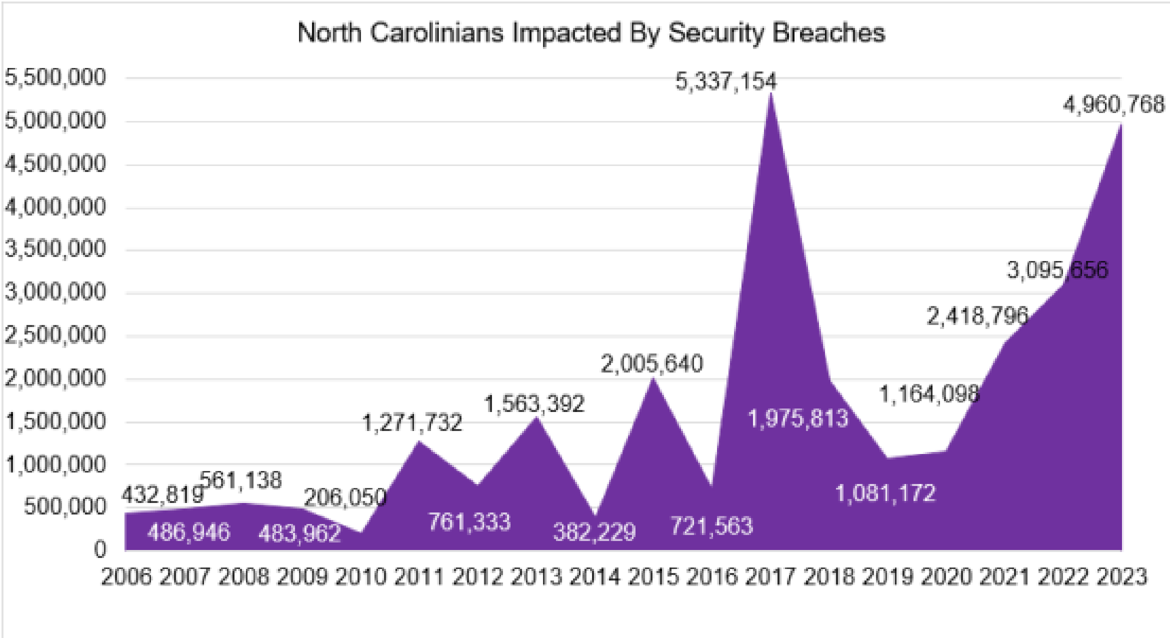
In North Carolina, businesses and organizations that experience data breaches are required to report the breach and the information that was compromised to the NC Department of Justice (DOJ). In 2023, the DOJ received 2,033 data breach notices from organizations according to their annual Data Breach Report. These breaches impacted more than 4.9 million North Carolinians – the second highest number of people impacted in a single year. Additionally, in 2023, hacking-related breaches were at a record high, causing 80 percent of all reported breaches. The report noted that most security breaches impacted general businesses (50%), healthcare industries (14%), and financial services/insurance (23%). It is common for these types of industries to collect many kinds of personal information, making them prime targets for hacking. Figure 4.57 and Figure 4.58 show the findings from the DOJ Annual Data Breach Report.

Figure 4.57 - Number of Security Breaches in North Carolina



Source: North Carolina Department of Justice

Figure 4.58 - North Carolinians Impacted by Security Breaches



Note: In 2017, Equifax experienced the largest-ever data breach in history affecting nearly 5 million North Carolinians, resulting in a high number of people having their information compromised that year.

Source: North Carolina Department of Justice

The Privacy Rights Clearinghouse, a nonprofit organization based in San Diego, maintains a timeline of 17,552 unique data breaches resulting from computer hacking incidents in the United States from 2002-2023. The database lists 359 data breaches on file in North Carolina, totaling 16,588,348 records breached since 2005. In September of 2016, The Outer Banks Hospital reported a breach where 943 records were impacted. While the majority of those breaches were not specifically targeted at the Outer Banks Region, some of them almost certainly included information on individuals who live in the region. Similarly, some Outer Banks residents were almost certainly affected by national and international data breaches.

PROBABILITY OF FUTURE OCCURRENCE

Cyber-attacks occur daily, but most have negligible impacts at the regional level. The possibility of a larger disruption affecting the region exists at all times, 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 Outer Banks Region are almost certain to happen in coming years. Major attacks or breaches specifically targeting systems in the region are less likely but cannot be ruled out.

Probability: 2 – Possible

VULNERABILITY ASSESSMENT

As discussed above, the impacts from a cyber-attack vary greatly depending on the nature, severity, and success of the attack.

METHODOLOGIES AND ASSUMPTIONS

Vulnerability to cyber-attacks was assessed based on past occurrences nationally and internationally as well as publicly available information on these vulnerabilities.

PEOPLE

Cyber-attacks can have a significant cumulative economic impact. According to the Internet Crime Complaint Center run by the Federal Bureau of Investigation, the U.S. experienced a loss of $27.6 billion between the years 2018 to 2022. 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 4.106 summarizes the potential consequences of a cyber threat.

Table 4.106 – 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 attacks against critical infrastructure.
Responders	Cyber-attacks can impact personal data and accounts. Injuries or fatalities could potentially result from a major cyber terrorist attacks 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.

Category	Consequences
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.

4.5.12 TERRORISM

HAZARD BACKGROUND

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.

For this analysis, this hazard encompasses the following sub-hazards: enemy attack, biological terrorism, agro-terrorism, chemical terrorism, conventional terrorism, cyber terrorism, radiological terrorism and public disorder. 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 North Carolina would be notified of any escalating military threats.

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.

Biological terrorism is the use of biological agents against persons or property. 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. Effects of chemical contaminants are similar to biological agents.

Radiological terrorism is the use of radiological materials against persons or property. 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 North Carolina State Bureau of investigation' Computer Crime Unit helps law enforcement across North Carolina solve sophisticated crimes involving digital evidence.

Mass demonstrations, or direct conflict by large groups of citizens, as in marches, protect rallies, 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.

The Southern Poverty Law Center (SPLC) reports 50 active hate groups in North Carolina, listed in Table 4.107. 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 4.107 – Hate Groups Active in North Carolina

Group	Type	Location
Americans for Legal Immigration (ALIPAC)	Anti-Immigrant	Raleigh
North Carolinians for Immigration Reform and Enforcement	Anti-Immigrant	Wade
Gays Against Groomers North Carolina	Anti-LGBTQ	Monroe
Camp Constitution	Antigovernment General	Charlotte
Education First Alliance	Antigovernment General	Apex
Mom Army Charlotte	Antigovernment General	Charlotte
Moms for Liberty - Alexander County, NC Chapter	Antigovernment General	Alexander County
Moms for Liberty - Bladen County, NC	Antigovernment General	Bladen County
Moms for Liberty - Buncombe County, NC	Antigovernment General	Buncombe County
Moms for Liberty - Cabarrus County, NC Chapter	Antigovernment General	Cabarrus County
Moms for Liberty - Chatham County, NC Chapter	Antigovernment General	Chatham County
Moms for Liberty - Forsyth County, NC Chapter	Antigovernment General	Forsyth County
Moms for Liberty - Gaston County, NC Chapter	Antigovernment General	Gaston County
Moms for Liberty - Guilford County, NC Chapter	Antigovernment General	Guilford County
Moms for Liberty - Iredell County, NC Chapter	Antigovernment General	Iredell County
Moms for Liberty - Johnston County, NC	Antigovernment General	Johnston County
Moms for Liberty - Mecklenburg, NC County Chapter	Antigovernment General	
Moms for Liberty - New Hanover County, NC Chapter	Antigovernment General	
Moms for Liberty - Onslow County, NC	Antigovernment General	Onslow County
Moms for Liberty - Orange County, NC Chapter	Antigovernment General	Orange County
Moms for Liberty - Pender County, NC	Antigovernment General	Pender County
Moms for Liberty - Stanly County, NC Chapter	Antigovernment General	Stanly County
Moms for Liberty - Wake County, NC Chapter	Antigovernment General	Wake County
Moms for Liberty - Wilson County, NC	Antigovernment General	Wilson County
No Left Turn in Education - North Carolina	Antigovernment General	Raleigh
North Carolina Moms for America	Antigovernment General	
North Carolina Parents Involved in Education	Antigovernment General	
Tactical Civics - North Carolina	Antigovernment General	
GDL - North Carolina	Antisemitism	

Group	Type	Location
Masharah Yasharahla - Government of Israel	General Hate	Raleigh
Proud Boys	General Hate	Charlotte
Proud Boys	General Hate	Fayetteville
Proud Boys	General Hate	Raleigh
Proud Boys	General Hate	Wilmington
Proud Boys	General Hate	Winston-Salem
Loyal White Knights	Ku Klux Klan	Pelham
III% United Patriots	Militia Movement	Statewide
III% United Patriots	Militia Movement	Mt. Olive
III% United Patriots	Militia Movement	Region 3
Stokes County Militia	Militia Movement	King
Watchmen	Militia Movement	Concord
Identity Dixie	Neo-Confederate	Statewide
Asatru Folk Assembly	Neo-Volkisch	Statewide
America's Remedy	Sovereign Citizens Movement	Charlotte
National Assembly	Sovereign Citizens Movement	Statewide
National Assembly	Sovereign Citizens Movement	Cherokee County
The American States Assembly	Sovereign Citizens Movement	Statewide
Active Club	White Nationalist	Statewide
National Justice Party - North Carolina	White Nationalist	Statewide
Patriot Front	White Nationalist	Statewide

Source: SPLC, https://www.splcenter.org/hate-map

None of the hate groups identified by the SPLC have a specifically identified footprint in Currituck or Dare counties, though it can be inferred that any group with a statewide footprint may have a presence in the area.

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

Warning Time: 4 – Less than six hours

Duration: 4 – More than one week

LOCATION

A terror threat could occur at any location in the Region, but are more likely to target highly populated areas, critical infrastructure, or symbolic locations.

Spatial Extent: 2 – Small

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

HISTORICAL OCCURRENCES

There has never been an act of terrorism in Dare or Currituck counties; however, given the number of visitors to the many national sites and monuments in the region, and the ability to strike at will in most any area, it is prudent for communities in the Outer Banks to recognize potential terrorist threat. The ability to respond to a terrorist incident is provided by county and community emergency operations plans.

In 2022, a state of emergency went into effect in Moore County, North Carolina after two power substations were targeted and shot multiple times with firearms. This act of vandalism caused a mass power outage leaving approximately 45,000 people without power. It was reported that one woman who relied on an oxygen tank died during the incident. Currently, authorities are still unsure of the exact motive of protest that caused this event to occur.

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 terrorism attack in any one area in the Region 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

VULNERABILITY ASSESSMENT

METHODOLOGIES AND ASSUMPTIONS

Terrorism impacts van vary widely by the type of terror attack suffered. Terror attacks can be chemical, biological, radiological, nuclear or explosive.

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.

The following hypothetical scenarios illustrate the potential impacts of biological, chemical, and explosive attacks on sites in the Outer Banks Region. Three specific sites were chosen to illustrate potential worst-case 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.

Scenario #1 – Biological Attack: Aerosol Anthrax

Scenario Overview: A truck fitted with an improvised spraying device disseminates a liquid slurry containing anthrax spores. The hypothetical target for this attack is the Independence Day Fireworks Display at Historic Corolla Park in Currituck County, which typically draws approximately 7,000 attendees, with additional viewers likely watching from a distance. The size of the affected area and the percentage of people within the area that develop inhalational anthrax are determined based on the following input variables: quantity of release agent is 50 liters, line of release distance is 500 meters (the minimum allowable by the model, assuming the truck drives along Highway 12), population density is 8,000 persons per square mile (assuming the average crowd expands beyond the park boundaries), and dissemination efficiency is 1% (assuming low-tech dissemination). The following assumptions inherent to the model also apply:

— Infectious dose for 50% of people = 10,000 cfu
— Infectious dose for 1% of people = 530 cfu
— This scenario assumes treatment is provided to patients after the infectious agent is identified. For calculation purposes, the untreated case fatality rate = 99%
— Protection factor of buildings = 50%
— Percentage of population outdoors = 15%

Table 4.108Table 4.109 outlines the expected losses based on the above parameters.

Table 4.108 – Estimated Casualties from Aerosol Anthrax

Injury Description	Population affected
Exposures	14,119
Percentage Infected	3.9%
Total inhalation anthrax cases	557

Source: EMCAPS tool

Per the Department of Homeland Security's National Planning Scenarios guidance, "the first cases will not present themselves until 36 hours after the release and a median incubation period of 10 days will be required." Symptoms include fever, headache, weakness, respiratory distress, profound sweating, chest discomfort, cough, and muscle pain. Initial diagnosis may prove difficult if the release occurs during flu season. Persons with primary aerosol exposure to anthrax need to receive antibiotic therapy prior to the onset of symptoms in order to prevent inhalation anthrax - this is an illness with an exceptionally high mortality rate (approximately 40% to 50%) even when met with aggressive medical care. Person-to-person spread does not occur. Actions of incident-site personnel tested after the attack include hazard identification, site control, establishment and operation of ICS, treatment of exposed victims, mitigation efforts, obtainment of personal protective equipment (PPE) and prophylaxis for responders, site remediation and monitoring, notification of airlines and other transportation providers, provision of public information, and effective coordination with national and international public health and governmental agencies" (DHS, 2005).

Scenario #2 – Chemical Attack: Toxic Gas – Chlorine Release

Scenario Overview: A bomb is attached to a tractor trailer tanker carrying compressed chlorine. The entire contents of the tank escape to the atmosphere and the plume spreads to the surrounding area. The hypothetical target for this attack is the annual Dare Day celebration, which brings approximately 5,000 people to downtown Manteo. The plume spreading and the effect on the population are calculated according to the following input variables: outdoor temperature is 90°F, wind speed is 9 mph, the setting is urban (defined by presence of obstructions from buildings and forested areas), and the population density is 3,000 persons per square mile, to account for the increase over normal population density brought by the festival. The following assumptions apply:

— 4,850-gallon tank, all contents released through 3-ft hole
— Partly cloudy, no precipitation
— 50% of people in plume area are indoors
— Effects of chlorine on population determined through evaluation of chlorine gas concentration zones, which were determined using ALOHA plume modeling software (see References)
— First effects on humans at concentration = 10 ppm
— Minimum lethal dose = 430 ppm for 30 min
— Median lethal dose (short-term exposure) = 1,000 ppm

Table 4.109 outlines the expected losses based on the above parameters.

Table 4.109 – Estimated Casualties from Chlorine Attack

Injury Description	Population affected
Fatality	64 persons
Eye pain & swelling, headache, restricted airflow – difficulty breathing, coughing, chest pain, lung inflammation and edema, bloody sputum, vomiting, skin irritation, possible chemical burns	99 persons
Eye pain & swelling, headache, throat irritation, rapid breathing, coughing, chest pain, lung inflammation and edema, bloody sputum, vomiting, skin irritation	221 persons
Eye pain & swelling, headache, throat irritation, rapid breathing, coughing, chest pain, skin irritation	449 persons
Eye irritation, headache, throat irritation, coughing, skin irritation	550 persons
Eye irritation, headache, coughing, skin irritation	522 persons

Source: EMCAPS tool

It is important to note that the psychological distressed but uninfected population (a.k.a. "worried well") reporting to hospitals could be as high as 9 times the actual number of cases.

Scenario #3 – IED: Truck Bomb

Scenario Overview: An Improvised Explosive Device (IED) utilizing an ammonium nitrate/fuel oil (ANFO) mixture is carried in a cargo truck to a populated area and detonated. The hypothetical target for this attack is the annual Seafood Festival at the Soundside Event Site in Nags Head, which brings between 10,000-12,500 people to downtown Manteo. The bomb size is assumed to be 1000 lbs ANFO and there is approximately 3 feet spacing between persons, equivalent to a moderately crowded pedestrian area as might be found on the festival grounds. It is assumed that the explosion takes place in a relatively open area (e.g. stadium parking lot, park, etc). The following assumptions apply:

- ANFO - TNT equivalence = 0.82
- Blast pressure damage impact taken from National Fire Protection Association (NFPA) 921 Guide for Fire and Explosion Investigations - 2001 Edition, Table 18.13.3.1[b]
- Buildings and other physical structures are not considered in these calculations

Table 4.110 outlines the expected losses based on the above parameters.

Table 4.110 – Estimated Casualties from IED Attack

Injury Description	Population
Fatalities	40 persons
Total Persons with At Least 1 Injury	660 persons
Total Injuries	1012 persons

Source: EMCAPS tool

Expected symptoms and injuries would include impact injuries (pulmonary blast), pulmonary contusion, barotrauma, fractures (internal, compound, spinal), smoke inhalation, GI blast injury (edema, hemorrhage, rupture), auditory blast injury (partial or total loss of hearing), lacerations, shrapnel, debris penetrations (glass, metal, etc.) and burns. Per the scenario, over 50% of injuries would be lacerations to civilians. Transportation would be limited or inaccessible near the blast, and services and utilities could be unavailable.

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 4.111 summarizes the potential consequences of a terror attack.

Table 4.111 – 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. Human impacts may be long-term based on attack vector.
Responders	Injuries; fatalities are possible. Responders face increased risks during an effort to stop an attack or rescue others while an attack is underway. Potential impacts to response capabilities may result from an attack.
Continuity of Operations (including Continued Delivery of Services)	Potential impacts to continuity of operations due to attack impacts; delays in providing services; impacts tied to attack vector

Category	Consequences
Property, Facilities and Infrastructure	Impacted roads; downed power lines and power loss; utility disruption. Several key critical sites could be targeted in an attack, causing cascading impacts to daily life in the region
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

4.5.13 INFRASTRUCTURE FAILURE

HAZARD BACKGROUND

The Outer Banks region depends on several key bridges, roads, and ferry crossings for access and services. There is limited redundancy in the transportation network, which means these key infrastructure are integral to the functioning of the communities in the planning area and would cause severe disruptions should they become inaccessible. Damage to any of this infrastructure could result from the majority 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 4.60.

The North Carolina Department of Transportation (NCDOT) maintains an inventory of bridges in North Carolina. Currently there are 15 bridges that were built in 1995 or before within the Outer Banks region. Two of these bridges were rated as Structurally Deficient (SD) while five were rated as Functionally Obsolete (FO). According to NCDOT, a bridge at least 10 years old is considered SD if it is in relatively poor condition due to deterioration or has insufficient load-carrying capacity due to the original design. Bridges that are narrow, have inadequate under-clearances, have insufficient load-carrying capacity, are poorly aligned with the roadway, or can no longer adequately serve existing traffic are considered FO. To qualify for federal replacement funds a must first be classified as SD. These bridges may be at a higher risk for infrastructure failure causing inaccessibility to the Region. Bridges built in 1995 or prior are listed below in Table 4.112.

Table 4.112 – Bridges Built in 1995 or Prior

County	Bridge Number	Route	Crossing	Deficiency	Year Built	Age (years)
Dare	270009	US64	Croatan Sound	SD	1955	69
Dare	270008	NC12	The Slash	SD	1956	68
Currituck	260016	US158E	Currituck Sound	FO	1966	58
Dare	270004	US158	Jean Guite Creek		1966	58
Currituck	260012	SR1142	C. Off Intercoastal W		1979	45
Dare	270043	NC400	Dough's Creek		1983	41
Currituck	260015	US158	Intracoastal Waterway		1986	38
Dare	270012	US64	Roanoke Sound		1990	34
Dare	270044	NC12 FERRY	Hatteras Inlet	FO	1991	33
Dare	270045	NC12 FERRY	Hatteras Inlet	FO	1991	33
Dare	270046	NC12 FERRY	Hatteras Inlet	FO	1991	33

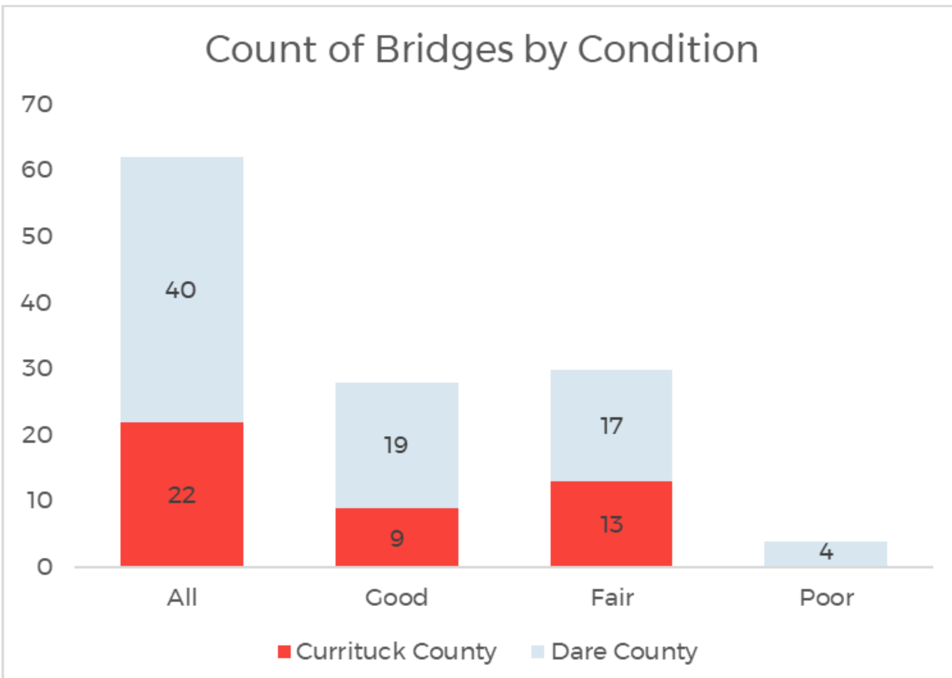
County	Bridge Number	Route	Crossing	Deficiency	Year Built	Age (years)
Dare	270005	SR1217	Cr Off Kitty Hawk Bay	FO	1994	30
Dare	270006	SR1217	Colington Creek		1994	30
Dare	270014	US64	Pond Island		1994	30
Currituck	260035	US158W	Currituck Sound		1995	29

Source: North Carolina Department of Transportation, updated August 2024

Spatial Extent: 2 – Small

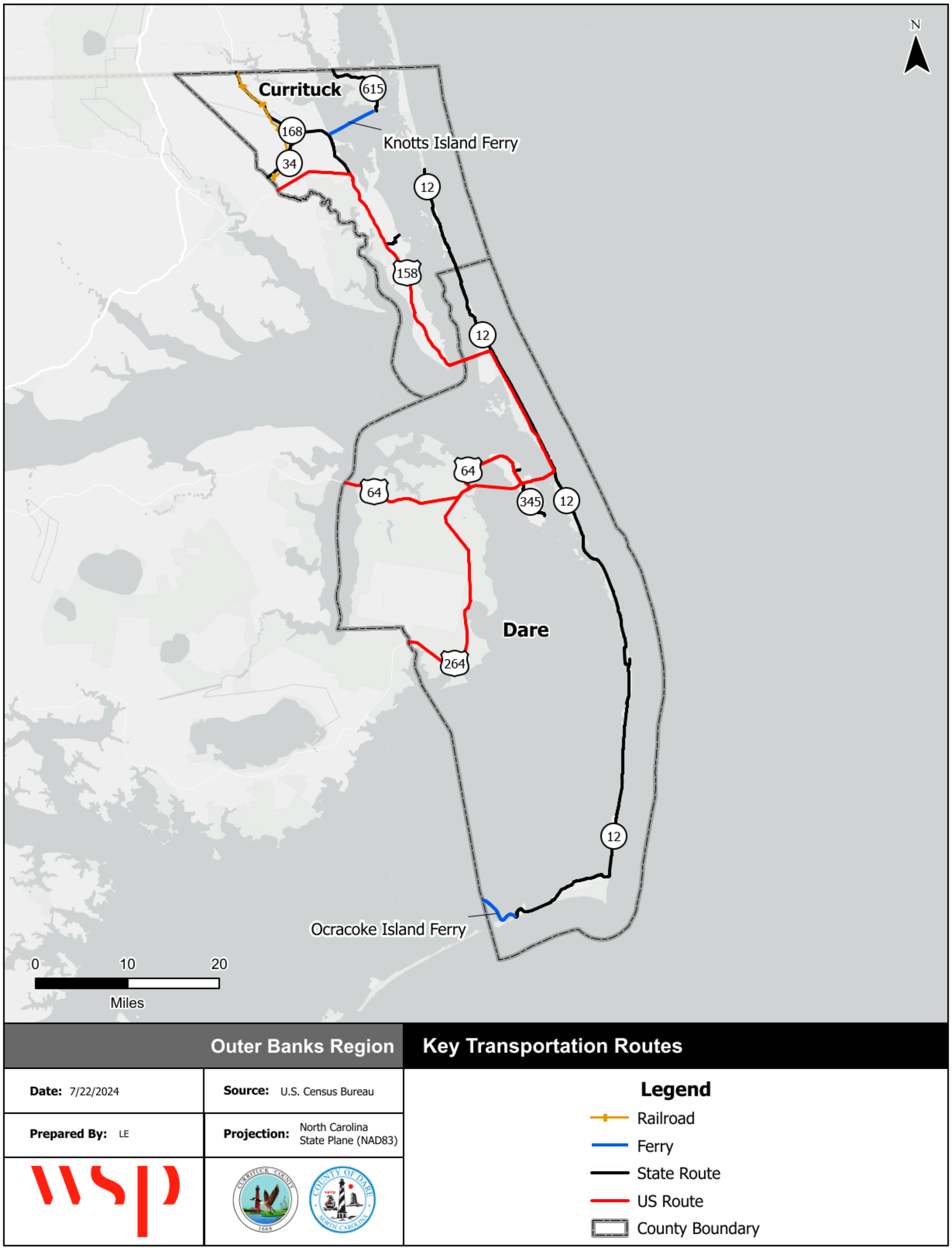
Figure 4.59 shows the distribution of bridges in Currituck County and Dare County by their rated condition according to data from the Federal Highway Administration as of June 2024. Per this data, most bridges in the region are in fair or good condition. There are four bridges in Dare County in poor condition.

Figure 4.59 – Bridge Condition by County



Source: U.S. Department of Transportation, 2024 - Bridge Condition by County - National Bridge Inventory - Bridge Inspection - Safety Inspection - Bridges & Structures - Federal Highway Administration (dot.gov)

Figure 4.60 – Key Transportation Routes in the Planning Area



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 were closed or failed during a hurricane evacuation, it could put thousands of residents and visitors at risk.

According to a report published by The National Transportation Research Group known as TRIP, $672 billion in goods are shipped to and from sites in North Carolina every year. Approximately 81% of these goods are carried by trucks using the state's highway system. In addition to casualties, the loss of local roads could impact the accessibility for goods to be transported by trucks that are deemed necessary for residents living in the region.

Impact: 3 – Critical

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. In 2022, a review of statistical characteristics of bridge failures was conducted by a Highway Research Center at Chang'an University and found that design error, construction mistakes, hydraulic, collision, and overload are the top 5 leading causes of bridge failures.

In 1990, a portion of the Herbert Bonner Bridge collapsed after being hit by a dredge vessel that was carried by hurricane winds and waves. The incident left approximately 5,000 Hatteras residents as well as tourists and fishermen stranded on the island and without power or phone service, as the bridge also carried electrical and phone lines. The economic losses from the incident were estimated at $20 million.

The HMPC previously noted issues with frequent, unpredictable closure of the Alligator River Bridge due to mechanical failures. The bridge is over 60 years old and is a key access point between the barrier island, Roanoke Island, and the mainland.

PROBABILITY OF FUTURE OCCURRENCE

The likelihood of a major transportation infrastructure failure occurring in the Outer Banks Region 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) released their most recent Report Card for America's Infrastructure in 2021 giving the U.S a C- grade overall on infrastructure conditions. The Report Card noted that specifically in North Carolina, driving on roads in need of repair costs each driver $500 per year as 33% of roads in the state are in poor or fair condition. Additionally, it was noted that 9.3% of bridges are rated structurally deficient in North Carolina.

The ASCE estimated that $2.59 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. Due to the passing of the Bipartisan Infrastructure Law in 2021 by the federal government, North Carolina is expected to receive approximately $7.7 billion over the following 5 years in Federal highway formula grant funding for highways and bridges. According to NCDOT, this is about 28.7% more than the State's Federal-aid highway formula grant funding on an average annual basis. These investments may reduce the likelihood of future infrastructure failures.

Probability: 2 – Possible

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 of time 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 4.113 summarizes the potential consequences of a transportation infrastructure failure.

Table 4.113 – 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.

Category	Consequences
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

4.6 CONCLUSIONS ON HAZARD RISK

PRIORITY RISK INDEX

As discussed in Section 4.3 Risk Assessment Methodology and Assumptions, 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 4.114 summarizes the degree of risk assigned to each identified hazard using the PRI method.

Table 4.114 – Summary of PRI Results

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Drought	Possible	Minor	Large	More than 24 hrs	More than 1 week	2.2
Earthquake	Unlikely	Minor	Large	Less than 6 hrs	Less than 6 hrs	1.9
Extreme Heat	Highly Likely	Limited	Large	More than 24 hrs	Less than 1 week	3.0
Flooding	Highly Likely	Critical	Large	6 to 12 hours	Less than 1 week	3.5
Hurricane & Coastal Hazards	Likely	Catastrophic	Large	More than 24 hrs	Less than 1 week	3.3
Tornadoes & Thunderstorms	Highly Likely	Limited	Moderate	Less than 6 hrs	Less than 6 hrs	2.9
Severe Winter Weather	Highly Likely	Minor	Large	More than 24 hrs	Less than 1 week	2.7
Wildfire	Possible	Limited	Moderate	Less than 6 hrs	Less than 1 week	2.5
Hazardous Materials Incident	Likely	Minor	Negligible	Less than 6 hrs	Less than 24 hrs	2.0
Radiological Emergency	Unlikely	Limited	Negligible	Less than 6 hrs	More than 1 week	1.9
Cyber Threat	Possible	Critical	Small	Less than 6 hrs	More than 1 week	2.7
Terrorism	Unlikely	Critical	Small	Less than 6 hrs	More than 1 week	2.4
Infrastructure Failure	Possible	Critical	Small	Less than 6 hrs	More than 1 week	2.7

The results from the PRI have been classified into three categories based on the assigned risk value which are summarized in Table 4.115:

— **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 negligible or nonexistent.

Table 4.115 – Summary of Hazard Risk Classification

High Risk **(≥ 3.0)**	Flooding Hurricane & Coastal Hazards Extreme Heat
Moderate Risk **(2.0 – 2.9)**	Tornadoes & Thunderstorms Severe Winter Weather Cyber Threat Infrastructure Failure Wildfire Terrorism Drought Hazardous Materials Incident
Low Risk **(< 2.0)**	Earthquake Radiological Emergency