SECTION 3.

HAZARD IDENTIFICATION & ANALYSIS

INTRODUCTION

As part of the Southeastern NC Region's hazard mitigation efforts and the preparation of this plan, the three-county region will need to decide on which specific hazards it should focus its attention and resources. To plan for hazards and to reduce losses, the Southeastern NC Region needs to know:

1) the type of natural hazards that threaten the region,
2) the characteristics of each hazard,
3) the likelihood of occurrence (or probability) of each hazard,
4) the magnitude of the potential hazards, and
5) the possible impacts of the hazards on the community.

The following section identifies each hazard that poses an elevated threat to the counties and municipalities located within the Southeastern NC Region. A rating system that evaluates the potential for occurrence for each identified threat is provided (see Table 3-8). The following natural hazards were determined to be of concern for the region:

1. Hurricanes and Coastal Storms
2. Flooding
3. Winter Storms and Freezes
4. Thunderstorms/Windstorms, Lightning, and Hail
5. Tornados
6. Wildfires
7. Earthquakes
8. Dam/Levee Failures
9. Droughts and Extreme Heat
10. Tsunamis
11. Coastal Hazards
12. Sinkholes

A detailed explanation of these hazards and how they have impacted the region is provided on the following pages. The weather history summaries provided throughout this discussion have been compiled from the National Oceanic and Atmospheric Administration (NOAA) as provided through the National Climatic Data Center (NCDC). The NCDC compiles monthly reports that track weather events and any financial or life loss associated with a given occurrence. These reports are compiled and stored in an online database that is organized by state and county for the entire United States. The data presented within this section as well as Appendix E are the results of this research.

HURRICANES AND COASTAL STORMS

Hurricanes are cyclonic storms that originate in tropical ocean waters poleward of about 5° latitude. Basically, hurricanes are heat engines, fueled by the release of latent heat from the condensation of warm water. Their formation requires a low pressure disturbance, sufficiently 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.

Hurricanes that impact North Carolina form in the so-called Atlantic Basin, from the west coast of Africa westward into the Caribbean Sea and Gulf of Mexico. Hurricanes in this basin generally form between June 1 and November 30, with a peak around mid-September. As a hurricane develops, barometric pressure at its center falls and winds increase. Winds at or exceeding 39 mph result in the formation of a tropical storm, which is given a name and closely monitored by the NOAA National Hurricane Center in Miami, Florida. When winds are at or exceed 74 mph, the tropical storm is deemed a hurricane.

Because hurricanes derive their strength from warm ocean waters, they are generally subject to deterioration once they make landfall. The forward momentum of a hurricane can vary from just a few miles per hour to up to 40 mph. This forward motion, combined with a counterclockwise surface flow make the right front quadrant of the hurricane the location of the most potentially damaging winds.

Hurricane intensity is measured using the Saffir-Simpson Scale, ranging from 1 (minimal) to 5 (catastrophic). The following scale categorizes hurricane intensity linearly based upon maximum sustained winds.

- Category 1: Winds of 74 to 95 miles per hour. 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.

- Category 2: Winds of 96 to 110 miles per hour. 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.

- Category 3: Winds of 111 to 129 miles per hour. 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.

- Category 4: Winds of 130 to 156 miles per hour. Catastrophic damage will occur: Well-built homes can sustain severe damage with loss of most of the roof structure and/or 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.

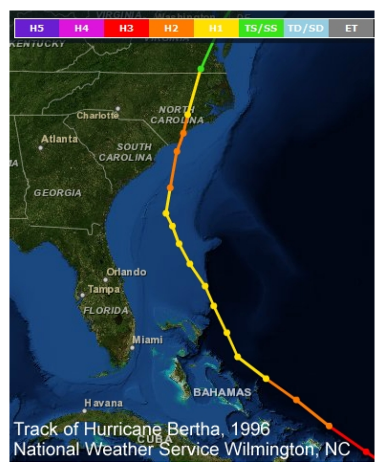
- Category 5: Winds greater than 157 miles per hour. Catastrophic damage will occur: A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Similar to hurricanes, coastal storms are ocean-fueled storm events capable of causing substantial damage to coastal areas due to their associated strong winds and heavy surf. The nor'easter is a particularly devasting type of coastal storm, named for the winds that blow in from the northeast and drive the storm up the US East Coast alongside 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. Coastal storm events 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.

North Carolina has an extensive hurricane history dating back to colonial times. During the nineteenth century, storms occurred in 1837, 1846, 1856, 1879, 1883, and 1899. During the 1950s, North Carolina was impacted by several hurricanes, including Hazel, Connie, Diane, and Ione. Between 1960 - 1990, there was a decrease in landfalling hurricanes, with the exception of Hurricane Donna in 1960, Hurricane Diana in 1984, and Hurricane Hugo in 1989. Recent history has included a number of hurricanes/tropical storms, including several major storms, with Emily (1993), Opal (1995), Bertha (1996), Fran (1996), Bonnie (1998), Dennis (1999), Floyd (1999), Isabel (2003), Charley (2004), Ophelia (2005), Ernesto (2006), Irene (2011), Andrea (2013), and Arthur (2014) all leaving their mark on North Carolina. These storms had varying impacts on the Southeastern NC Region. Following are brief descriptions of several storms in recent history which had a significant impact on the region.

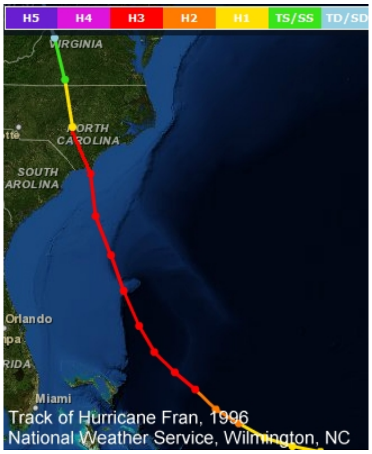
July 5 to July 12, 1996 (Hurricane Bertha)

Hurricane Bertha formed on July 5, 1996. As a Category One hurricane, Bertha moved across the northeastern Caribbean. The storm's highest sustained winds reached 115 mph north of Puerto Rico. Bertha made landfall near Wilmington on July 12 as a Category Two hurricane, with estimated winds of 105 mph. Bertha claimed two lives in North Carolina and did substantial damage to agricultural crops and forestland. Storm surge flooding and beach erosion were severe along the coast. Damages were estimated to exceed $60 million for homes and structures, and over $150 million for agriculture. Corn, tobacco, and other crops received severe damage from the storm. Rainfall totals of over 5 inches were common in eastern North Carolina, resulting in widespread flooding and power outages. The Southeastern NC Region experienced approximately $17,500,000 in crop damage and $27,000,000 in property damage.



Track of Hurricane Bertha, 1996
National Weather Service Wilmington, NC

August 23 to September 5, 1996 (Hurricane Fran)

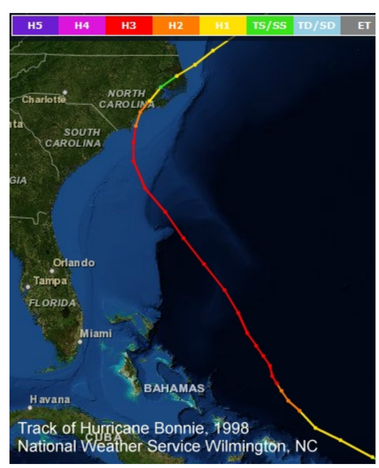


Hurricane Fran was the most destructive hurricane of the 1996 season. The storm was created on August 23, reaching hurricane status on August 29, while about 450 miles to the northeast of the Leeward Islands. It strengthened to a Category Three hurricane northeast of the central Bahamas on September 4. Hurricane Fran, with winds estimated at 115 mph, made landfall over Cape Fear on the evening of September 5, then continued northward over the eastern United States causing widespread damage. Fran was responsible for 34 deaths overall (24 in North Carolina alone), mostly caused by flash flooding in the Carolinas, Virginia, West Virginia, and Pennsylvania.

The storm surge on the North Carolina coast destroyed or seriously damaged thousands of beach front structures. Immediately following the storm, nearly 1.8 million people were without electrical power. Most electrical service was restored within 8-10 days. In Brunswick County, storm surge was around 6 feet, with beach erosion around 15 feet on the eastern islands. Seven beach houses on the east end of Holden Beach were damaged or destroyed. The storm passed through New Hanover County with winds gusting around 110 mph, storm surge 12 feet above mean sea level (MSL), and 40 foot beach erosion destroying most docks and piers. Pleasure Island was hardest hit, as 25 homes were carried off foundations and many others badly damaged. Wrightsville Beach was not hit as hard, but 15 homes were at least 75% damaged. In Wilmington, 14 homes were destroyed and 385 homes suffered major damage. In Pender County, a 12-foot storm surge on Topsail Island caused 40 feet of beach erosion and wiped out dunes as overwash destroyed most of the first row of beach houses and heavily damaged the rest. More than 890 businesses and 30,000 homes were damaged by the storm which also damaged or destroyed 8.25 million acres of forest. The damage in North Carolina alone was estimated at $5.2 billion. The Southeastern NC Region experienced approximately $385,000,000 in property damage, $49,000,000 in crop damages, and two (2) deaths. The agricultural damage was the greatest in Pender County.

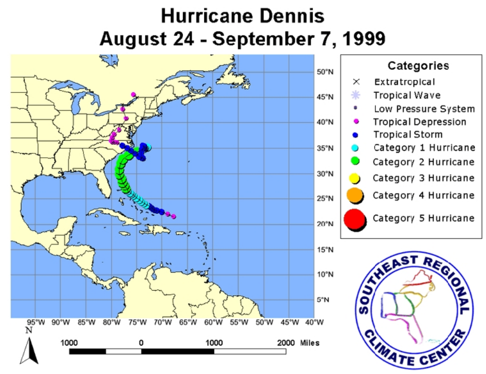
August 19 to 30, 1998 (Hurricane Bonnie)

Hurricane Bonnie originated as a tropical wave over Africa. It slowly increased speed and made its way across the Atlantic, near the Leeward Islands and then Hispaniola. It made landfall near Wilmington as a border Category 2/3 hurricane with approximately 115 mph winds and a diameter of 400 miles on August 27, 1998. Rainfall totals between 8-11 inches were recorded in portions of eastern North Carolina. Storm surge ranged from 5-8 feet with most barrier island overwash from the sound side, not the ocean side. The storm slowly moved off land on August 28, 1998. In its wake, the total damage was estimated in the $1 billion range. There was an estimated $360 million in insured property damage, including $240 million in North Carolina alone. The Southeastern NC Region experienced approximately $72,200,000 in property damage.



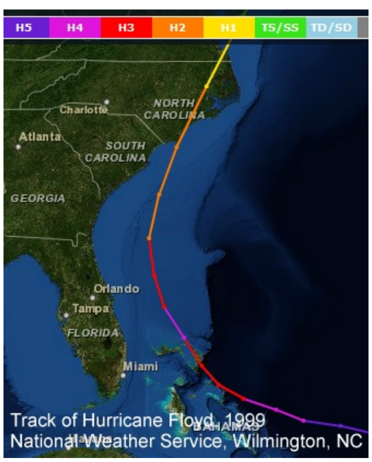
August 24 to September 7, 1999 (Hurricane/Tropical Storm Dennis)

Hurricane Dennis developed over the eastern Bahamas on August 26, 1999, and drifted parallel to the southeastern United States from the 26th to the 30th. The center of Dennis approached to within 60 miles of the Carolina coastline on August 30th as a strong Category 2 hurricane. Although, the storm never made landfall, rainfall amounts approached ten inches in coastal southeastern North Carolina and beach erosion was substantial. Dennis made a return visit in September as a tropical storm, moving west-northwest through eastern and central North Carolina and then lingering off the coast for several days.



For most counties, Tropical Storm Dennis left relatively little in its wake although on the Outer Banks beach 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. For almost a week after Tropical Storm Dennis made landfall, associated rain fell on 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.

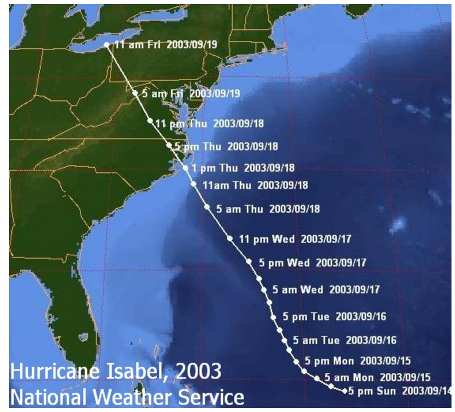
September 7 to 18, 1999 (Hurricane Floyd)



Hurricane Floyd brought flooding rains, high winds, and rough seas to a good portion of the United States coastline from September 14th through the 18th. Although Hurricane Floyd reached Category 4 intensity in the Bahamas, it weakened to a Category 2 hurricane by the time it made landfall in North Carolina. Due to Floyd's large size, heavy rainfall covered a larger area and lasted longer than a typical Category 2 storm. Flooding caused major problems across the region resulting in at least 77 deaths and damages estimated in the billions. In North Carolina alone, 7,000 homes were destroyed; 17,000 homes were inhabitable; and 56,000 homes were damaged.

Extreme flooding was experienced across most counties. Inland flooding exceeded Hurricane Bertha, Fran, Bonnie, and Dennis combined. Most counties reported their worst flooding ever. The Northeast Cape Fear River had the worst flood of the century, while the Black River flood was the worst since 1945. Unbelievable numbers of homes were covered with water and over half a million customers throughout the warning area were without power. High water closed most roads, including US 17, isolating many areas. A dam failed at Boiling Spring Lakes, inundating the area. In Pender County, more than 3,000 hogs, 90,000 turkeys, and 200 cows were lost due to drowning. Animal waste and septic tanks added pollution to the flooding. Two human fatalities occurred as motorists drove into flooded parts of highways. Unofficially the flooding from Hurricane Floyd has been compared to a 500-year flood.

September 6 to 19, 2003 (Hurricane Isabel)

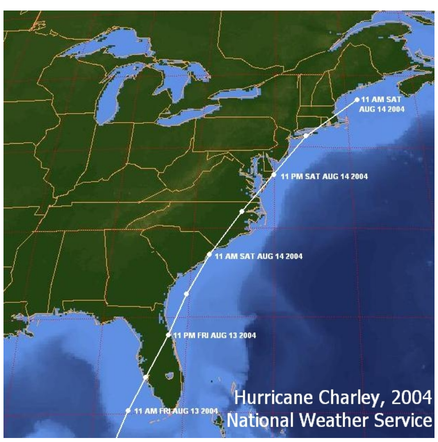


Hurricane Isabel, 2003
National Weather Service

Hurricane Isabel began her path to the east coast of the United States as a tropical storm around September 6, 2003. On September 7th, Isabel was upgraded to a hurricane with 90 mile per hour (mph) sustained winds. By September 8th , Isabel became the third major hurricane of the year at a Category 4 with winds reaching almost 135 mph. Isabel continued her path towards the east coast with a well-formed eye and catastrophic winds that eventually reached 160 mph on September 11, 2003. According to the National Oceanic and Atmospheric Administration (NOAA), at that point Isabel's hurricane force winds extended 60 miles out from the center and tropical storm force winds extended approximately 185 miles out. The storm began to weaken and on September 16th was reduced to a Category 2. Large ocean swells and dangerous surf were experienced from South Carolina to New Jersey.

The hurricane made landfall on September 19th along the southern Outer Banks. Widespread power outages were experienced in eastern North Carolina and Virginia. The fringe of Isabel's circulation caused offshore winds gusting near 60 mph along the beaches of Pender, New Hanover, and Brunswick counties. Damage was minimal, mainly to scattered tree limbs and some roof shingles. Beach erosion damaged a roadway on Bald Head Island in Brunswick County.

August 9 to August 15, 2004 (Hurricane/Tropical Storm Charley)

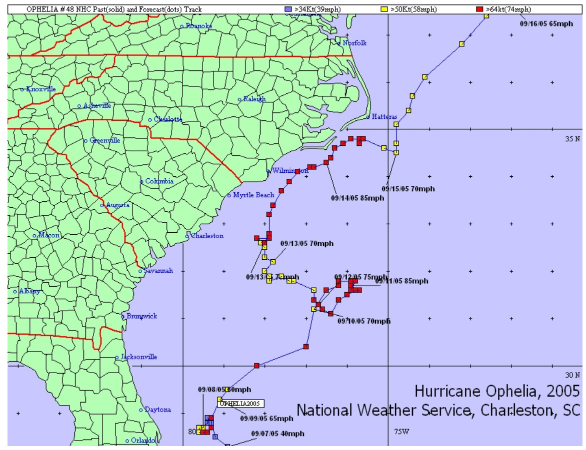

Hurricane Charley, 2004
National Weather Service

Hurricane Charley initially made landfall on the west coast of Florida between Fort Myers and Tampa as a Category 4 hurricane. The storm crossed Florida, and exited the coast as a Category 1 storm. It continued northeast and made landfall again near Cape Romain as a weak Category 1 hurricane with sustained winds at 75 mph. It moved up the coast and then inland around Myrtle Beach. In Horry and Georgetown counties, insurance claims totaled $5 million, mostly along the Grand Strand. There were downed trees, roof damage, and flooding along the coast in this area.

Tropical Storm Charley moved northeast across the Coastal Plains of Eastern North Carolina during the afternoon hours of August 14th. Brunswick County was hit the hardest, with peak winds around 85 mph. Damage was extensive, with 2,231 homes damaged, 231 with major damage, and 40 homes destroyed in the county. Many beach homes were damaged, with 221 homes damaged at Sunset Beach alone. Crop damage in Brunswick County was also widespread, with 50% of the tobacco crop lost, and 30% of the corn and field vegetables destroyed. New Hanover County was the next hardest hit, with many businesses damaged in Wilmington and surrounding cities. The majority of the county had power outages from downed limbs on power lines. Rainfall ranged from two (2) inches near the cost, to around four (4) inches from eastern Bladen County, south through

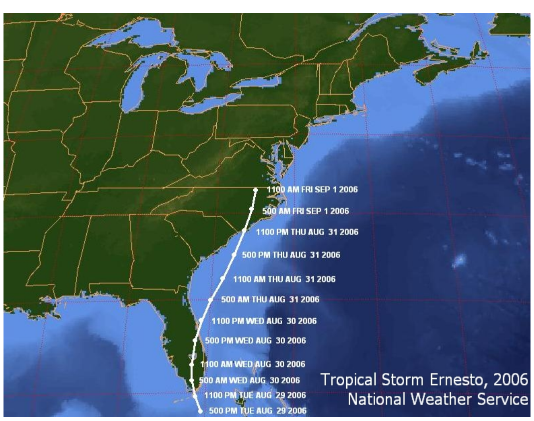
Columbus County. Vegetative debris was widespread, plugging storm drains and contributing to ponding and flooding the next day. Storm surge was minimal, with some minor overwash. Property damages were estimated at $10,175,875 across the Southeastern NC Region.

September 6 to September 17, 2005 (Hurricane Ophelia)



Category one Hurricane Ophelia, with maximum sustained winds of 85 mph, approached the North Carolina coast on the September 13th. The hurricane remained offshore brushing the southern coastal counties of North Carolina on the September 14th and 15th. The large eyewall (50 miles in diameter) was over New Hanover, Pender, and Brunswick counties with hurricane strength wind gusts reported at Wrightsville Beach. There were unofficial reports of wind gusts to 84 mph at Bald Head Island and Kure Beach. Rainfall was heaviest in the eastern portion of Brunswick County. Average rainfall over the Southeastern NC Region ranged from 6 to 10 inches. The storm continued to track slowly northeast. Ophelia brushed by Outer Banks Hyde and Dare counties on the September 16th with hurricane force wind gusts. Damage over the Southeastern NC Region was mainly minor roof damage and flooding. There were moderate reports of downed trees and the utility company reported over 51,000 people without power at the height of the storm. Beach erosion was also a problem. A longshore current gouged a five (5) foot escarpment along the coast of New Hanover and Pender counties. Damage to the area and the cost for clean up was $6 million for Pender and New Hanover counties, with $2.3 million for Brunswick County. Most of the money went to the clean up of storm debris.

August 24 to September 1, 2006 (Tropical Storm Ernesto)



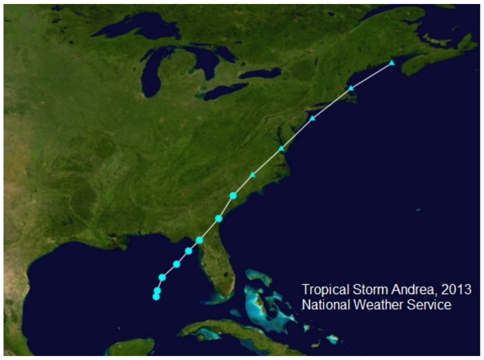
Tropical Storm Ernesto, with maximum sustained winds of 70 mph, made landfall on August 31st during the late evening hours. The strong tropical storm moved across the coastal plains region during the early morning hours of September 1st. In general, wind gusts ranged from 40 to 60 mph with the highest gusts near 70 mph along the coastal sections of New Hanover and Brunswick counties. Most of the property damage was due to rainfall and fresh water flooding, with little structural damage from wind. Rainfall storm totals ranged from 4.5 inches in Columbus County to nearly 12 inches along the coast of Pender County. In Pender County, the Northeast Cape Fear River crested at 16.7 feet, almost 7 feet above the flood stage of 10 feet. This was the second highest crest on record, exceeded only by Hurricane Floyd at 22.5 feet. Flooding on the Northeast Cape Fear River caused 1,600 people to evacuate near the Town of Burgaw, including the Birch Creek and

River Bend communities. The heavy rains contributed to multiple sewer spills, most notable in New Hanover County. Crop damage was extensive, particularly in Columbus and Pender counties. In Pender County, over 12,000 acres of corn were destroyed, 13,000 soybeans, 7,000 acres of cotton, and 760 acres of tobacco were also damaged. Thousands of turkeys and chickens were also lost due to the tropical storm. Along the coast, storm surge was less than 3 feet. Beach erosion was minor to moderate, with some dune loss mainly at Topsail Island.

August 26 to 27, 2011 (Hurricane Irene)

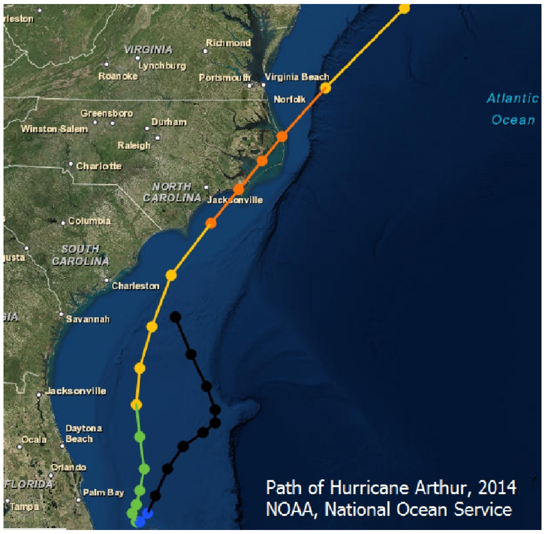
Hurricane Irene made landfall during the morning of the 27th, near Cape Lookout, as a large Category 1 hurricane. Due to the large size of the hurricane, strong damaging winds, major storm surge, and flooding rains were experienced across much of eastern North Carolina. Several destructive tornados occurred during the evening of the 26th associated with the hurricane. Millions of dollars in damages were reported across the area. Property and crop damages were estimated to be 209 million dollars. Storm surge damages were estimated at 420 million dollars. Across the Southeastern NC Region, winds gusting as high as 60 mph resulted in downed trees and power lines with power outages. Rainfall amounts across the Region ranged from three to over eight inches resulting in flooding of roads and low-lying areas. The Southeastern NC Region experienced approximately $4.35 million in property damage.

June 5 to 7, 2013 (Tropical Storm Andrea)



Tropical Storm Andrea made landfall in the Florida Big Bend area during the late afternoon on June 6th. Andrea had the greatest impacts across Eastern NC on June 7th as it moved inland across the area, bringing torrential rain, brief tropical storm force winds, and isolated severe weather. Heavy rain preceded the storm, with tropical rain continuing throughout the day. Rainfall totals were impressive, with many spots receiving 3-4 inches. Brunswick County had the highest totals with an area east of Bolivia receiving 6.46 inches. There were numerous reports of street flooding. The strongest winds came during and slightly after the center of Andrea passed that afternoon. The Wilmington State Port clocked in at 43 kts, with 42 kts reported at the Wilmington International Airport. North Topsail Beach also came in at 43 kts. A 30 foot Grady White vessel was blown off its lift at the dock at Wrightsville Beach.

July 1 to 4, 2014 (Hurricane/Tropical Storm Arthur)



Path of Hurricane Arthur, 2014
NOAA, National Ocean Service

A depression formed off the Florida coast on June 30th and strengthened as it moved north. The tropical system became a hurricane off the Georgia coast and was named Arthur. Hurricane Arthur continued to move north northeast and further strengthened to a Category 2 hurricane with 100 mph winds as it made its closest pass to Wilmington, North Carolina the evening of July 3rd (40 miles). Tropical storm force winds were felt over much of northeast South Carolina and southeast North Carolina. Heavy rain was also a factor, with many locations receiving over three inches of rainfall. The strongest wind recorded in the Region was 66 mph, at Bald Head Island. Tropical storm force winds were experienced for about 10 hours, with numerous power outages reported. Beach erosion was minimal. The storm exited the Region in the early morning on July 4th.

Retired Names

Some hurricanes are so significant and have such a great impact on an area that the names are retired. The name of a hurricane may be retired if the country affected by the storm makes the request to the World Meteorological Organization (WMO). When the name is retired it may not be used again for at least ten years to avoid public confusion with other storms. Several of the hurricanes that affected the Region were so destructive that their names were retired. The following is a list of those hurricanes: Hazel, Connie, Ione, Donna, Fran, Floyd, Isabel, Charley, and Irene.

Extent

North Carolina's geographic location of the Atlantic Ocean and its proximity to the Gulf Stream make it prone to hurricanes. In fact, North Carolina has experienced the fourth greatest number of hurricane landfalls of any state in the twentieth century (trailing Florida, Texas and Louisiana).

The Southeastern NC Region is located in the eastern North Carolina coastal plain. The geographic proximity of the region to the coast increases the likelihood of occurrence for hurricanes. Hurricane extent is defined by the Saffir-Simpson Scale which classifies hurricanes into Category 1 through Category 5 (see pages 3-2 and 3-3). The greatest classification of hurricane to impact the Southeastern NC Region was Hurricane Fran, which was a Category 3 hurricane when it passed through the region. Using Table 3-8 as a guide, it was determined that hurricanes are "likely" to occur in the Southeastern NC Region.

FLOODING

Flooding is a localized hazard that is generally the result of excessive precipitation. It is the most common environmental hazard, due to the widespread geographical distribution of river valleys and coastal areas, and the attraction of residents to these areas. Floods can be generally considered in two categories: flash floods, the product of heavy localized precipitation in a short time period over a given location; and general floods, caused by precipitation over a longer time period and over a given river basin.

Flash floods occur within a few minutes or hours of heavy amounts of rainfall or from a dam or levee failure. Flash floods can destroy buildings and bridges, uproot trees, and scour out new drainage channels. Heavy rains that produce flash floods can also trigger mudslides. Most flash flooding is caused by slow-moving thunderstorms, repeated thunderstorms in a local area, or by heavy rains from hurricanes and tropical storms. Although flash flooding occurs often along mountain streams, it is also common in urban areas where much of the ground is covered by impervious surfaces.

The severity of a flooding event is determined by a combination of river basin physiography, local thunderstorm movement, past soil moisture conditions, and the degree of vegetative clearing. Abnormal weather patterns may also contribute to flooding of a local area. Large-scale climatic events, such as the El Nino-Southern Oscillation in the Pacific have been linked to increased storm activity and flooding in the United States. Nationally, July is the month in which most flash flooding events occur, and nearly 90% of flash floods occur during the April through September period.

While flash floods occur within hours of a rain event, general flooding is a longer-term event, and may last for several days. The primary types of general flooding are riverine flooding, coastal flooding, and urban flooding. Riverine flooding is a function of excessive precipitation levels and water runoff volumes within the watershed of the stream or river. Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall produced by hurricanes, tropical storms, and other large coastal storms. Urban flooding occurs where manmade development has obstructed the natural flow of water and decreased the ability of natural groundwater to absorb and retain surface water runoff. This is partly a result of the use of waterways for transportation purposes in earlier times. Sites adjacent to rivers and coastal inlets provided convenient places to ship and receive commodities. The price of this accessibility was increased flooding in the ensuing urban areas. Urbanization increases the magnitude and frequency of floods by increasing impermeable surfaces, increasing the speed of drainage collection, reducing the carrying capacity of the land, and occasionally overwhelming sewer systems.

The periodic flooding of lands adjacent to rivers, streams, and shorelines (land known as floodplain) is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. When stream flow exceeds the capacity of the normal water course, some of the above-normal stream flow spills over onto adjacent lands within the floodplain. The recurrence interval of a flood is defined as the average time interval, in years, expected between a flood of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence interval.

Floodplains are divisible into areas expected to be inundated by spillovers from stream flow levels associated with specific flood-return frequencies. The National Flood Insurance Program (NFIP) uses flood zone designations to indicate the magnitude of flood hazards in specific areas. The following are flood hazard zones located within the Southeastern NC Region and a definition of what each zone means.

- Zone A: Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.

- Zone AE: Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. In most instances, base flood elevations derived from detailed analyses are shown at selected intervals within these zones.

- Zone AEFW: 100-year floodway; The floodway is an area that includes the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water-surface elevation by more than a designated height.

- Zone VE: Areas subject to inundation by the 1% annual chance flood event with additional hazards due to storm-induced velocity wave action.

- 0.2% Annual Chance (X-500): Areas of minimal flood hazard, usually depicted on FIRMs as above the 500-year flood level.

From 1996-2014, the Southeastern NC Region experienced seventy-six (76) flooding events that were reported to the National Climatic Data Center (see Appendix E for a detailed description of hazard events). On average, the flood level during these flooding events was reported to be 6-8 feet above flood stage. The most significant flood level was in September 1999, when the Cape Fear River crested at 22.48 feet at Burgaw, NC. Further information on the history of flooding events associated with hurricanes in the region is provided in the hurricane discussion of this plan.

Flood hazard varies by location and type of flooding. Coastal areas are most at risk from flooding caused by hurricanes, tropical storms, and nor'easters. Low-lying coastal areas in close proximity to the shore, sounds, or estuaries are exposed to the threat of flooding from storm surge and wind-driven waves, as well as from intense rainfall. Areas bordering rivers may also be affected by large discharges caused by heavy rainfall over upstream areas.

Inland areas are most at risk from flash flooding caused by intense rainfall over short periods of time. Urban areas are particularly susceptible to flash floods. Large amounts of impervious surfaces in urban areas increase runoff amounts and decrease the lag time between the onset of rainfall and stream flooding. Man-made channels may also constrict stream flow and increase flow velocities.

The dominant sources of flooding in the Southeastern NC Region are storm surge and riverine flooding. Based on Table 3-8, the likelihood of occurrence of flooding in the Southeastern NC Region is "highly likely."

WINTER STORMS AND FREEZES

Severe winter storms can produce an array of hazardous weather conditions, including heavy snow, blizzards, freezing rain and ice pellets, and extreme cold. Severe winter storms are extratropical cyclones fueled by strong temperature gradients and an active upper-level jet stream. The winter storms that impact North Carolina generally form in the Gulf of Mexico or off the southeast Atlantic Coast. Few of these storms result in blizzard conditions, defined by the presence of winds in excess of 35 mph, large amounts of snow or blowing snow, and visibilities of less than 1/4 mile for an extended period of time (at least 3 hours). While the frequency and magnitude of snow events are highest in the mountains due to the elevation, the geographical orientation of the mountains and Piedmont contribute to a regular occurrence of freezing precipitation events (e.g., ice pellets and freezing rain) in the Piedmont.

Winter storm events may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Sleet is a raindrop that freezes into an ice pellet formation before reaching the ground, where it usually bounces upon hitting the surface and does not stick to objects. However, sleet can accumulate like snow and cause a hazard to motorists. Freezing rain is rain that falls to the ground when the temperature is below freezing, forming a glaze of ice on roadways and other surfaces. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Even small accumulations of ice can cause a significant hazard, especially on power lines, roads, and trees. A freeze event is weather marked by low temperatures below the freezing point (zero degrees Celsius or 32 degrees Fahrenheit).

Severe winter weather is typically associated with much colder climates; however, in some instances winter storms do occur in the warmer climate of North Carolina. Winter storms can paralyze a community by shutting down normal day-to-day operations. Winter storms can produce an accumulation of snow and ice on trees and utility lines resulting in loss of electricity and blocked transportation routes. Frequently, especially in rural areas, loss of electric power means loss of heat for residential customers, which poses an immediate threat to human life. Because of the rare occurrence of these events, central and eastern North Carolina communities are often not prepared because they cannot afford to purchase expensive road and debris clearing equipment for these relatively rare events. In 2014 and 2015, there were four (4) occurrences of severe winter weather within the Southeastern NC Region (see Appendix E for a detailed description of hazard events).

The entire State of North Carolina has a likelihood of experiencing severe winter weather. The threat varies by location and by type of storm. Coastal areas typically face their greatest threat from nor'easters and other severe winter coastal storms. Freezing rain and ice storms typically occur once every several years at inland locations, and severe snowstorms have been recorded occasionally.

The Southeastern NC Region is unlikely to be hit with severe blizzard conditions (i.e., high winds and blowing snow), but is subject to freezing rain, icing, and snowfall. The extent of winter storms can be measured by the amount of snowfall received (in inches). The greatest one-day snowfall recorded in the Southeastern NC Region was in December 1989, which resulted in approximately 17.5 inches of snowfall in New Hanover County. Based on historic information and the geographic location of the three-county area, the likelihood of occurrence for a severe winter storm is "possible."

SEVERE THUNDERSTORMS/WINDSTORMS, LIGHTNING, AND HAIL

Thunderstorms are underrated in the damage, injury, and death they can bring. Lightning precedes thunder, because lightning causes thunder. As lightning moves through the atmosphere, it can generate temperatures of up to 54,000 degrees Fahrenheit. This intense heating generates shockwaves which turn into sound waves, thus generating thunder.

Warm, humid conditions encourage thunderstorms as the warm, wet air updrafts into the storm. As warm, moisture rich air rises, it forms cumulus nimbus clouds, or thunderstorm clouds, usually with a flattened top or an anvil shape, reaching to altitudes of over 40,000 feet. If this air is unstable, the conditions are favorable for causing hail, damaging winds, and tornados.

Damage to property from direct or indirect lightning can take the form of an explosion or a burn. Damage to property has increased over the last 35 years. This increase is probably due to increased population. Yearly losses are estimated at $35 million by the National Weather Service. This amount is compiled from newspaper reports, but many strikes are not reported. Lightning causes an average of between 55 and 60 fatalities and 300 injuries per year. Between 1995 and 2008, there were 648 fatalities in the United States attributed to lightning strikes. The National Lightning Safety Institute estimates US lightning costs and losses between $5 and $6 billion per year. This information is compiled from insurance reports and other sources that keep track of weather damages.

Thunderstorm winds also cause widespread damage and death. Thunderstorm "straight line" wind occurs when rain-cooled air descends with accompanying precipitation. According to the National Weather Service, a severe thunderstorm is a storm which produces tornados, hail 0.75 inches or more in diameter, or winds greater than 58 mph. At the very extreme, winds of 160 mph have been recorded. These winds can smash buildings and uproot and snap trees, and are often mistaken for tornados.

'Downbursts' are often spawned during thunderstorms. Downbursts are an excessive burst of wind that is sometimes mistaken for tornadic activity. These are defined as surface winds in excess of 125 mph, which are caused by small scale downdrafts from the base of a convective cloud. A downburst occurs when rain-cooled air within a convective cloud becomes heavier than its surroundings. Since cool air is heavier than warm air, it rushes toward the ground with a destructive force. Exactly what triggers the sudden downward rush is still unknown.

Downbursts appear to strike at a central point and blow outward. (Picture a bucket of water dashed against grass. If it hits straight on, the grass will be flattened in a circular pattern. If it hits at an angle, the grass will be flattened in a teardrop pattern).

Downbursts can be further classified into two categories:

- Microburst: Less than 2 ½ miles wide at the surface, duration less than 5 minutes and winds up to 146 miles per hour.

- Macroburst: Greater than 2 ½ miles wide at the surface, duration of 5-30 minutes with winds up to 117 miles per hour.

The Southeastern NC Region is extremely susceptible to thunderstorms/lightning and windstorms, suffering 459 such events from 1956 to 2014. Thunderstorm extent is defined by the number of thunder events and wind speeds reported. According to a 50-year history from the National Climatic Data Center, the strongest recorded thunderstorm wind in the Southeastern NC Region was reported in June 1995, at 85 knots (approximately 98 mph). Additionally, the Southeastern NC Region suffered 235 hail events from 1957 to 2014 (see Appendix E for detailed descriptions of hazard events). Hail extent can be defined by the size of the hail stone. The largest hail stone reported in the Southeastern NC Region was 2.5 inches. Based on Table 3-8, the likelihood of occurrence is "highly likely."

TORNADOS

Tornados are produced during severe thunderstorms, which are created near the convergence zone between warm, moist air and cold, dry air. Tornados derive their energy from the heat contained in warm, moist air masses. Tornados do not form during every thunderstorm. They occur when the moist, warm air is trapped beneath a stable layer of cold, dry air by an intervening layer of warm, dry air. This effect is called an inversion. If this inversion is disturbed, the moist air will push through the stable air that is holding it down. This warm air will then condense as the latent heat it holds is released. This air will then spiral upwards. With the help of different types of winds, this spiral gains speed, producing a tornado.

The path of a tornado is generally less than 0.6 mile wide. The length of the path ranges from a few hundred yards to dozens of miles. A tornado will rarely last longer than 30 minutes. The combinations of conditions that cause tornados are common across the southern U.S. in early spring, especially in April and May. Tornados have been reported lifting and moving objects weighing more then 300 tons up to 30 feet in the air. They can also lift homes off their foundations and move them 300 feet. They collect an incredible amount of debris, which can be projected outward at high velocities. Typically, tornados are accompanied by heavy rain. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris, also accompanied by lightning or large hail. According to the National Weather Service, tornado wind speeds normally range from 40 mph to more than 300 mph. The most violent tornados have rotating winds of 250 mph or more and are capable of causing extreme destruction and turning normally harmless objects into deadly missiles.

The National Weather Service issues a tornado watch for a specific geographic area when conditions favor tornadic activity. A tornado warning is issued when a tornado has actually been sighted or indicated by weather radar.

Waterspouts are weak tornados that form over warm water and are most common along the Gulf Coast and Southeastern states. Waterspouts occasionally move inland, becoming tornados that cause damage and injury. However, most waterspouts dissipate over the open water, causing threats only to marine and boating interests. Typically, waterspouts are weak and short-lived and, because they are so common, most go unreported unless they cause damage.

The intensity, path length, and width of tornados are rated according to a scale originally developed by T. Theodore Fujita and Allen D. Pearson in 1971. At the time Fujita derived the scale, little information was available on damage caused by wind, so the original scale presented little more than educated guesses at wind speed ranges for specific tiers of damage. Further research suggested that wind speeds for strong tornados on the Fujita scale were greatly overestimated, and on February 1, 2007, the Fujita scale was decommissioned (in the US only) in favor of what scientists believe is a more accurate Enhanced Fujita (EF) Scale. The EF Scale is thought to improve on the F-scale on many counts – it accounts for different degrees of damage that occur with different types of structures, both man-made and natural. The expanded and refined damage indicators and degrees of damage standardize what was somewhat ambiguous. It also is thought to provide a much better estimate for wind speeds, and sets no upper limit on the wind speeds for the strongest level, EF5. The Enhanced Fujita Scale is provided in Table 3-1.

Table 3-1. Enhanced Fujita Tornado Scale

Category	Wind Speed	Equivalent Saffir-Simpson Scale	Potential Damage
EF0	65-85 mph	N/A	Light Damage: Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	86-110 mph	Cat 1/2/3	Moderate Damage: Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135 mph	Cat 3/4/5	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.
EF3	136-165 mph	Cat 5	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.
EF4	166-200 mph	Cat 5	Devastating Damage: Well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200 mph	N/A	Explosive Damage: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 300 feet; steel reinforced concrete structures badly damaged; high-rise buildings have significant structural deformation.

Source: National Oceanic and Atmospheric Administration.

A total of ninety (90) tornado events have been documented by the National Climatic Data Center in the Southeastern NC Region since 1951 (see Appendix E for detailed descriptions of hazard events). Tornado hazard extent is measured by the Enhanced Fujita Tornado Scale (see Table 3-1). The greatest magnitude reported was an F2 tornado, which touched down on August 13, 2004, in Pender County, resulting in three (3) deaths, twenty- nine (29) injuries, and $1,300,000 in property damage. In conclusion, tornados represent a significant threat to the Southeastern NC Region due primarily to their relative frequency and large impact. Based on Table 3-8, the likelihood of occurrence is "likely."

WILDFIRES

A wildfire is an uncontrolled burning of grasslands, brush, or woodlands. The potential for wildfire depends upon surface fuel characteristics, recent climate conditions, current meteorological conditions and fire behavior. Hot, dry summers and dry vegetation increase susceptibility to fire in the fall, a particularly dangerous time of year for wildfire.

While natural fires occur in any area in which there is vegetation, flammability varies by species, moisture content, and is influenced by the climate. Temperate, primarily deciduous forests, such as those in North Carolina, are most vulnerable to fire in autumn, when the foliage dries out. Grasses are least prone to ignition in the morning, when their moisture content is greatest.

Many wildfires have been caused by lightning strikes, however, humans are the greatest cause of wildfires. The progressive expansion of human activities into heavily vegetated areas has not only increased the number of wildfires but also increased the losses to life and property. The majority of fires which threaten life and property have been due to human actions. Main sources of ignition have been agricultural fires and discarded cigarette butts and campfires which have gotten out of control.

There are three classes of wildland fires: surface fire, ground fire, and crown fire. A surface fire is the most common of these three classes and burns along the floor of a forest, moving slowly and killing or damaging trees. A ground fire (muck fire) is usually started by lightning or human carelessness and burns on or below the forest floor. Crown fires spread rapidly by wind and move quickly by jumping along the tops of trees. Wildfires are usually signed by dense smoke that fills the area for miles around.

According to Forest Statistics for North Carolina, 2002, published by the USDA-Forest Service, 895,000 acres of the Region's total acreage (1,231,700 acres) are in forestland. This figure represents 72.7% of the Region. The majority of the timberland (560,800 acres, or 62.7%) is in private ownership. Private ownership includes combined acreage for both corporate and individual owners. The rest of the timberland is owned by the State (47,300 acres or 5.3%), Federal (10,400 acres or 1.2%), County & Municipal (500 acres or 0.1%), and the Forestry Industry (275,500 or 30.8%).

Table 3-2 provides a summary of wildfire occurrences by County for the entire region. The largest wildfire event recorded for the Region was the 1955 Green Swamp Fire in Brunswick County, which burned 117,000 acres.

Table 3-2. Southeastern NC Region Wildfire Data

	Brunswick County		New Hanover County		Pender County	
Year	**Fires**	**Acres**	**Fires**	**Fires**	**Acres**	**Acres**
2005	83	873.9	24	38.9	54	80.2
2006	65	998.8	34	29.7	64	206.9
2007	119	824.9	41	55.2	95	2,378.8
2008	76	776.7	15	1,259.5	71	413.1

	Brunswick County		New Hanover County		Pender County	
Year	**Fires**	**Acres**	**Fires**	**Fires**	**Acres**	**Acres**
2009	47	507.1	20	51.2	22	60.3
2010	58	867.2	19	37.7	33	137.0
2011	108	1,313.9	18	31.1	72	32,086.3
2012	71	311.9	9	100.4	23	464.2
2013	29	349.8	6	16.0	26	16.7
2014	63	248.3	6	2.7	48	1,716.0
Totals	**719**	**7,072.5**	**192**	**1,622.4**	**508**	**37,559.5**

Source: NC Forest Service.

As population densities spread out into areas surrounding the forestland, citizens and private property increasingly become more susceptible to the effects of wildfires. While the incorporated government jurisdictions in the Southeastern NC Region have significantly less forestland within their corporate limits and extraterritorial jurisdictions (ETJs) than in the unincorporated areas, the municipal governments' boundaries exist at the "urban/wildland interface" - the area where human development meets undeveloped, forested areas which provide fuel for fires. This "urban/wildland interface" presents the greatest risk to life and property from wildfires.

Overall, however, the risk of wildfire damages in the Southeastern NC Region is mitigated by the fact that forested tracts are generally of manageable size, accessible to fire fighting equipment and personnel, and circumscribed by roadways or waterways that limit the extent and severity of wildfires. Based on Table 3-8, the likelihood of occurrence is "highly likely."

EARTHQUAKES

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

Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site and regional geology.

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. Each unit increase in magnitude on the Richter Scale corresponds to a ten-fold increase in wave amplitude, or a 244-fold increase in energy. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale. It is a twelve-level scale based on direct and indirect measurements of seismic effects. The scale levels are typically described using roman numerals. Table 3-3 provides a summary of the Modified Mercalli Scale of Earthquake Intensity and its relation to the Richter Scale.

Table 3-3. Modified Mercalli Scale of Earthquake Intensity

Scale	Intensity	Description of Effects	Maximum Acceleration (mm/sec)	Corresponding Richter Scale
I	Instrumental	Detected only on seismographs	<10	
II	Feeble	Some people feel it	<25	<4.2
III	Slight	Felt by people resting; like a truck rumbling by	<50	
IV	Moderate	Felt by people walking	<100	
V	Slightly Strong	Sleepers awake, church bells ring	<250	<4.8
VI	Strong	Trees sway; suspended objects swing; objects fall off shelves	<500	<5.4
VII	Very Strong	Mild alarm; walls crack; plaster falls	<1000	<6.1
VIII	Destructive	Moving cars uncontrollable; masonry fractures; poorly constructed buildings damaged	<2500	
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	<5000	<6.9
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	<7500	<7.3
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards	<9800	<8.1
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves	>9800	>8.1

Source: Local Hazard Mitigation Planning Manual, NC Division of Emergency Management.

Earthquakes are relatively infrequent but not uncommon in North Carolina. Earthquake extent can be measured by Richter Scale and the Modified Mercalli Intensity (MMI) Scale (see Table 3-3), and the distance of the epicenter from the Southeastern NC Region. The earliest North Carolina earthquake on record is that of March 8, 1735, near Bath. It is likely that this earthquake was less than Intensity V (slightly strong; sleepers awake). During the great earthquake of 1811 (Intensity VI), centered in the Mississippi Valley near New Madrid, Missouri, tremors were felt throughout North Carolina. The most property damage in North Carolina ever attributed to an earthquake was caused by the August 31, 1886, Charleston, South Carolina, shock. The quake left approximately 65 people dead in Charleston and caused chimney collapses, fallen plaster, and cracked walls in Abbottsburg, Charlotte, Elizabethtown, Henderson, Hillsborough, Raleigh, Waynesville, and Whiteville. On February 21, 1916, the Asheville area was the center for a large intensity VI earthquake, which was felt in Alabama, Georgia, Kentucky, South Carolina, Tennessee, and Virginia. Subsequent minor earthquakes have caused damage in North Carolina in 1926, 1928, 1957, 1959, 1971, 1973, and 1976. The most recent tremor, measured at 2.9 magnitude, happened near Charlotte on March 21, 2011.

In North Carolina, earthquake epicenters are generally concentrated in the active Eastern Tennessee Seismic Zone. The Eastern Tennessee Seismic Zone is part of a crescent of moderate seismic activity risk extending from Charleston, South Carolina, northwestward into eastern Tennessee and then curving northeastward into central Virginia. While there have been no earthquakes with a MMI intensity greater than IV since 1928 in this area, it has the potential to produce an earthquake of significant intensity in the future.

North Carolina's susceptibility to earthquakes decreases from west to east in relation to the Eastern Tennessee Seismic Zone. Generally, there are three different zones of seismic risk in North Carolina. The eastern portion of the State faces minimal effects from seismic activity. Locations in the middle and southeastern areas of the State face a moderate hazard from seismic activity, while the area from Mecklenburg County west through the Blue Ridge faces the greatest risk from seismic activity. These different levels of risk correspond to proximity to areas with historical seismic activity and changes in topography. Brunswick, New Hanover, and Pender Counties are located in the portion of North Carolina that is susceptible to the effects of earthquakes. The likelihood of occurrence for earthquakes is "unlikely."

DAM/LEVEE FAILURE

According to the Dam Safety Law of 1967, a dam is defined as a structure erected to impound or divert water. This term is roughly synonymous with the term "levee" and these terms can be used interchangeably. Dams provide tremendous benefits, including water for drinking, power generation, and flood protection. At the same time, however, dams also represent a great risk to public safety, the environment, and local and regional economies when they fail. Flooding may result at many points along a watercourse when a dam failure occurs. Dams are dynamic structures that experience both internal and external changes in their conditions over time. Old pipes may deteriorate and continued development along rivers can cause more runoff. That runoff can result in the overtopping of dams. In addition, large storm events, such as hurricanes or severe thunderstorms, can overwhelm a dam's ability to function properly.

According to "Success and Challenges: National Dam Safety Program 2002" completed in 2002 by the Association of State Dam Safety Officials, forty (40) dams failed in North Carolina following Hurricane Floyd in September of 1999 and over 100 dams overtopped, causing property damage and requiring evacuation of downstream areas to avoid injury and loss of life.

According to data obtained from the North Carolina Dam Safety Program within the Division of Energy, Mineral, and Land Resources of the NC Department of Environmental and Natural Resources, there are twenty-one (21) dams located in the Southeastern NC Region. Most of these dams (10) are located in Brunswick County with the remaining dams located in New Hanover County (5) and Pender County (6). Table 3-4 provides information regarding those dams.

Table 3-4. Dams Located in the Southeastern NC Region

State ID Code	Dam Name	River or Stream	Dam Status	Hazard Classification	Nearest Town
BRUNS-001	North Lake Dam	Allen Creek	Exempt	Low	Orton
BRUNS-002	Pine Lake Dam	Allen Creek	Exempt	Low	Orton
BRUNS-003	Boiling Springs Lake Dam	Allen Creek	Impounding	High	Orton
BRUNS–004	Hewitt Lake Dam	Shallotte Creek-Os	Exempt	Low	Windy Point
BRUNS-005	Orton Lake Dam	Orton Creek	Exempt	Low	Orton
BRUNS-006	Motsu Disposal Dike	Cape Fear River-Os	Exempt-DOD	Low	Southport
BRUNS-007	Shallotte Wastewater Lagoon No. 1	Shallotte River	Impounding	High	Shallotte
BRUNS-009	Shallotte Wastewater Lagoon No. 2	Shallotte River	Impounding	High	Shallotte
BRUNS-010	ADM-904 Aeration Basin Dike	N/A	Impounding	Intermediate	Southport
BRUNS-011	Boiling Springs Lake Upper Dam	Allen Creek	Impounding	High	Boiling Springs Lake
NEWHA-001	Greenfield Lake Dam	Cape Fear River-Os	Exempt	Low	Wilmington
NEWHA-002	Diamond Shamrock Dam	Cape Fear River-Ne	Exempt	Low	
NEWHA-003	Sutton 1972 Cooling Pond	Cape Fear River	Exempt	Low	Wilmington
NEWHA-004	Sutton 1971 Ash Pond	Cape Fear River	Exempt	Low	Wilmington
NEWHA-005	Sutton 1984 Ash Pond	Cape Fear River	Impounding	Low	Wilmington
PENDE-001	Lake Ann Dam	Jones Creek	Exempt	Low	Still Bluff
PENDE-002	Bond Pond Dam	Moore's Creek	Exempt	Low	
PENDE-003	Squires Lake Dam	White Oak Creek	Exempt	Intermediate	Atkinson
PENDE-004	Olde Point Pond Dam	Cape Fear River-Os	Exempt	Low	
PENDE-005	Camp Kirkwood Lake Dam	Cape Fear River-Ne	Exempt	Low	Wilmington
PENDE-006	Belvedere Golf Course Dam		Exempt	Low	

Source: North Carolina Dam Inventory December 2, 2014, North Carolina Dam Safety Program.

Fifteen (15) of the dams are considered exempt. Exempt status means that a dam is not regulated by dam safety laws because of the size of the dam and/or a low hazard classification. Fifteen (15) of the 21 dams have a low hazard classification and two (2) have an intermediate classification. There are four (4) dams with a high hazard classification: Boiling Spring Lakes Dam (a.k.a., Sanford Lake Dam), Shallotte Waste Lagoon Number 1, Shallotte Wastewater Lagoon Number 2, and Boiling Springs Lake Upper Dam. According to NCDC, a dam failed at Boiling Spring Lakes, inundating the area on September 15, 1999, as a result of Hurricane Floyd. That dam was rebuilt with a concrete ogee-type spillway and is now known as Upper Dam, a high hazard dam due to the proximity of State Route 87 located just downstream of the dam. Table 3-5 provides a description of the dam hazard classifications.

Table 3-5. North Carolina Dam Hazard Classifications

Hazard Classification	Description	Quantitative Guidelines
Low	Interruption of road service, low volume roads Economic damage	Less than 25 vehicles per day Less than $30,000
Intermediate	Damage to highways, interruption of service Economic damage	25 to less than 250 vehicles per day $30,000 to less than $200,000
High	Loss of human life* Economic damage	Probable loss of 1 or more human lives More than $200,000

**Probable loss of human life due to breached roadway or bridge on or below the dam.*
Source: NC Division of Energy, Mineral, and Land Resources.

There is a low probability of failure of the Boiling Spring Lakes Upper Dam due to the construction of the concrete spillway that should minimize the potential for overtopping. The Sanford Dam currently has an existing spillway that is out of compliance with the regulatory requirement to withstand flood levels that correspond with half (½) of the PMP (Probable Maximum Precipitation). Therefore, the potential does exist for overtopping of this dam. The City of Boiling Spring Lakes received funding assistance for design in 2011, and contract documents have been prepared for the construction of a new “additional” spillway to provide adequate hydraulic capacity. With the support of Brunswick County and surrounding communities, the City is currently pursuing grant funding through FEMA for this important project to mitigate the potential for catastrophic failure, and to prevent flooding that has isolated residents from emergency services. In the event of a dam breach or levee failure, the extent of flooding would be similar to that of a flooding event which on average was reported to be 6-8 feet above flood stage (see page 3-11). The likelihood of occurrence of a dam failure affecting the Southeastern NC Region is “likely.”

DROUGHTS/HEAT WAVES

The National Drought Mitigation Center (NDMC) generally defines a drought as a hazard of nature that is a result of a deficient supply of precipitation to meet the demand. Droughts occur in all types of climate zones and have varying effects on the area experiencing the drought. Droughts tend to be associated with heat waves. An extended drought period may have economic impacts (agriculture, industry, tourism, etc.), social impacts (nutrition, recreation, public safety, etc.), and environmental impacts (animal/plant, wetland, and water quality).

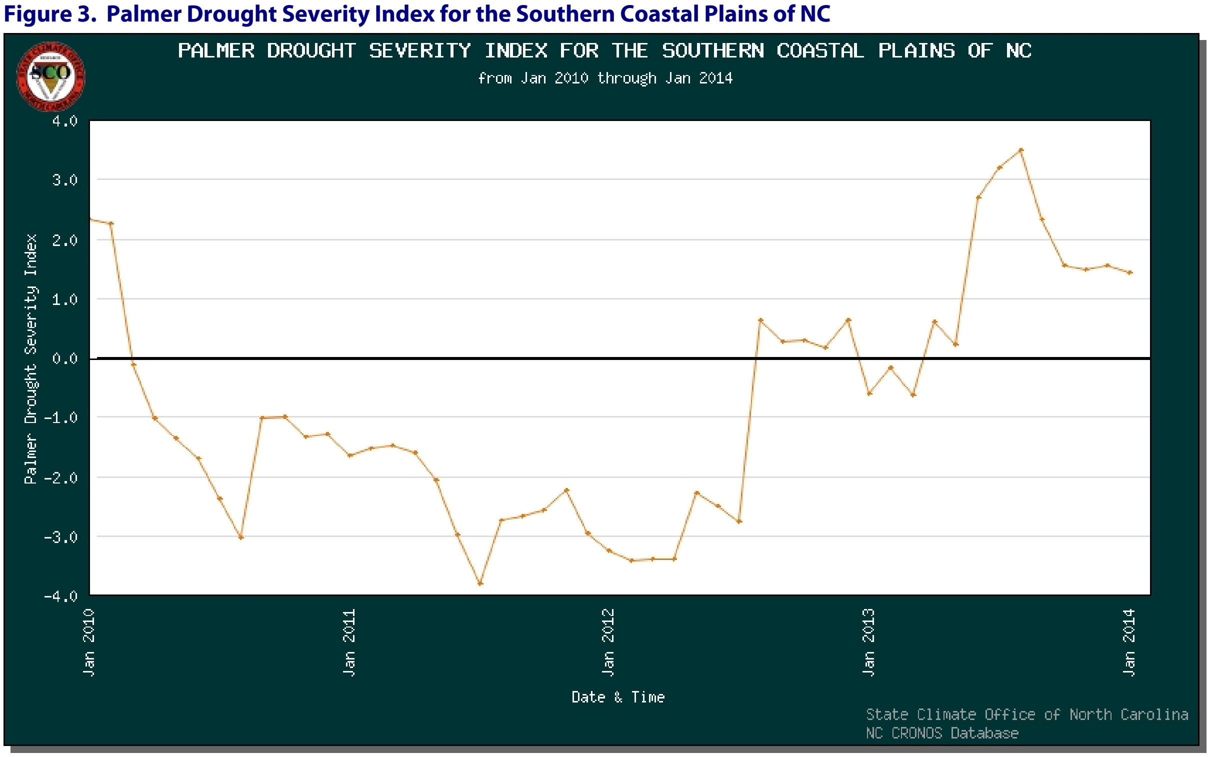
NDMC also reports that droughts are related to the balance between precipitation and evapotranspiration or to the timing of seasonal occurrences such as rainy seasons. Often times, development and human involvement aggravates the impact of droughts. Planning for droughts has become increasingly more important. Thirty-eight states have some type of drought plan in place. North Carolina is one of those states with a drought plan focusing on response.

The Drought Monitoring Council was an interagency coordination and information exchange body created in 1992. In 2002, the council did a creditable job monitoring and coordinating drought responses, while increasing public awareness of the council’s function and effectiveness. In 2003, the General Assembly recognized the Drought Monitoring Council’s leadership and performance by giving them official statutory status and assigning them the responsibility for issuing drought advisories. The council's name was changed to the Drought Management Advisory Council (DMAC) to reflect the broader role of the council, which extends beyond monitoring drought conditions. The drought advisories provide accurate and consistent information to assist local governments and other water users in taking appropriate drought response actions in specific areas of the state that are exhibiting impending or existing drought conditions.

According to the NC Drought Management Advisory Council, there are four categories of drought. From least detrimental to worst, the drought categories are moderate, severe, extreme, and exceptional. State and federal officials use the different drought categories as a barometer to assist local governments and other water users in taking appropriate drought response actions. For instance, drought officials recommend to water users and local governments experiencing moderate drought to minimize non-essential water uses. Non-essential uses include those that do not have health or safety impacts such as car washing and cleaning streets or sidewalks. However, officials recommend that water users eliminate non-essential water use when areas are experiencing severe drought, a category that is one step worse than moderate drought.

In addition to the DMAC classifications, the Palmer Drought Severity Index (PDSI) attempts to measure the duration and intensity of the long-term drought-inducing circulation patterns. Long-term drought is cumulative, so the intensity of drought during the current month is dependent on the current weather patterns plus the cumulative patterns of previous months. Since weather patterns can change almost literally overnight from a long-term drought pattern to a long-term wet pattern, the PDSI can respond fairly rapidly. Note that man-made changes are not considered in this calculation. PDSI index values generally range from -6 to +6, where negative values denote dry spells, and positive values denote wet spells. The following graph depicts the PDSI ratings for the Southern Coastal Plains region which includes the counties of Brunswick, New Hanover, and Pender.

Figure 3. Palmer Drought Severity Index for the Southern Coastal Plains of NC



Extreme heat may exacerbate or induce drought conditions. Differing from drought, extreme heat can have devastating effects on health. Extreme heat is often referred to as a "heat wave." According to the National Weather Service, there is no universal definition for a heat wave, but the standards US definition is any event lasting at least three (3) days where temperatures reach ninety (90) degrees Fahrenheit or higher. However, it may also be defined as an event at least three days long where temperatures are 10 degrees greater than the normal temperature for the affected area. Heat waves are typically accompanied by humidity but may also be very dry. These conditions can pose serious health threats causing an average of 1,500 deaths each summer in the United States.

Drought typically covers a large area and cannot be confined to any geographic or political boundaries. According to the Palmer Drought Severity Index, North Carolina has a relatively low risk for drought hazard. However, local areas may experience much more severe and/or frequent drought events than what is represented on the Palmer Drought Severity Index. It is also notable that drought conditions typically do not cause significant damage to the built environment.

Similar to drought, extreme heat can occur anywhere in the US and has no geographic or political boundaries. Brunswick, New Hanover, and Pender counties are in a region where extreme heat is common in the summer months. However, coastal areas may have a slightly reduced risk due to ocean winds, a natural temperature stabilizer.

There are two ways of monitoring drought outlined within this plan. For the purposes of this plan, the PDSI as outlined above will be utilized to determine extent. The NC State Climate Office indicated that the Southern Coastal Plains region experienced severe drought conditions during the summer months of 1999, 2001, 2002, 2007, 2008, 2010, 2011, and 2012 (-3.81 PDSI in July 2011). Drought effects are often severe. Drought can last for extended periods and it affects all citizens, businesses and government. Brunswick, New Hanover, and Pender counties and the municipalities within those counties have the authority to restrict use of certain water resources. These restrictions and how they are imposed are found in local ordinances. Based on Table 3-8, the likelihood of occurrence for drought is "likely."

TSUNAMIS

The word tsunami is Japanese and means "harbor wave." A tsunami is a wave or series of waves most commonly caused by an earthquake or by a large undersea landslide, volcanic eruption, or other undersea disturbances. From the area of disturbance, tsunami waves will travel outward in all directions and can originate hundreds or even thousands of miles away from affected coastal areas.

In the open ocean, tsunami waves travel at speeds of up to 600 miles per hour but are too small to be observed, and the time between wave crests may be 5 to 90 minutes. As the waves approach shallow coastal waters, they slow down and may rise to several feet or, in rare cases, up to 100 feet. Although the waves slow down as they reach shallow water, the energy remains constant. The first wave is almost never the largest; successive waves may be spaced ten or more minutes apart and continue arriving for many hours. The coastal areas at greatest risk are less than 50 feet above sea level and within one mile of the shoreline. Tsunamis can cause great loss of life and property damage where they come ashore, and most tsunami deaths are the result of drowning. Associated risks include water pollution, damaged gas lines, and flooding. Tsunami activity is possible along the East Coast of the United States, but is a greater risk along the Pacific Rim states (Washington, Oregon, California, Alaska, and Hawaii). As many as 40 tsunami or tsunami-like events have been reported along the East Coast since the early 1600s. Although an East Coast tsunami would be rare, two off-shore areas are currently under investigation according to a 2002 National Geophysical Data Center report. One area of interest consists of large cracks northeast of Cape Hatteras, North Carolina, that could foretell of the early stages of an underwater landslide resulting in a tsunami. The other area of interest consists of submarine canyons approximately 150 kilometers from Atlantic City, New Jersey. Significant factors for consideration with regard to these areas are recent discoveries along the East Coast that demonstrate the existence of pressurized hydrates and pressurized water layers in the continental shelf. This has produced speculation among the scientific community on possible triggers that could cause sudden and perhaps violent releases of compressed material that could factor into landslide events and the resulting tsunami waves.

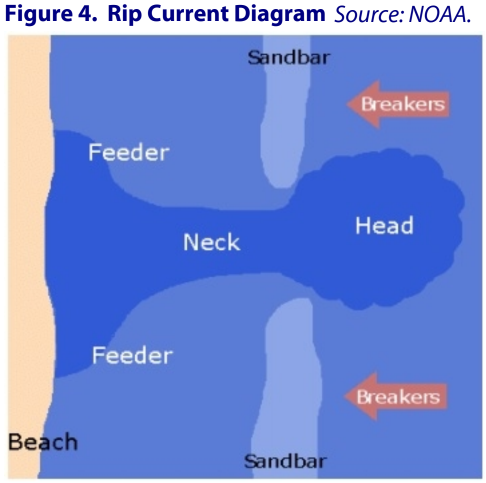
Historical records do not indicate any past significant tsunami occurrences for the Southeastern NC Region, and such an event is generally considered possible but "unlikely." However, the potential for tsunami impacts along the entire Eastern United States coast does exist as evidenced by other recorded tsunami occurrences in the area. The potential local and extent of the tsunami hazard for the Southeastern NC Region is similar and slightly more extensive than the established flood hazard area. The probability of a future tsunami event affecting the Southeastern NC Region is considered to be very low, though coastal areas are at the greatest risk. Even upon impact, the consequences of a tsunami strike are thought to be low for the Region given off-shore terrain. Therefore, there is no indication that this hazard is a significant enough threat to the state or the Region to warrant further analysis or a detailed vulnerability assessment.

COASTAL HAZARDS

Rip Currents

A rip current is an extremely dangerous hazard, killing approximately 100 people each year (according to the National Weather Service). Rip currents form in the surf-zone as waves disperse. According to NOAA, waves break on the sandbar, move towards the beach and then return to the ocean through a channel. Water becomes trapped between the beach and the sandbar, causing the water to move away from the beach in a narrow, river-like channel. There are three parts to a rip current: 1) the feeder; 2) the neck; and 3) the head. The feeder current flows parallel to the shore, converging at the neck and flowing, as a rip current, towards the head. At the head, the current expands and releases slack. Rip currents are typically mushroom-shaped and brown in color due to sand being picked up. However, some may have no color at all. Rip currents also vary in size and shape.

Figure 4. Rip Current Diagram *Source: NOAA.*



According to the National Oceanic and Atmospheric Administration, there are four different types of rip currents including traveling, fixed, permanent, and flash.

- Flash: A flash current is short in duration (less than 10 minutes) and is enhanced by large swell. This causes unpredictable conditions where they occur.
- Permanent: This type of rip current develops along jetties, groins, and piers.
- Fixed: These rip currents are dependent upon the shape of bays, coasts, reefs, or sandbars.
- Traveling: This type of rip current forms along long beach currents which run parallel to the beach. The long beach current pushes the rip away from its original location, weakening it.

Rip currents form along coastal areas in large bodies of water including oceans and the Great Lakes. All of the coastal areas in the Southeastern NC Region are uniformly at-risk to rip currents. Further, these areas are equally susceptible to any of the four types of rip currents. The Fort Fisher revetment in New Hanover County is notorious for permanent rip current occurrences. Piers throughout the Region also have permanent rip currents. The most dangerous rip currents of any type occur during high surf when wave height and wave period are the highest.

A total of fourteen (14) rip current events have been documented by the National Climatic Data Center in the Southeastern NC Region from 1997 to 2014 (see Appendix E for detailed descriptions of hazard events) resulting in twelve (12) deaths and eleven (11) injuries. The probability of future rip current occurrences is "likely." This hazard occurs naturally along the shorelines of the Southeastern NC Region. Inclement weather conditions may hasten the severity of this hazard. This is a very dangerous natural hazard in the Southeastern NC Region that, unlike other hazards, only affects life instead of property. Therefore, no vulnerability assessment will be performed in Section 5, Vulnerability Assessment.

Storm Surge

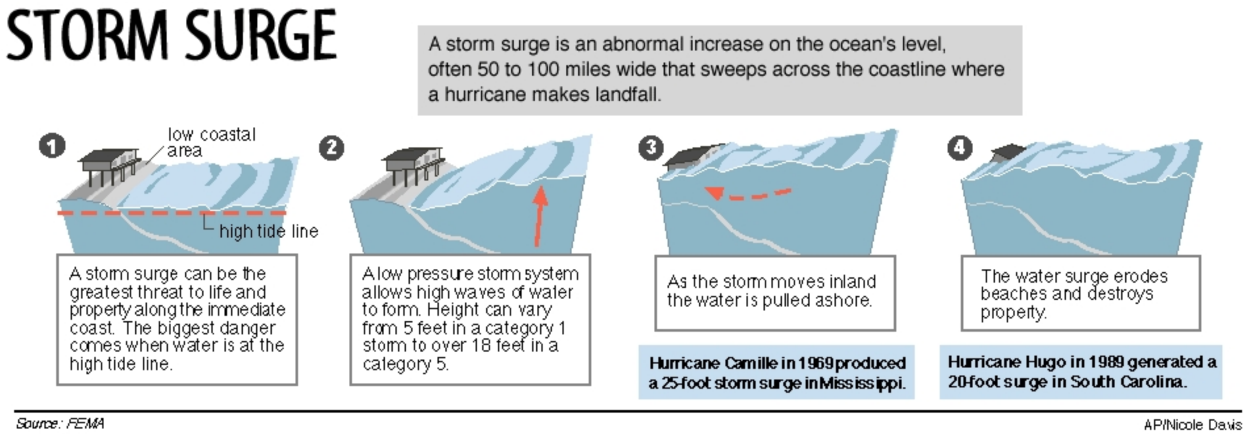
Storm surges are caused by the wind and pressure forces 'pushing' the water into the continental shelf and onto the coastline. The storm surge pushes the tide to rise many feet above its normal level. The height of these surges can reach over 20 feet. A surge, aided by the hammering of the waves, can act like a bulldozer, destroying everything in its path. They also are responsible for coastal flooding and erosion. The storms that generate the large waves of coastal surges can develop year round, but they typically occur from late fall to early spring. Hurricanes and other tropical cyclones also generate storm surges.

Factors controlling storm surges include the following:

- Concave shoreline configurations or narrow bays create resonance within the area due to winds forcing in water, elevating the surface of the water higher.

- Low barometric pressures cause the water surface to rise, thus increase the height of the storm surge.
- Storms that arrive during peak astronomical tides have higher surge heights and more flooding.
- Storms with higher wind speeds drive greater amounts of water across the shallow continental shelf. This increases the volume and elevation of water pushed up against the coast.

Figure 5. Storm Surge



Storm surges cause flooding by dune overwash, tidal elevation rise in inland bays and harbors, and backwater flooding through the mouth of coastal rivers. Storm surge can result in street, business, and residential flooding. The waves accompanying a storm event can strike with enough force to destroy wall systems and undermine foundations, causing collapse. Erosion of a dune system by waves and overwash can expose buildings to destructive flooding, foundation scour, and other damage.

A common way to describe the hazard probability of a storm surge return period has been the 1-percent chance of being equaled or exceeded in any given year, also known as the 100 year flood. The Southeastern NC Region has an expected storm surge elevation with a 10-year recurrence interval of 2+ meters. Dense development on the Region's shorelines increases the number of people and structures at risk.

Although storm surges typically occur during tropical events, several notable non-tropical storm surge events have occurred since 1960. For instance, the Ash Wednesday storm of 1962 affected over 620 miles of shoreline over 4 high tides. This storm caused $300 million in damages. The Halloween Nor'easter of 1991 also caused severe flooding and coastal erosion along the entire East Coast.

Most of the Region has a chance of being impacted by a storm surge, whether through high velocity waves, or flooding. The probability of the Region being impacted by storm surge is likely (see Table 3-8). This impact can be seen on Figures 6 and 7, Hurricane Storm Surge Inundation (Slow and Fast Models). As shown in the figures, areas closest to coastal areas are at high risk for storm surge inundation in addition to most riverine floodplains along major rivers. While areas not located immediately along the coast or major rivers may not be directly impacted by storm surge inundation except in extreme storm events, they might experience flooding caused by storm surge and extremely high tides that affect the drainage of areas further inland.

Figure 6. Storm Surge Inundation - SLOSH Slow Moving Storm

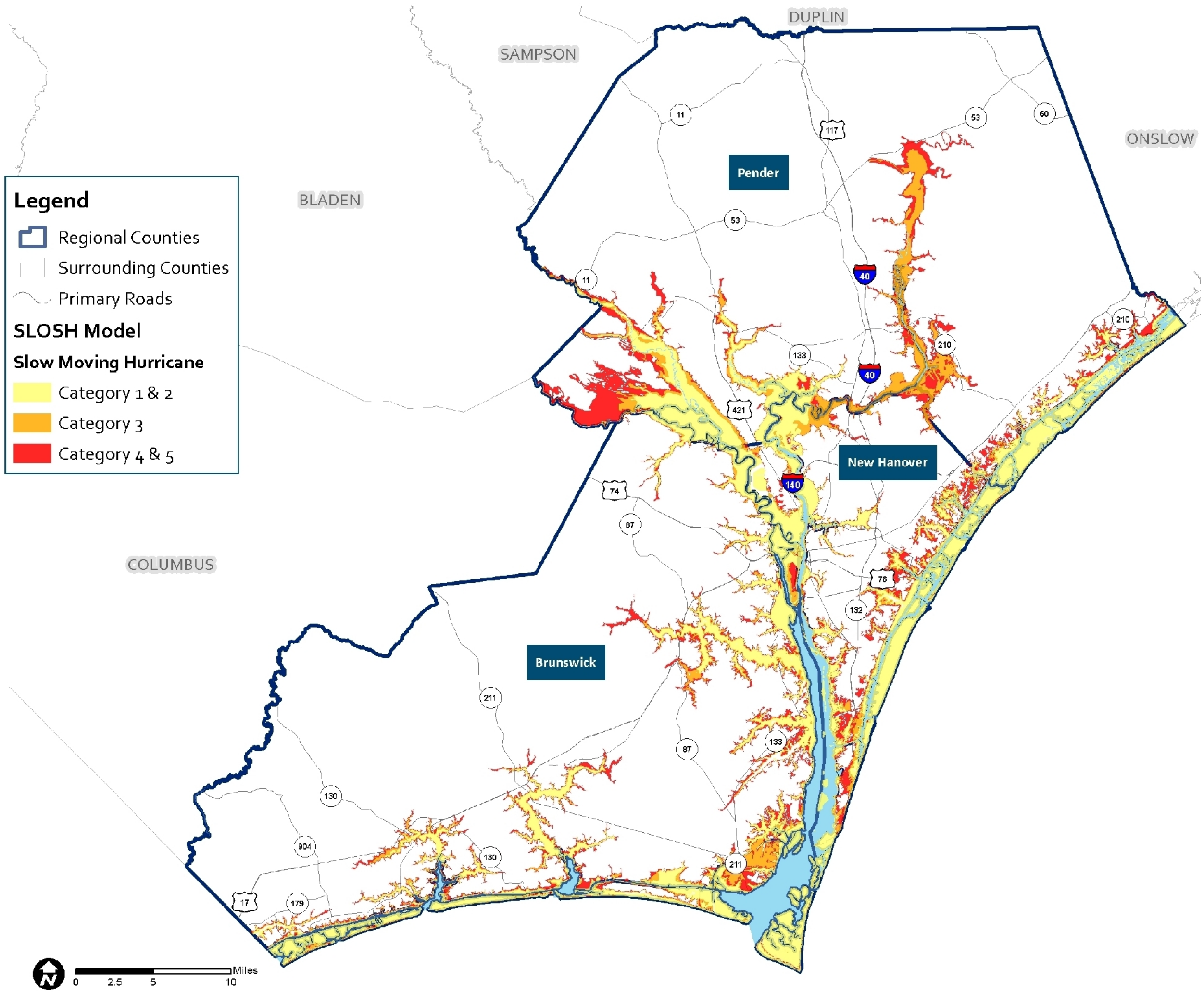
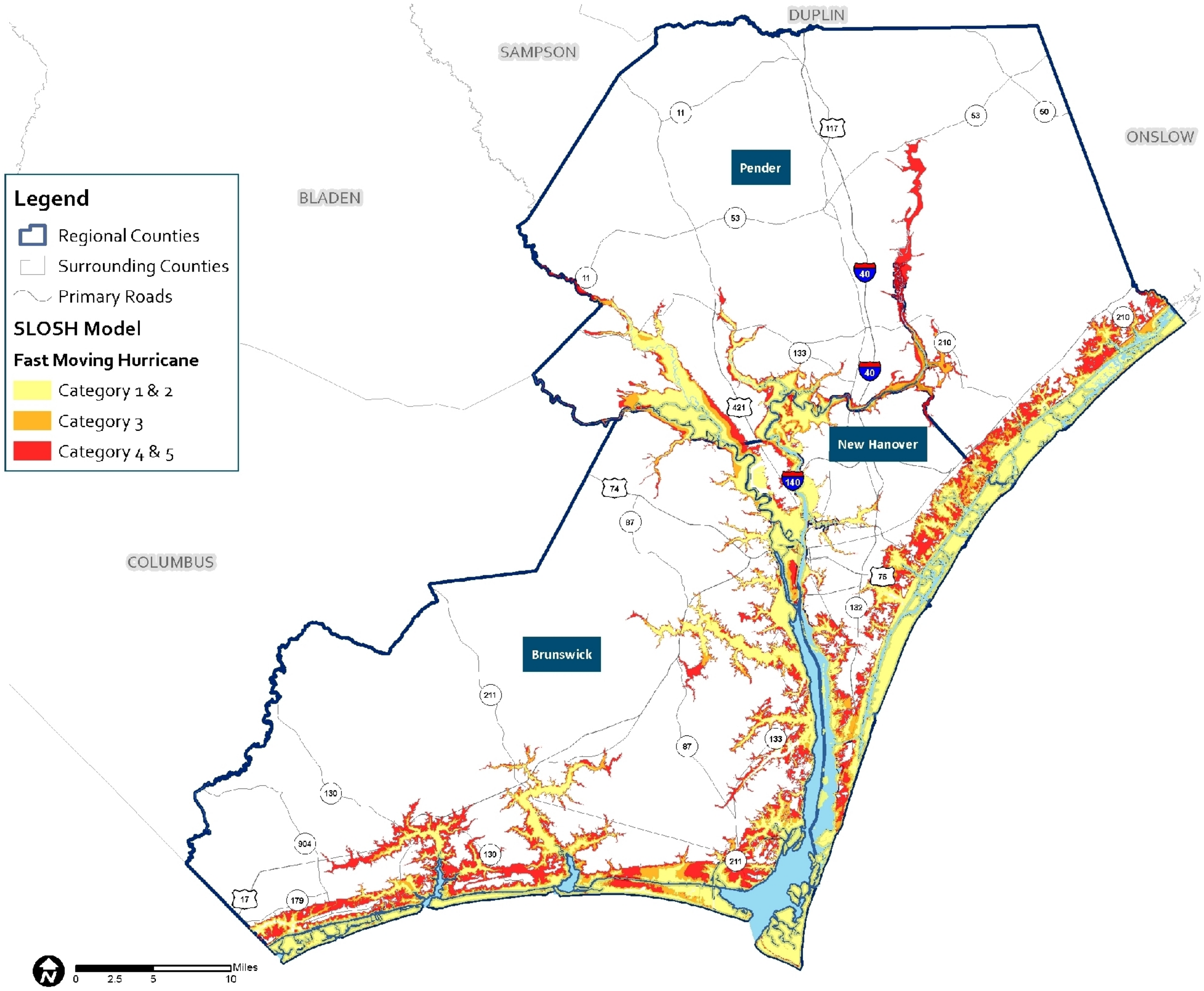


Figure 7. Storm Surge Inundation - SLOSH Fast Moving Storm



According to the National Oceanic and Atmospheric Administration, there have been eight (8) reported storm surge events which have affected the Southeastern NC Region since 1996.

Table 3-6. Historical Storm Surge Impacts

Location	Date	Magnitude	Description
New Hanover County	9/15/1996	12 feet	Hurricane Fran caused storm surge of 12 feet MSL. Between storm surge and the expansive beach erosion, most docks and piers were destroyed.
New Hanover County Brunswick County	10/8/1996	3 feet above normal	Remnants of Tropical Storm Josephine caused high tides 3 feet higher and seawater flooding around 1 foot deep on sections of roads on barrier islands.
New Hanover County	8/26/1998	7-9 feet	Hurricane Bonnie caused storm surge between 7 to 9 feet with most barrier island overwash from the south side, not the ocean side.

Location	Date	Magnitude	Description
New Hanover County	9/15/1999	9-10 feet	Hurricane Floyd caused storm surge between 9 and 10 feet, inundating barrier islands.
Southeastern NC Region	2/3/1998	2 feet above normal	A nor'easter caused heavy surf and high tides 2 feet above normal, causing 4 feet of dune erosion and minor overwash
New Hanover County	10/27/2007		High astronomical tides and northeast winds caused minor sound flooding.
Brunswick County	9/6/2008		Storm surge from Tropical Storm Hanna breached a 6 foot high sandbag wall, severely undermining streets.
Pender County	9/25/2008	1-2 feet	A strong low pressure system produced heavy rain and coastal flooding. Virginia Creek backed up at high tide with 1 to 2 feet of water on Sloop Point Road.

Source: National Oceanic and Atmospheric Administration.

Erosion

Erosion is a hydrologic hazard defined as the wearing away of land and loss of beach, shoreline, or dune material. It is measured as the rate of change in the position or horizontal (landward) displacement of a shoreline over a period of time. Short-term erosion typically results from episodic natural events such as hurricanes and storm surge, windstorms and flooding hazards, but may be exacerbated by human activities such as boat wakes, removal of dune and vegetative buffers, shoreline hardening and dredging. Long-term erosion is a function of multi-year impacts such as wave action, sea level rise, sediment loss, subsidence and climate change. Climatic trends can change a beach from naturally accreting to eroding due to increased episodic erosion events caused by waves from an above-average number of storms and high tides, or the long-term effects of fluctuations in sea level.

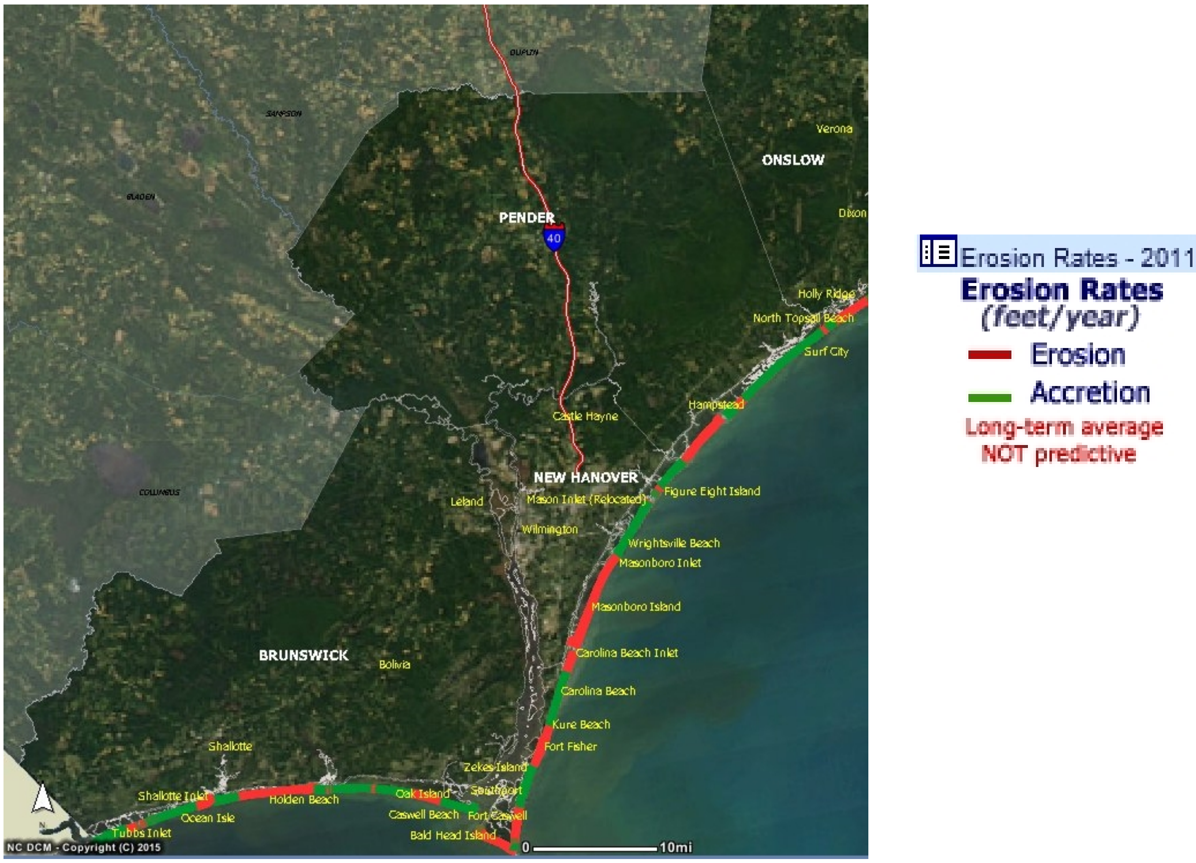
Natural recovery from erosion can take years to decades. If a beach and dune system does not recover quickly enough naturally, coastal and upland property may be exposed to further damage in subsequent coastal erosion and flooding events. Human actions to supplement natural coastal recovery, such as beach nourishment, dune stabilization and shoreline protection structures (e.g., sea walls, groins, jetties, etc.) can mitigate the hazard of coastal erosion, but may also exacerbate it under some circumstances.

Death and injury are not associated with coastal erosion; however, it can cause the destruction of buildings and infrastructure and represents a major threat to the local economies of coastal communities that rely on the financial benefits of recreational beaches.

All of the Southeastern NC Region's coastal and riverine areas are susceptible to the erosion hazard. The severity of coastal erosion is typically measured through a quantitative assessment of annual shoreline change for a given beach cross-section of profile (feet or meters per year) over a long period of time. Erosion rates vary as a function of shoreline type and are influenced primarily by episodic events, but can be used in land use and hazard management to define areas of critical concern.

Erosion in the Southeastern NC Region has occurred primarily in areas directly adjacent to the Atlantic Ocean. Figure 8 illustrates historic shoreline data for areas that have experienced accreting or eroding shorelines as of 2011. These are point values which are monitored by the North Carolina Division of Coastal Management.

Figure 8. Southeastern NC Region Erosion Rates, 2011 *Source: NCDCM.*



Coastal erosion remains a natural, dynamic and continuous process for the coastal areas in the Southeastern NC Region and thus has a high probability of future occurrence. The damaging impacts of coastal erosion are lessened through continuous (and costly) beach nourishment and structural shoreline protection measures; however, it is likely that the impacts of coastal erosion will increase in severity due to future episodic storm events.

SINKHOLES

Sinkholes form in areas with underlying limestone and other rock types that are soluble in natural water. The collapse of overlying sediments into the underground cavities produces sinkholes. Most underlying limestone is porous, allowing the acidic rain water to percolate through their strata, dissolving some limestone and carrying it away in solution. It is for this reason that sinkholes contribute to groundwater contamination, rapidly carrying away contaminated water. Over time, this persistent erosional process can create extensive underground voids and drainage systems in much of the carbonate rocks.

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

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

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

According to the NC Division of Water Resources, many sinkholes have occurred in the Southeastern NC Region. The susceptible areas are shown in Figure 9. The Castle Hayne and Riverbed Formation occur in this area making conditions more likely. In addition, areas of groundwater pumping may accelerate the formation of sinkholes.

Figure 9. Sinkhole Activity in NC *Source: NCDWR.*

Notable sinkhole examples occur near Snow's Cut and Carolina Beach State Park (New Hanover County), along Interstate 40 (Pender County), and Sunny Point Military Ocean Terminal and Boiling Spring Lakes (Brunswick County). For example, Boiling Spring Lakes was drained via sinkholes in 1978. In addition, Big Lake in Boiling Spring Lakes was drained in 2003 and 2007 to repair it from damage due to sinkholes. Many smaller sinkholes in the area have since filled with water becoming small ponds. In 2001, a sinkhole in Pender County closed a portion of Interstate 40 and extreme flooding in 2014 created two sinkholes in Hampstead. Based on Table 3-8, the likelihood of occurrence for sinkholes is "possible."

EXPLANATION OF HAZARDS NOT IDENTIFIED

The following hazards were not identified within the context of this document for the reasons indicated.

Hazard	Why Not Identified
Landslides	There is no history of landslides in the Southeastern NC Region.
Volcanoes	There is no history of volcanic activity in the Southeastern NC Region.

RANKING OF NATURAL HAZARD POTENTIAL

The hazards outlined within the preceding sections, as well as hazards that have occurred in years prior to 2010 (when the last Hazard Mitigation Plans were prepared), have been ranked below based on a score derived from several factors. Each hazard was ranked based on frequency, number of injuries caused, number of resulting deaths, and dollar amount of property damage losses since 1951. These factors have been ranked on a scale of 1 (High) to 9 (Low). The table is organized to display the ranking of each hazard with respect to a given factor. As evidenced by the table, the hazards have been listed in order by total hazard potential. Refer to Appendix E for a listing of natural hazard events by year.

Table 3-7. Southeastern NC Region Ranking of Hazard Potential

Hazard	Ranking by Frequency	Ranking by Injuries	Ranking by Deaths	Ranking by Property Damage Loss	Total All Factors
Thunderstorms/Windstorms, Lightning, & Hail	1	1	2	2	6
Tornados	2	2	3	3	10
Hurricanes and Coastal Storms	4	5	4*	1	14
Coastal Hazards	5	3	1	7*	16
Flooding	3	4	5*	4	16
Wildfires	6	5*	5*	5	21
Winter Storms and Freezes	8	5*	4*	6	23
Droughts and Extreme Heat	7	5*	5*	7*	24
Sinkholes***	9*	6*	6*	8*	29
Tsunamis**	9*	6*	6*	8*	29
Dam/Levee Failures**	9*	6*	6*	8*	29
Earthquakes**	9*	6*	6*	8*	29

**Indicates a tie score.*
***Due to the lack of historical data, earthquakes, tsunamis, sinkholes, and dam/levee failures were given the same score for all factors.*
Source: National Oceanic and Atmospheric Administration.

HAZARD DAMAGE AND LIKELIHOOD OF OCCURRENCE SUMMARY

The following table provides an estimate of damage potential and likelihood of occurrence based on the preceding sections. All factors were taken into account when filling out this table including input from county/municipal staff members, data documenting historical occurrences, and instances of storms impacting the region since the last Hazard Mitigation Plan Updates in 2010.

Table 3-8. Southeastern NC Region Hazard Impact

Type of Hazard & Associated Elements	Likelihood of Occurrence[1] (Highly Likely, Likely, Possible, Unlikely)	Impact Rating[2] (Intensity Scales or Relative Terms)	Potential Impact[3] (Catastrophic, Critical, Limited, Negligible)
Hurricanes and Coastal Storms	Likely	Severe	Catastrophic
Flooding	Highly Likely	Severe	Critical
Winter Storms and Freezes	Possible	Moderate	Limited
Thunderstorms/Windstorms, Lightning, and Hail	Highly Likely	Severe	Critical
Tornados	Likely	Severe	Critical
Wildfires	Highly Likely	Moderate	Limited
Earthquakes	Unlikely	Moderate	Critical
Dam/Levee Failures	Likely	Moderate	Limited
Droughts and Extreme Heat	Likely	Moderate	Limited
Tsunamis	Unlikely	Moderate	Limited
Coastal Hazards	Likely	Severe	Negligible
Sinkholes	Possible	Moderate	Negligible

NOTES:

[1] Likelihood of occurrence was estimated using historic data and the following chart (based on the 2010 plans):

Likelihood	Frequency of Occurrence
Highly Likely	Near 100% probability in the next year.
Likely	Between 10 and 100% probability in the next year, or at least one chance in the next 10 years.
Possible	Between 1 and 10% probability in the next year, or at least one chance in the next 100 years.
Unlikely	Less than 1% probability in the next year, or less than one chance in the next 100 years.

[2] The hazard's intensity was estimated using historic data and various standardized scales as outlined in Table 3-7, Ranking of Hazard Potential. This table provides a composite score of hazard impact and potential based on four factors including: frequency; number of injuries; number of deaths; and ranking based on total property damage losses. The classification listed in the table above is based on the following classifications:

Severe: Hazard potential ranking of 0 to 20
Moderate: Hazard potential ranking of 21 or greater

[3] The potential impact was estimated by considering the magnitude of the event, how large an area within the community is affected, and the amount of human activity in that area, then using the following chart as a tool (based on the 2010 plans):

Level	Area Affected	Impact
Catastrophic	More than 50%	• Multiple deaths • Complete shutdown of facilities for 30 days or more • More than 50 percent of property is severely damaged
Critical	25 to 50%	• Multiple severe injuries • Shutdown of critical facilities for 1-2 weeks • More than 25 percent of property is severely damaged
Limited	10 to 25%	• Some injuries • Shutdown of some critical facilities 24 hours to one week • More than 10 percent of property is severely damaged
Negligible	Less than 10%	• Minor injuries • Minimal quality-of-life impact • Shutdown of some critical facilities and services for 24 hours or less • Less than 10 percent of property is severely damaged
N/A	Hazard has no discernable impact on the built environment	