4 Risk Assessment

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

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

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

A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;

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

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

4.1 OVERVIEW

This section describes the Hazard Identification and Risk Assessment process for the development of the Eno-Haw Regional Hazard Mitigation Plan. It describes how the County met the following requirements from the 10-step planning process:

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

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

This regional hazard risk assessment covers all of Alamance, Durham, Orange, and Person Counties including the unincorporated areas of these counties as well as incorporated jurisdictions participating in this plan.

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

1. Identify Hazards | 2. Profile Hazard Events | 3. Inventory Assets | 4. Estimate Losses

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

- **Section 4.2**: **Hazard Identification** identifies the natural and human-caused hazards that threaten the planning area.
- **Section 4.3: Risk Assessment Methodology and Assumptions**
- **Section 4.4: Asset Inventory** details the population, buildings, and critical facilities at risk within the planning area.
- **Section 4.5**: **Hazard Profiles, Analysis, and Vulnerability** discusses the threat to the planning area, describes previous occurrences of hazard events and the likelihood of future occurrences, and assesses the planning area's exposure to each hazard profiled; considering assets at risk, critical facilities, and future development trends.
- **Section 4.6: Conclusions on Hazard Risk** summarizes the results of the Priority Risk Index and defines each hazard as a Low, Medium, or High Risk hazard.

4.2 HAZARD IDENTIFICATION

To identify hazards relevant to the planning area, the HMPC began with a review of the list of hazards identified in the 2018 State Hazard Mitigation Plan, the 2015 Eno-Haw Regional Hazard Mitigation Plan, and the 2015 Person-Roxboro Hazard Mitigation Plan as summarized in Table 4.1. The HMPC used these lists to identify a full range of hazards for potential inclusion in this plan update and to ensure consistency across these planning efforts. All hazards on the below list were evaluated for inclusion in this plan update.

Table 4.1 – Full Range of Hazards Evaluated

Hazard	Included in 2018 State HMP?	Included in 2015 Eno-Haw HMP or 2015 Person-Roxboro HMP?
Flooding	Yes	Yes
Hurricanes and Coastal Hazards	Yes	Yes
Severe Winter Weather	Yes	Yes
Excessive Heat	Yes	Yes
Earthquakes	Yes	Yes
Wildfire	Yes	Yes
Dam Failures	Yes	Yes
Levee Failure	No	Yes
Drought	Yes	Yes
Tornadoes/Thunderstorms	Yes	Yes (evaluated as a separate hazards)
Geological (Landslides, Sinkholes, Coastal Erosion)	Yes	Yes (Landslide & Sinkhole)
Hazardous Substances	Yes	No
Radiological Emergency	Yes	No
Terrorism/Mass Casualty	Yes	No
Infectious Disease	Yes	No
Cyber Threat	Yes	No
Electromagnetic Pulse	Yes	No
Civil Unrest	No	No
Critical Infrastructure Failure	No	No

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

One significant resource in this effort was the National Oceanic and Atmospheric Administration's National Center for Environmental Information (NCEI), which has been tracking various types of severe weather since 1950. Their Storm Events Database contains an archive by county of destructive storm or weather data and information which includes local, intense and damaging events. NCEI receives storm data from the National Weather Service (NWS). The NWS receives their information from a variety of sources, which include but are not limited to: county, state and federal emergency management officials, local law enforcement officials, SkyWarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry and the general public, among others. The NCEI database contains 783 records of severe weather events that occurred in the Eno-Haw Region in the 20-year period from 1999 through 2018. Table 4.2 summarizes these events.

Table 4.2 – NCEI Severe Weather Reports for Eno-Haw Region Counties, 1999 – 2018

Type	# of Events	Property Damage	Crop Damage	Deaths	Injuries
Blizzard	0	$0	$0	0	0
Cold/Wind Chill	0	$0	$0	0	0
Drought	0	$0	$0	0	0
Extreme Cold/Wind Chill	0	$0	$0	0	0
Excessive Heat	0	$0	$0	0	0
Flash Flood	129	$13,778,000	$0	0	0
Flood	12	$38,520,000	$15,000,000	0	0
Frost/Freeze	0	$0	$0	0	0
Hail	229	$2,017,500	$60,500	0	0
Heat	1	$0	$0	1	0
Heavy Rain	2	$0	$0	0	0
Heavy Snow	4	$0	$0	0	0
High Wind	8	$4,000	$0	0	0
Hurricane	10	$3,000,309,000	$503,000,000	0	0
Ice Storm	5	$3,634,000	$0	0	0
Lightning	25	$3,025,000	$0	4	6
Strong Wind	59	$1,289,150	$24,000	1	3
Thunderstorm Wind	493	$2,279,250	$165,000	2	5
Tornado	15	$2,155,000	$10,000	0	2
Tropical Storm	5	$1,700,000	$25,000	0	0
Wildfire	0	$0	$0	0	0
Winter Storm	119	$3,000,000	$0	0	0
Winter Weather	106	$95,000	$0	0	0
Total:	**1,215**	**$3,071,735,900**	**$518,284,500**	**8**	**16**

Source: National Center for Environmental Information Events Database, June 2018
Note: Losses reflect totals for all impacted areas for each event.

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

Records of designated counties for FEMA major disaster declarations start in 1964. Since then, Alamance, Durham, Orange, and Person Counties have been designated in 15 different major disaster declarations. Table 4.3 summarizes the count of declarations per county, and Table 4.4 provides details for these declarations.

Table 4.3 – Summary of Disaster Declarations by County

County	Major Declarations Received
Alamance	11
Durham	9
Orange	10
Person	11

Source: FEMA Disaster Declarations Summary, updated March 15, 2019

Table 4.4 – FEMA Major Disaster Declarations, Eno-Haw Region

County*	Disaster #	Date	Incident Type	Event Title
A, O, P	4412	10/10/2018	Hurricane	Tropical Storm Michael
A, D, O, P	4393	9/14/2018	Hurricane	Hurricane Florence
A, O, P	4167	3/31/2014	Severe Ice Storm	Severe Winter Storm
A	1969	4/19/2011	Severe Storm(s)	Severe Storms, Tornadoes, and Flooding
P	1801	10/8/2008	Severe Storm(s)	Tropical Storm Hanna
A	1553	9/18/2004	Hurricane	Hurricane Ivan
D, O, P	1490	9/18/2003	Hurricane	Hurricane Isabel
A, O, P	1457	3/27/2003	Severe Ice Storm	Ice Storm
A, D, O, P	1448	12/12/2002	Severe Ice Storm	Severe Ice Storm
A, D, O, P	1312	1/31/2000	Severe Storm(s)	Severe Winter Storm
A, D, O, P	1292	9/16/1999	Hurricane	Hurricane Floyd Major Disaster Declarations
D	1211	3/22/1998	Severe Storm(s)	Severe Storms, Tornadoes, and Flooding
A, D, O, P	1134	9/6/1996	Hurricane	Hurricane Fran
A, D, O, P	1087	1/13/1996	Snow	Blizzard of 96
D	827	5/17/1989	Tornado	Tornadoes

Source: FEMA Disaster Declarations Summary, March 15, 2019
*County code: A = Alamance, D = Durham, O = Orange, P = Person

Using the above information and additional discussion, the HMPC evaluated each hazard's significance to the planning area in order to decide which hazards to include in this plan update. Some hazard titles have been updated either to better encompass the full scope of a hazard or to assess closely related hazards together. Table 4.5 summaries the determination made for each hazard.

Table 4.5 – Hazard Evaluation Results

Hazard	Included in this plan update?	Explanation for Decision
Flood	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. Multiple disaster declarations for the region are related to flooding. NCEI reports 138 flood-related events.

Hazard	Included in this plan update?	Explanation for Decision
Hurricane and Tropical Storm	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. Past disaster declarations and NCEI storm reports indicate hurricanes are a significant hazard for the region.
Severe Winter Weather	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. Past disaster declarations indicate this is a significant hazard for the region. NCEI reports 234 severe winter weather related events.
Extreme Heat	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. NCEI reports 1 heat event for the region.
Earthquake*	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. The region could face minor impacts from the Eastern Tennessee Seismic zone and the Charleston fault.
Wildfire	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard.
Dam Failure	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. There are multiple dams in the region.
Levee Failure	No	The 2015 Eno-Haw and Person-Roxboro plans addressed this hazard in conjunction with dam failure. The USACE's National Levee Database does not identify any USACE or non-USACE levees in the region.
Drought	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. There is significant agricultural exposure to drought in Alamance, Orange, and Person Counties.
Severe Weather (Thunderstorm, Lightning, and Hail)	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed these hazards. Multiple past disaster declarations indicate this is a significant hazard in the region. NCEI reports 827 related events in the past 20 years.
Tornado	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. NCEI reports 15 tornado segments passing through the region in the past 20 years. Past disaster declarations have included tornados.
Landslide*	Yes	The 2015 Eno-Haw and Person-Roxboro plans and 2018 State plan addressed this hazard. USGS data indicates the region has moderate susceptibility to landslide.
Sinkholes	No	The 2015 Eno-Haw plan did not address this hazard. The 2015 Person-Roxboro plan included this hazard but found very low risk with no past incidents and unlikely probability. USGS data does not indicate a geological basis for sinkhole risk in the region.
Erosion	No	The 2018 State plan addressed this hazard for coastal areas. The 2015 Eno-Haw and Person-Roxboro plans did not address this hazard. Any riverine erosion risk will be discussed within the flood hazard profile.
Hazardous Materials Incident	Yes	The 2018 State plan addressed this hazard, but the 2015 Eno-Haw and Person-Roxboro plans did not. The HMPC decided this hazard should be included given the presence of fixed facilities and transportation route that carry hazardous substances.
Radiological Emergency	Yes	The 2018 State plan addressed this hazard, but the 2015 Eno-Haw and Person-Roxboro plans did not. Most of the region falls within the IPZ of Harris Nuclear Station, but none of the region is within the EPZ. The HMPC decided this hazard should be included.

Hazard	Included in this plan update?	Explanation for Decision
Terrorism/Mass Casualty	Yes	The 2018 State plan addressed Terrorism, but the 2015 Eno-Haw and Person-Roxboro plans did not. The HMPC wants to address this hazard in terms of an active shooter event.
Infectious Disease	Yes	The 2018 State plan addressed this hazard, but the 2015 Eno-Haw and Person-Roxboro plans did not. The HMPC wants to address this hazard.
Cyber Threat	Yes	The 2018 State plan addressed this threat, but the 2015 Eno-Haw and Person-Roxboro plans did not. The HMPC wants to address this hazard.
Electromagnetic Pulse	No	The 2018 State plan addressed this threat, but the 2015 Eno-Haw and Person-Roxboro plans did not. The region considers this threat more appropriately addressed at the State level.
Critical Infrastructure Failure	Yes	The 2018 State plan did not address this hazard, but HMPC representatives feel it is a local issue that should be included.
Civil Unrest	Yes	The 2018 State plan did not address this hazard, but HMPC representatives feel it is a local issue that should be included.

*These hazards were found to be low-risk hazards through the risk assessment process; therefore, they are not prioritized for mitigation actions.

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

- Dam Failure
- Drought
- Earthquake
- Extreme Heat
- Flood
- Hurricane & Tropical Storm
- Landslide
- Severe Weather (Thunderstorm Wind, Lightning, & Hail)
- Severe Winter Storm
- Tornado
- Wildfire
- Civil Unrest
- Critical Infrastructure Failure
- Cyber Threat
- Hazardous Materials Incident
- Infectious Disease
- Radiological Emergency
- Terrorism/Mass Casualty

4.3 RISK ASSESSMENT METHODOLOGY AND ASSUMPTIONS

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

Each hazard is profiled in the following format:

Hazard Description

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

Location

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

Extent

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

Past Occurrences

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

Probability of Future Occurrence

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

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

Climate Change

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

Vulnerability Assessment

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

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

- Geographic Information System (GIS) datasets, including building footprints, topography, aerial photography, and transportation layers;
- Hazard layer GIS datasets from state and federal agencies;
- Written descriptions of inventory and risks provided by the State Hazard Mitigation Plan; and
- Written descriptions of inventory and risks provided by the previous Eno-Haw Regional Hazard Mitigation Plan.
- Exposure and vulnerability estimates provided by the NCEM IRISK database.
- Crop insurance claims by cause from USDA's Risk Management Agency

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

Census blocks and Summary File 1 from the 2010 Census were used to determine population at risk. This included the total population, as well as the vulnerable elderly and children age groups. To determine population at risk, the census blocks were intersected with the hazard area. To better determine the actual number of people at risk, the intersecting area of the census block was calculated and divided by the total area of the census block to determine a ratio of area at risk. This ratio was applied to the population of the census block. For example, a census block has a population of 400 people. Five percent of the census block intersects the 1-percent-annual-chance flood hazard area. The ratio estimates that 20 people are then at risk within the 1-percent-annual-chance flood hazard area (5% of the total population for that census block).

Two distinct risk assessment methodologies were used in the formation of the vulnerability assessment. The first consists of a ***quantitative*** analysis that relies upon best available data and technology, while the second approach consists of a ***qualitative*** analysis that relies on local knowledge and rational decision making. The quantitative analysis involved the use of NCEM's IRISK database, which provides modeled damage estimates for flood, wind, and wildfire hazards.

Vulnerability can be quantified in those instances where there is a known, identified hazard area, such as a mapped floodplain. In these instances, the numbers and types of buildings subject to the identified hazard can be counted and their values tabulated. Where hazard risk cannot be distinctly quantified and modeled, other information can be collected in regard to the hazard area, such as the location of critical facilities, historic structures, and valued natural resources (e.g., an identified wetland or endangered species habitat). Together, this information conveys the vulnerability of that area to that hazard.

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

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

Priority Risk Index

The conclusions drawn from the hazard profiling and vulnerability assessment process can be used to prioritize all potential hazards to the Eno-Haw planning area. The Priority Risk Index (PRI) was applied for this purpose because it provides a standardized numerical value so that hazards can be compared against one another (the higher the PRI value, the greater the hazard risk). PRI values are obtained by assigning varying degrees of risk to five categories for each hazard (probability, impact, spatial extent, warning time, and duration). Each degree of risk was assigned a value (1 to 4) and a weighting factor as summarized in Table 4.6.

The results of the risk assessment and PRI scoring are provided in Section 4.6 Conclusions on Hazard Risk.

Table 4.6 – Priority Risk Index

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

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

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

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

4.4 ASSET INVENTORY

4.4.1 Population

NCEM's IRISK database provided the asset inventory used for this vulnerability assessment. Population data in IRISK is derived from the 2010 Census and includes a breakdown of population into two subpopulations considered to be at greater risk than the general population, the elderly and children. Table 4.7 details the population counts by jurisdiction used for the vulnerability assessment. Note that more current population estimates are provided in Section 3 Planning Area Profile but are not integrated into the risk assessment, which relies on IRISK.

Table 4.7 – Population Counts by Jurisdiction, 2010

Jurisdiction	2010 Census Population	Elderly (Age 65 and Over)	Children (Age 5 and Under)
Alamance			
City of Burlington	43,522	6,358	2,742
City of Graham	56,075	8,192	3,533
City of Mebane	16,584	2,423	1,045
Town of Elon	14,590	2,020	893
Town of Green Level	10,006	1,462	630
Town of Haw River	2,368	346	149
Town of Ossipee	3,773	551	238
Town of Swepsonville	544	79	34
Village of Alamance	1,151	168	73
Unincorporated Alamance County	1,462	214	92
Subtotal Alamance	**150,075**	**21,813**	**9,429**
Durham			
City of Durham	225,814	22,031	16,715
Unincorporated Durham County	38,181	3,725	2,826
Subtotal Durham	**263,995**	**25,756**	**19,541**
Orange			
Town of Carrboro	20,883	2,012	1,076
Town of Chapel Hill	59,351	5,722	3,117
Town of Hillsborough	8,467	816	436
Unincorporated Orange County	45,470	4,381	2,342
Subtotal Orange	**134,171**	**12,931**	**6,971**
Person			
City of Roxboro	13,079	1,986	785
Unincorporated Person County	26,396	4,007	1,584
Subtotal Person	**39,475**	**5,993**	**2,369**
Region Total	**587,716**	**66,493**	**38,310**

Source: NCEM IRISK Database; 2010 Decennial Census

Note: The population counts in IRISK are compiled from a census tract level and are estimated for incorporated jurisdictions based on a State dataset of extra-territorial jurisdiction boundaries. As a result, the population estimates for some jurisdictions skew large due to the inclusion of unincorporated areas. In the case of the City of Roxboro, which does not have an official extra-territorial jurisdiction, the state's estimate skews the City's population to 56% greater than the actual population by including parts of unincorporated Person County in the City of Roxboro estimates. The HMPC raised concerns about the errors in these estimates in order for corrections to be made in any future updates to IRISK.

4.4.2 Property

Building counts were also provided by the IRISK database. These values were generated using building footprints and local parcel data. The methodology for generating the building asset inventory is described in greater detail in Section 4.3. Note that these building counts were provided in 2010, and the Eno-Haw Region has since experienced a substantial amount of growth and new development. Therefore, the exposure reflected in the following tables is an underestimate of actual present-day exposure. Section 3 Planning Area Profile describes the growth that has occurred since 2010 and provides a means of estimating the degree to which exposure and vulnerability may have increased.

Table 4.8 – Building Counts and Values by Jurisdiction, 2010

Jurisdiction	Building Count	Building Value
Alamance		
City of Burlington	24,403	$5,515,560,224
City of Graham	7,269	$1,316,164,837
City of Mebane	5,835	$1,292,288,024
Town of Elon	2,760	$719,062,825
Town of Green Level	1,177	$113,426,782
Town of Haw River	2,352	$409,669,987
Town of Ossipee	330	$135,545,050
Town of Swepsonville	573	$110,607,193
Village of Alamance	798	$111,618,918
Unincorporated Alamance County	29,650	$3,375,672,801
Subtotal Alamance	**75,147**	**$13,099,616,641**
Durham		
City of Durham	75,589	$18,139,339,725
Unincorporated Durham County	21,038	$3,615,069,306
Subtotal Durham	**96,627**	**$21,754,409,031**
Orange		
Town of Carrboro	5,782	$1,446,024,246
Town of Chapel Hill	15,108	$5,302,835,624
Town of Hillsborough	3,883	$704,636,732
Unincorporated Orange County	24,533	$3,203,843,233
Subtotal Orange	**49,306**	**$10,657,339,835**
Person		
City of Roxboro	6,617	$918,466,278
Unincorporated Person County	17,714	$1,424,187,837
Subtotal Person	**24,331**	**$2,342,654,115**
Total	**245,410**	**$47,854,019,622**

Source: NCEM IRISK Database

To supplement the asset inventory and provide a clearer picture of the current asset exposure in the Eno-Haw Region, current parcel data was evaluated to identify recent development that was not included in NCEM's IRISK database. The building footprint layer from IRISK was compared to current parcel data; any parcels with an improved value that did not already have a building in IRISK were summarized in the table below. This information is not incorporated into the risk assessment, which was prepared using IRISK. However, this summary of recent development provides some context to understand the degree to which the IRISK exposure and vulnerability numbers differ from current conditions. This information is presented by individual jurisdiction in each jurisdiction's respective annex of this plan.

Table 4.9 provides a summary recent development not included in IRISK as an estimate of additional asset exposure in the Region.

Table 4.9 – Parcel Development Not Included in IRISK, as of November 2019

Jurisdiction	Improved Parcel Count	Total Improved Value
Alamance County		
Alamance	137	$38,010,047
Burlington	1,926	$538,509,617
Elon	375	$104,400,254
Graham	699	$181,053,856
Green Level	286	$38,970,385
Haw River	92	$10,716,505
Mebane	1,310	$495,097,215
Ossipee	12	$1,598,119
Swepsonville	501	$89,335,581
Unincorporated Alamance County	3,588	$552,421,404
Durham County		
Durham	10,417	$3,803,326,892
Unincorporated Durham County	1,073	$354,853,208
Orange County		
Carrboro	545	$172,753,800
Chapel Hill	419	$224,217,019
Hillsborough	815	$254,184,904
Unincorporated Orange County	3,291	$771,519,650
Person County		
Roxboro	131	$14,402,001
Unincorporated Person County	1,624	$217,189,070
Region Total	**27,241**	**$7,862,559,527**

Source: County parcel data, retrieved November 2019; IRISK database building footprints

4.4.3 Critical Facilities

The IRISK database also identifies Critical Infrastructure and Key Resources (CIKR) buildings as well as High Potential Loss Properties. These properties were also identified in 2010 and are likely an underestimate of the exposure of current CIKR and High Potential Loss Properties. These properties are detailed in Table 4.10 and Table 4.11, respectively.

Table 4.10 – Critical Infrastructure and Key Resources by Type and Jurisdiction

Jurisdiction	Food and Agriculture	Banking and Finance	Chemical & Hazardous	Commercial	Communications	Critical Manufacturing	Defense	Government Facilities	Healthcare	IT	National Monuments and Icons	Nuclear Reactors, Materials and Waste	Postal and Shipping	Transportation Systems	Energy	Emergency Services	Water	Total
Alamance																		
Unincorporated Alamance County	2,325	0	0	783	0	273	0	89	14	0	0	0	0	211	6	12	25	**3,738**
Burlington	45	43	0	1,453	2	448	1	119	112	0	0	2	0	486	23	5	40	**2,779**
Graham	27	13	0	331	0	92	1	99	18	0	0	2	0	102	2	1	7	**695**
Mebane	32	10	0	265	0	108	1	15	14	0	0	0	0	76	2	4	2	**529**
Elon	4	1	0	75	0	14	0	152	62	0	0	0	0	13	1	1	1	**324**
Green Level	15	0	0	76	0	16	0	5	0	0	0	0	0	7	1	0	0	**120**
Haw River	22	0	0	104	1	60	0	5	1	0	0	0	0	6	3	1	10	**213**
Ossipee	0	0	0	21	0	4	0	2	0	0	0	0	0	1	3	0	0	**31**
Swepsonville	2	0	0	13	0	5	0	2	0	0	0	0	0	6	0	1	1	**30**
Alamance	33	0	0	18	0	15	0	12	1	0	0	0	0	4	0	0	1	**84**
Durham																		
Unincorporated Durham County	1,230	4	0	766	0	544	0	98	41	0	0	0	0	351	1	0	17	**3,052**
Durham	88	62	0	3,552	0	1,215	0	1,013	364	0	0	0	4	1,404	77	0	37	**7,816**
Orange																		
Unincorporated Orange County	1,790	0	0	567	0	269	0	58	31	0	0	0	0	170	5	10	5	**2,905**
Carrboro	45	5	0	145	0	34	0	23	21	0	0	0	0	30	8	2	9	**322**
Chapel Hill	17	35	0	420	11	39	0	326	113	0	0	0	1	66	112	6	26	**1,172**
Hillsborough	9	53	0	234	1	59	0	56	15	0	0	0	0	25	10	4	6	**472**
Person																		
Unincorporated Person County	2,279	1	0	306	0	86	0	46	9	0	0	0	0	46	52	1	0	**2,826**
Roxboro	118	14	0	448	0	104	0	74	45	2	0	0	0	48	4	1	5	**863**
Total	**8,081**	**241**	**0**	**9,577**	**15**	**3,385**	**3**	**2,194**	**861**	**2**	**0**	**4**	**5**	**3,052**	**310**	**49**	**192**	**27,971**

Source: NCEM Risk Management Tool

Table 4.11 – High Potential Loss Properties by Use and Jurisdiction

Jurisdiction	Residential	Commercial	Industrial	Government	Agricultural	Religious	Utilities	Total
Alamance								
Unincorporated Alamance	6	58	28	25	0	28	20	165
Burlington	72	288	144	42	0	54	42	642
Graham	14	55	39	28	0	12	8	156
Mebane	35	42	31	7	0	9	2	126
Elon	12	44	5	51	0	9	1	122
Green Level	0	1	4	1	0	0	1	7
Haw River	0	5	13	1	0	5	6	30
Ossipee	0	1	2	0	0	1	3	7
Swepsonville	0	5	3	2	0	0	0	10
Village of Alamance	0	1	4	2	0	3	0	10
Durham								
Unincorporated Durham County	24	78	83	21	0	6	18	230
Durham	451	704	133	239	0	60	51	1,638
Orange								
Unincorporated Orange County	37	6	4	0	0	8	4	59
Carrboro	47	15	1	1	0	0	9	73
Chapel Hill	377	124	3	10	0	16	32	562
Hillsborough	24	2	2	0	1	6	0	35
Person								
Unincorporated Person County	2	10	2	6	0	6	0	26
Roxboro	3	28	8	11	0	3	9	62
Total	**1,104**	**1,467**	**509**	**447**	**1**	**226**	**206**	**3,960**

Source: NCEM Risk Management Tool

In addition to examining CIKR overall, the following critical facilities and assets were examined against known hazard areas, where possible, in this risk assessment. These facilities are those that could severely disrupt emergency operations or response and recovery efforts should they be damaged by a hazard event. Note that these facilities are a subset of the CIKR inventory; critical facility exposure and risk is accounted for in the exposure and vulnerability of CIKR. Critical facilities are summarized in Table 4.12 and shown in Figure 4.1 through Figure 4.4.

Note that Orange County opted not to include a map of IRISK-identified facilities in this asset inventory due to concerns about the age of the data. Instead, Orange County has provided a separate map of critical infrastructure in the county which is included below and shown in full format in the County's annex.

Table 4.12 – Critical Facilities, Eno-Haw Region

Sector	Asset	Count	Value
Emergency Management	EOC	3	$3,448,049
	Fire	39	$17,183,404
	Police	11	$26,062,201
Healthcare and Public Health	Hospital	9	$200,929,521
Government	School	123	$213,884,625
	Community College	6	$36,814,561
	University	178	$134,561,560
Energy	Power Plant	14	$195,805,135
	Substation	6	$75,635,975
Water	Treatment Plant	155	$821,805,410
Agriculture and Food Distribution	Hog Farm	20	$2,934,299

Source: NCEM IRISK Database; GIS analysis

Due to the known underestimation of CIKR resources from the IRISK database, several participating counties and jurisdictions submitted lists of locally identified CIKR properties to be mapped. It is understood these locations are not recognized in the current IRISK database and therefore are not reflected in vulnerability assessment tables or impact analyses complied from that data source. However, it is the intention of staff from these participating jurisdictions to document these locations for future updates to the Hazard Mitigation Plan and IRISK database, in order to ensure inclusion of such locations in future data analysis processes.

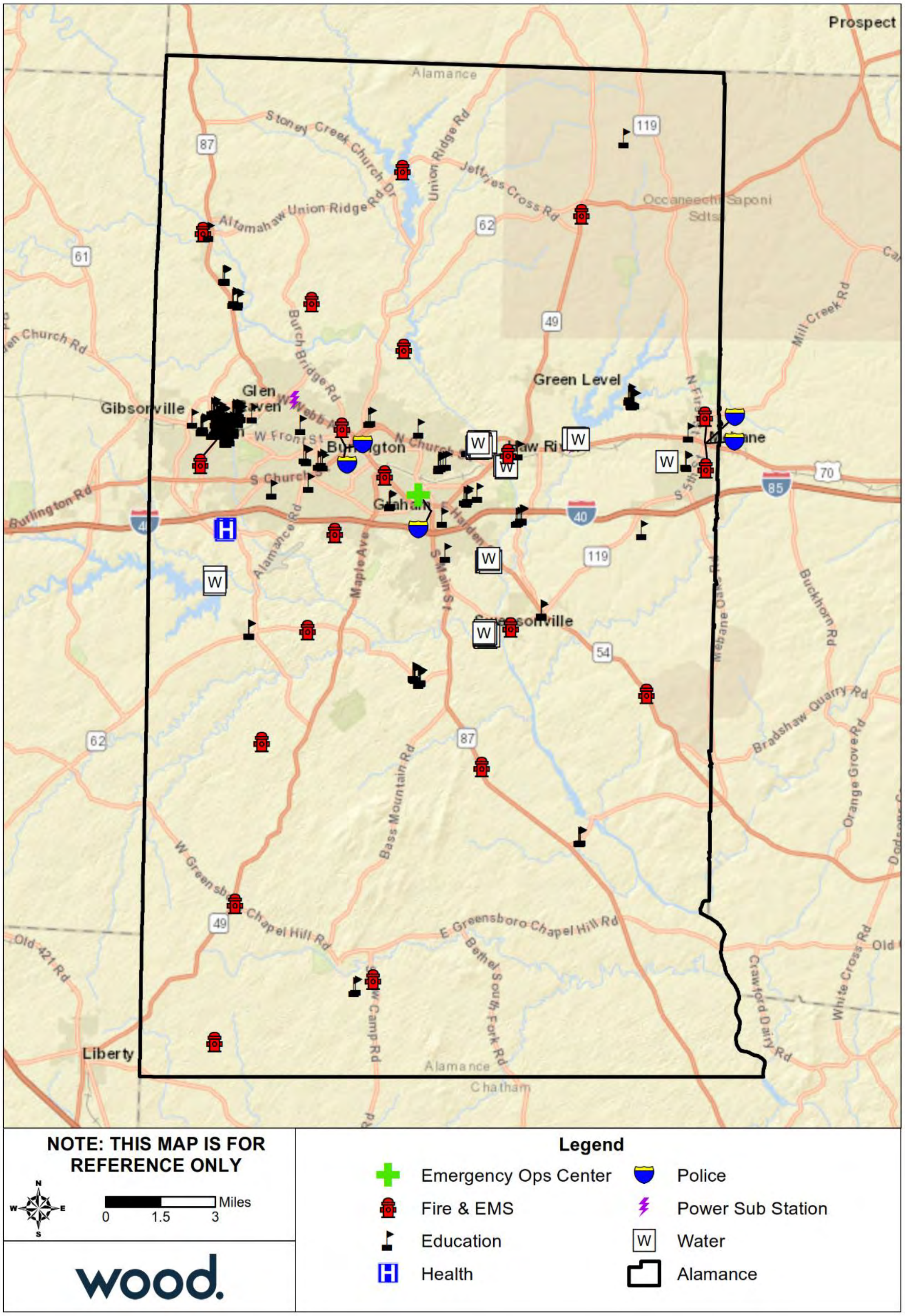
Table 4.13 summarizes the additional critical facilities identified by the HMPC that were not included in IRISK. These facilities are also included on the critical facility maps on the following pages, with the exception of the dams in Durham County, which are mapped under Section 4.5.1 Dam Failure.

Table 4.13 – Critical Facilities Not Included in IRISK, Eno-Haw Region

County	Asset	Count
Durham	EOC	1
	Dam	59
	EMS	12
	Fire	27
	Police	10
Person	Airport	1
	Fire/EMS	17
	Fuel Station	4
	Municipal	9
	Police Station	1
	Power Substation	3
	Utility	4
	Water	2

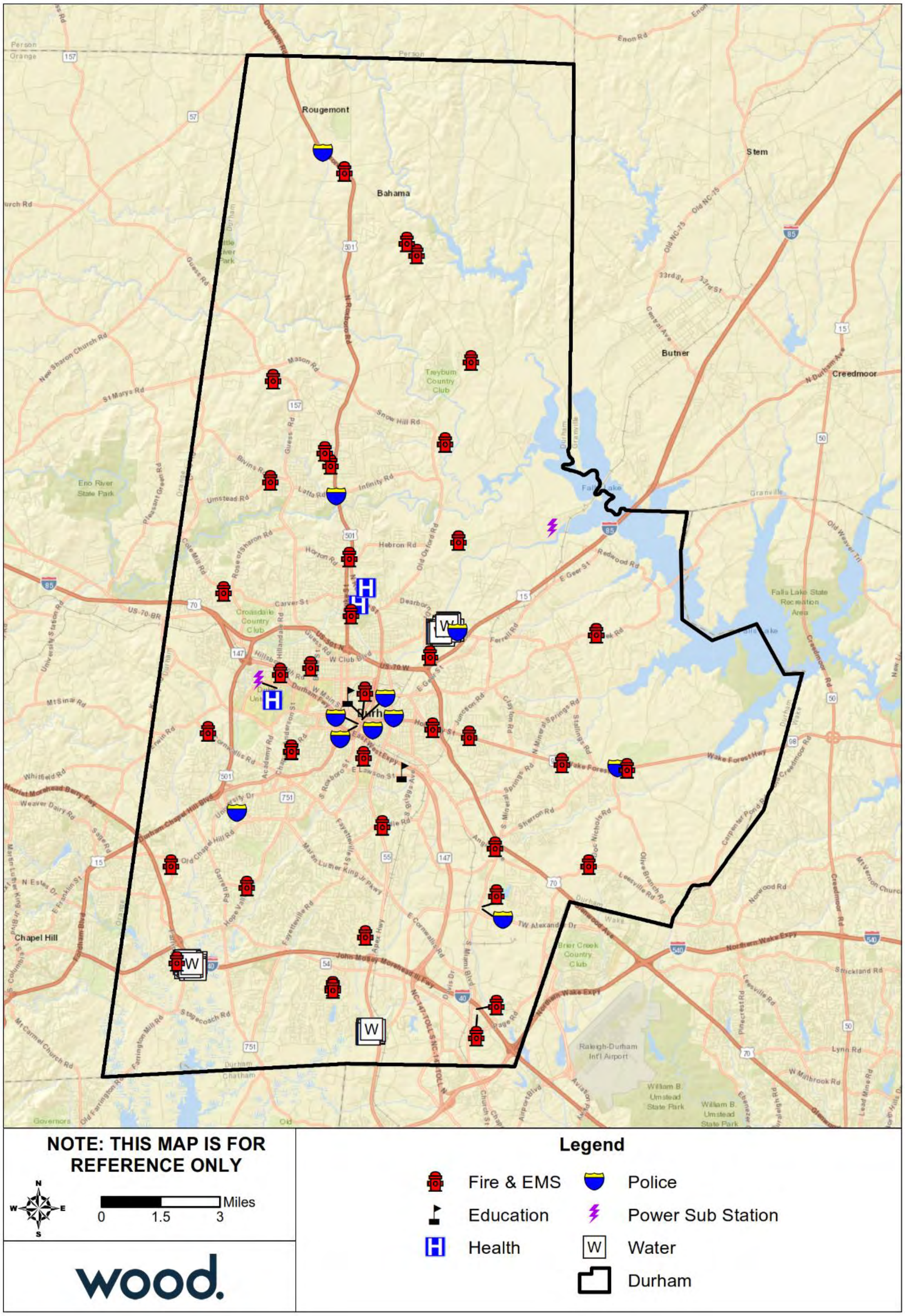
Source: Durham City, Durham County, Person County, City of Roxboro

Figure 4.1 – Critical Facilities, Alamance County



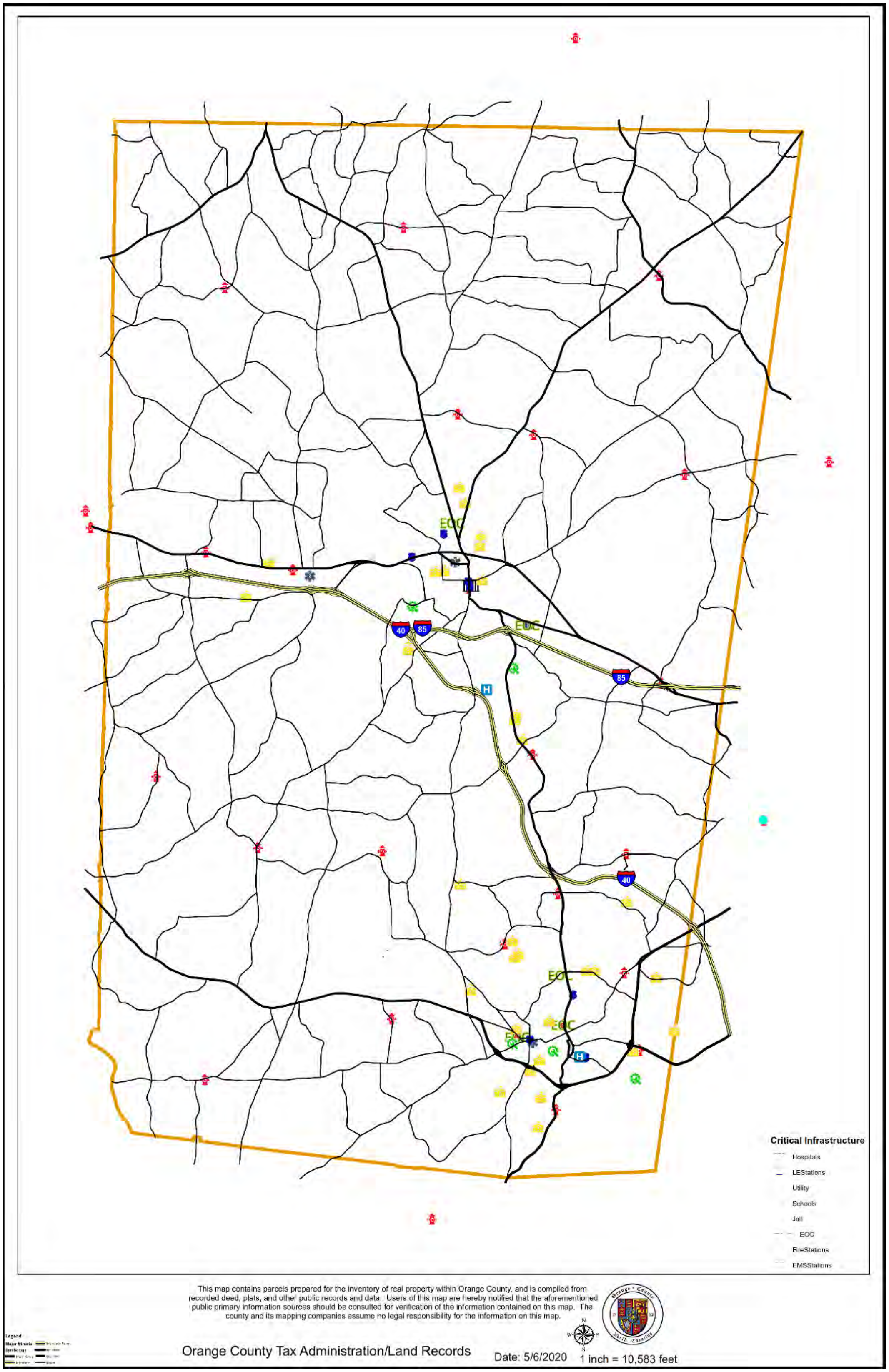
Source: NCEM IRISK Database, GIS Analysis

Figure 4.2 – Critical Facilities, Durham County



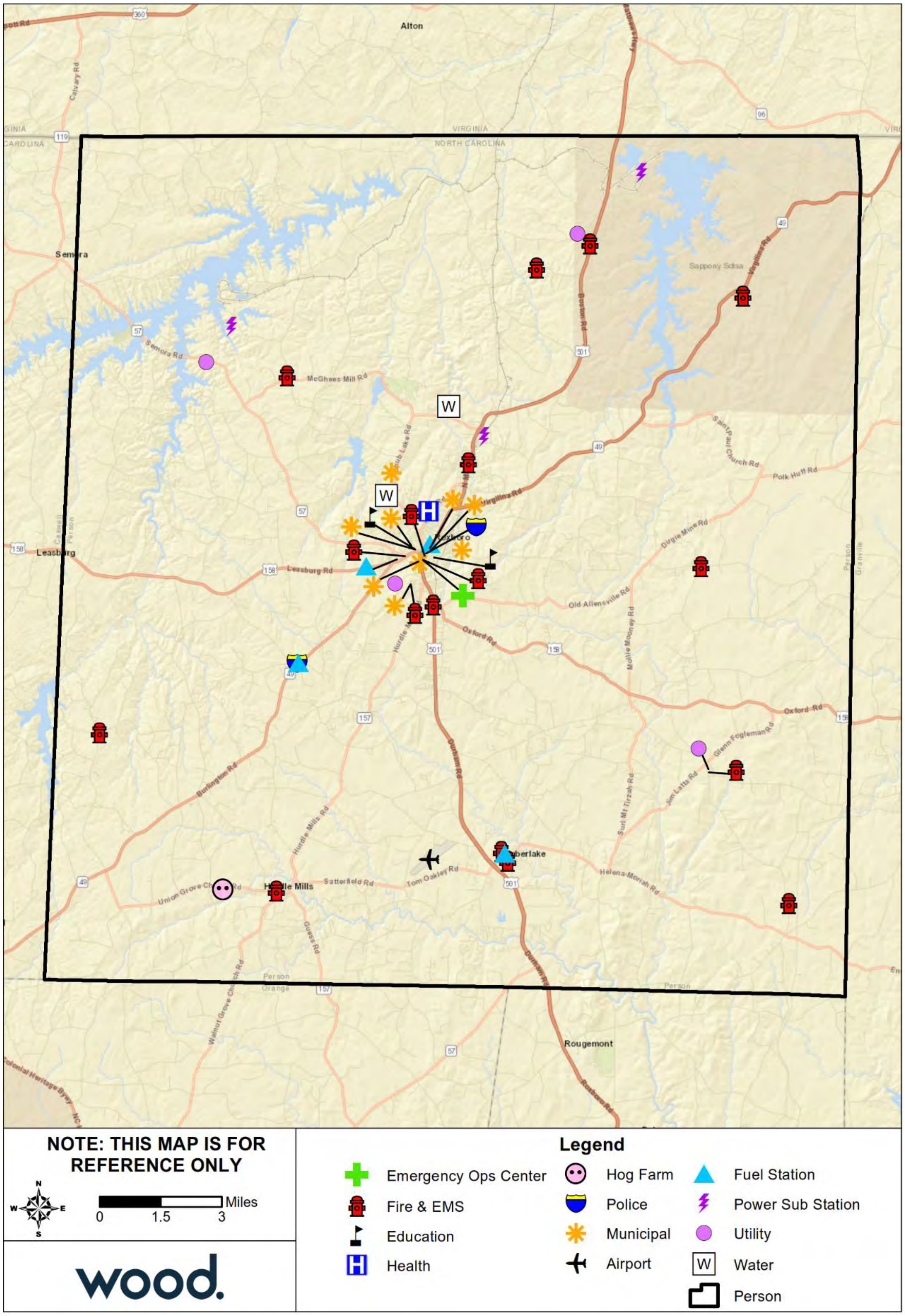
Source: NCEM IRISK Database, Durham County, GIS Analysis

Figure 4.3 – Critical Facilities, Orange County



Source: Orange County Emergency Management

Figure 4.4 – Critical Facilities, Person County



Source: NCEM IRISK Database, Person County, GIS Analysis

4.4.4 Agriculture

The agricultural industry is also highly vulnerable to natural hazards, which can cause both crop and livestock losses. The exposure of agriculture in the region was measured using the USDA's 2017 Census of Agriculture. Table 4.14 below summarizes the agricultural exposure in the Region by county.

Table 4.14 – Summary of Agriculture Exposure by County

County	Number of Farms	Acreage in Farms	Proportion of Total Land Area in Farms	Acreage with Crop Insurance	Estimated Market Value of Land & Buildings
Alamance County	720	80,042	29.5%	10,146 (12.7%)	$480,289,000
Durham County	241	18,603	10.1%	2,377 (12.8%)	$198,234,000
Orange County	686	69,908	27.5%	14,797 (21.2%)	$467,376,000
Person County	393	82,194	32.7%	29,592 (36.0%)	$310,527,000

Source: USDA 2017 Census of Agriculture

4.5 HAZARD PROFILES, ANALYSIS, AND VULNERABILITY

4.5.1 Dam Failure

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Dam Failure	Possible	Critical	Negligible	Less than 6 hrs	Less than 1 week	2.4

Hazard Background

A dam is a barrier constructed across a watercourse that stores, controls, or diverts water. Dams are usually constructed of earth, rock, concrete, or mine tailings. The water impounded behind a dam is referred to as the reservoir and is measured in acre-feet. One acre-foot is the volume of water that covers one acre of land to a depth of one foot. Dams can benefit farm land, provide recreation areas, generate electrical power, and help control erosion and flooding issues. A dam failure is the collapse or breach of a dam that causes downstream flooding. Dam failures may be caused by natural events, manmade events, or a combination. Due to the lack of advance warning, failures resulting from natural events, such as earthquakes or landslides, may be particularly severe. Prolonged rainfall and subsequent flooding is the most common cause of dam failure.

Dam failures usually occur when the spillway capacity is inadequate and water overtops the dam or when internal erosion in dam foundation occurs (also known as piping). If internal erosion or overtopping causes a full structural breach, a high-velocity, debris-laden wall of water is released and rushes downstream, damaging or destroying anything in its path. Overtopping is the primary cause of earthen dam failure in the United States.

Dam failures can also result from any one or a combination of the following:

- Prolonged periods of rainfall and flooding;
- Inadequate spillway capacity, resulting in excess overtopping flows;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross-section of the dam and abutments, or maintain gates, valves, and other operational components;
- Improper design, including the use of improper construction materials and construction practices;
- Negligent operation, including the failure to remove or open gates or valves during high flow periods;
- Failure of upstream dams on the same waterway; or
- High winds, which can cause significant wave action and result in substantial erosion.

Water released by a failed dam generates tremendous energy and can cause a flood that is catastrophic to life and property. Dam failures are generally catastrophic if the structure is breached or significantly damaged. A catastrophic dam failure could challenge local response capabilities and require evacuations to save lives. Impacts to life safety will depend on the warning time and the resources available to notify and evacuate the public. Major casualties and loss of life could result, as well as water quality and health issues. Potentially catastrophic effects to roads, bridges, and homes are also of major concern. Associated water quality and health concerns could also be issues. Factors that influence the potential severity of a full or partial dam failure are the amount of water impounded; the density, type, and value of development and infrastructure located downstream; and the speed of failure.

Dam failure can occur with little warning. Intense storms may produce a flood in a few hours or even minutes for upstream locations. Flash floods occur within six hours of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching. Other failures and breaches can take much longer to occur, from days to weeks, as a result of debris jams or the accumulation of melting snow.

Dam failures are of particular concern because the failure of a large dam has the potential to cause more death and destruction than the failure of any other manmade structure. This is because of the destructive power of the flood wave that would be released by the sudden collapse of a large dam. Dams are innately hazardous structures. Failure or poor operation can result in the release of the reservoir contents—this can include water, mine wastes, or agricultural refuse–causing negative impacts upstream or downstream or at locations far from the dam. Negative impacts of primary concern are loss of human life, property damage, lifeline disruption, and environmental damage.

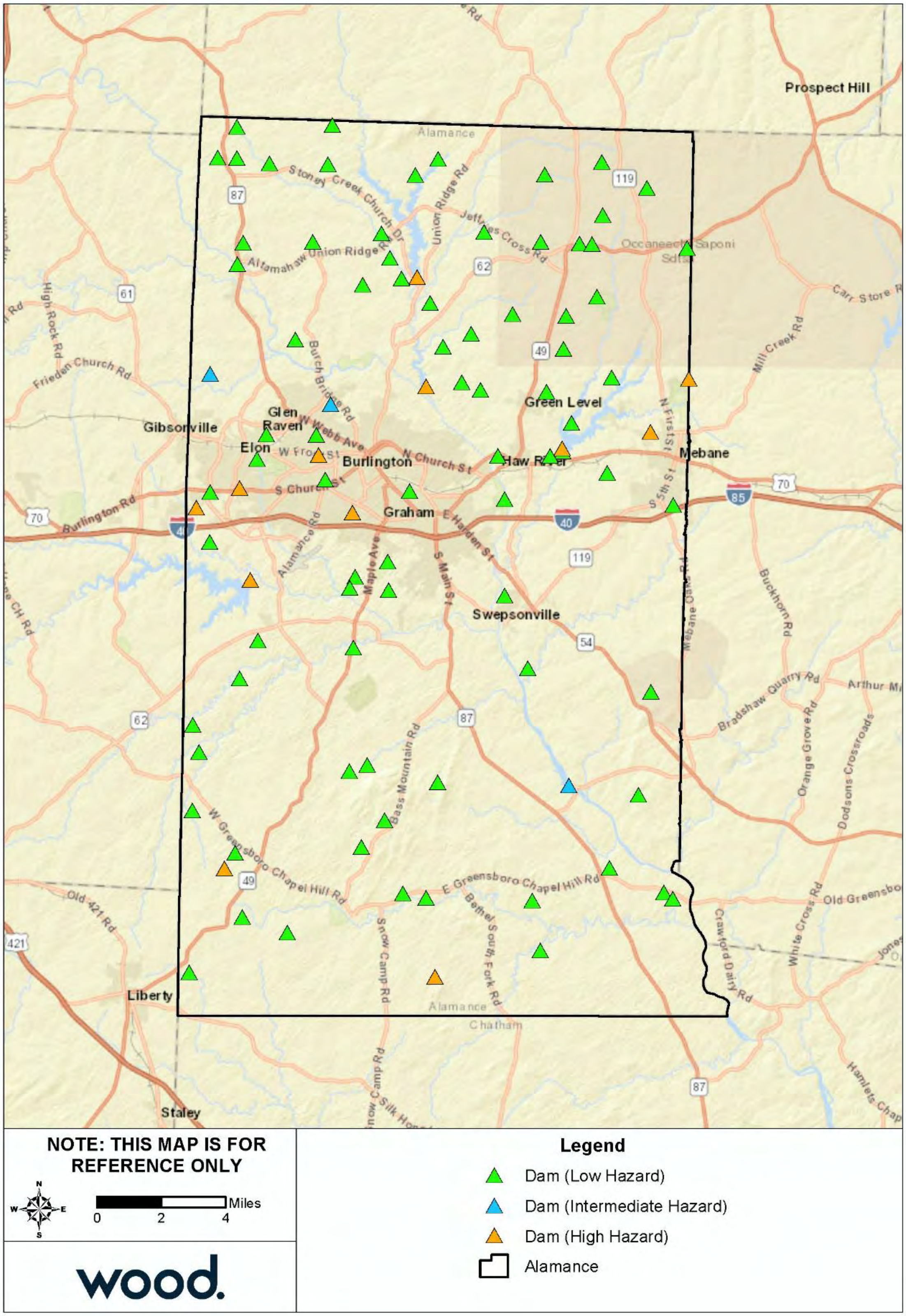
Warning Time: 4 – Less than 6 hours

Duration: 3 – Less than 1 week

Location

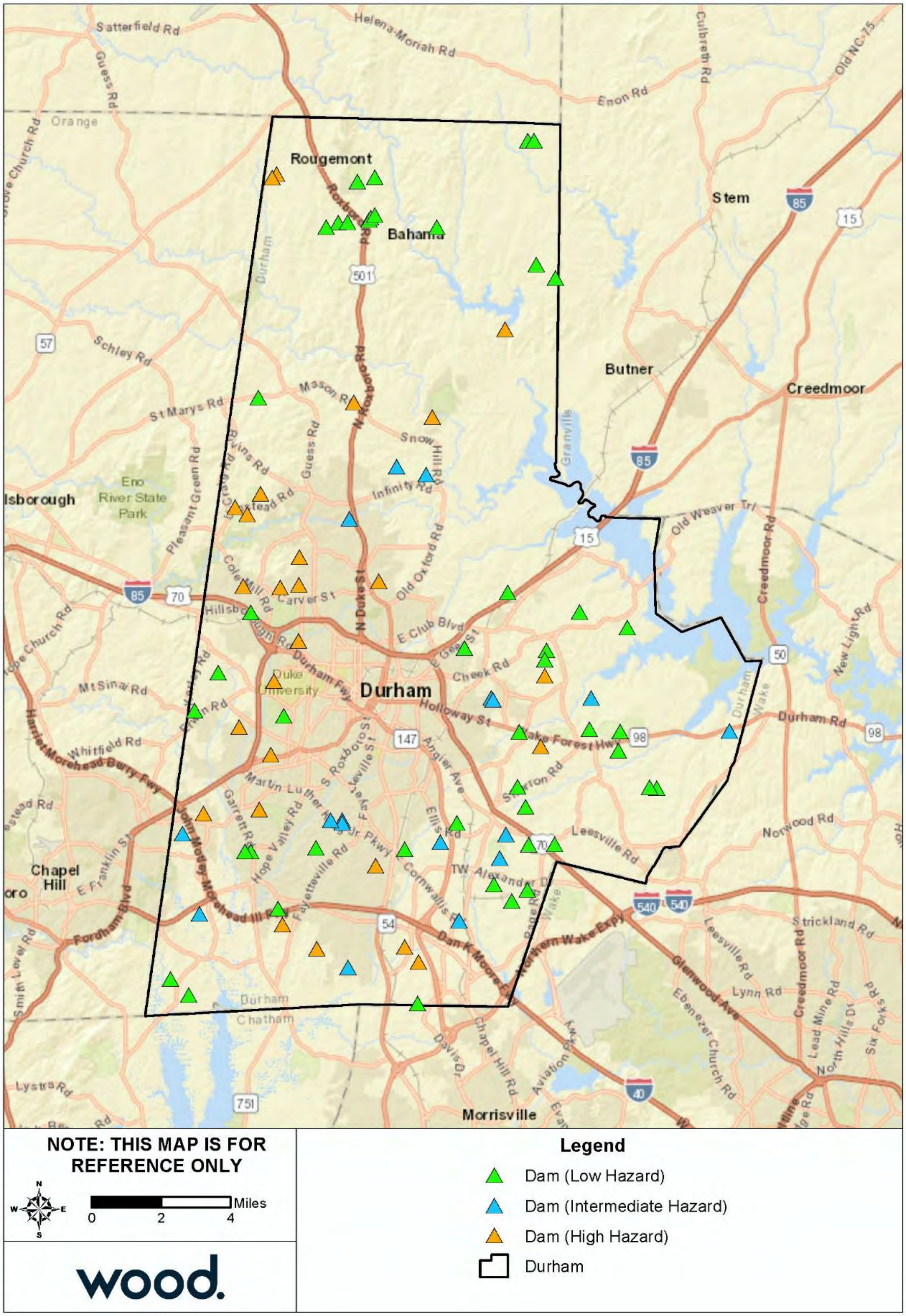
The North Carolina Dam Inventory, maintained by North Carolina Department of Environmental Quality, provides a detailed inventory of all dams in the state. As of July 2018, there are 260 dams in the Eno-Haw region, 95 in Alamance County, 90 in Durham County, 48 in Orange County, and 27 in Person County. Of the 260, 164 are rated low hazard, 33 are rated intermediate hazard, and 63 are rated high hazard. Figure 4.5 through Figure 4.8 show the location of all dams in the Eno-Haw Region by county. Table 4.15 through Table 4.18 list all dams with high hazard potential in the region by county.

Figure 4.5 – Dam Locations in Alamance County



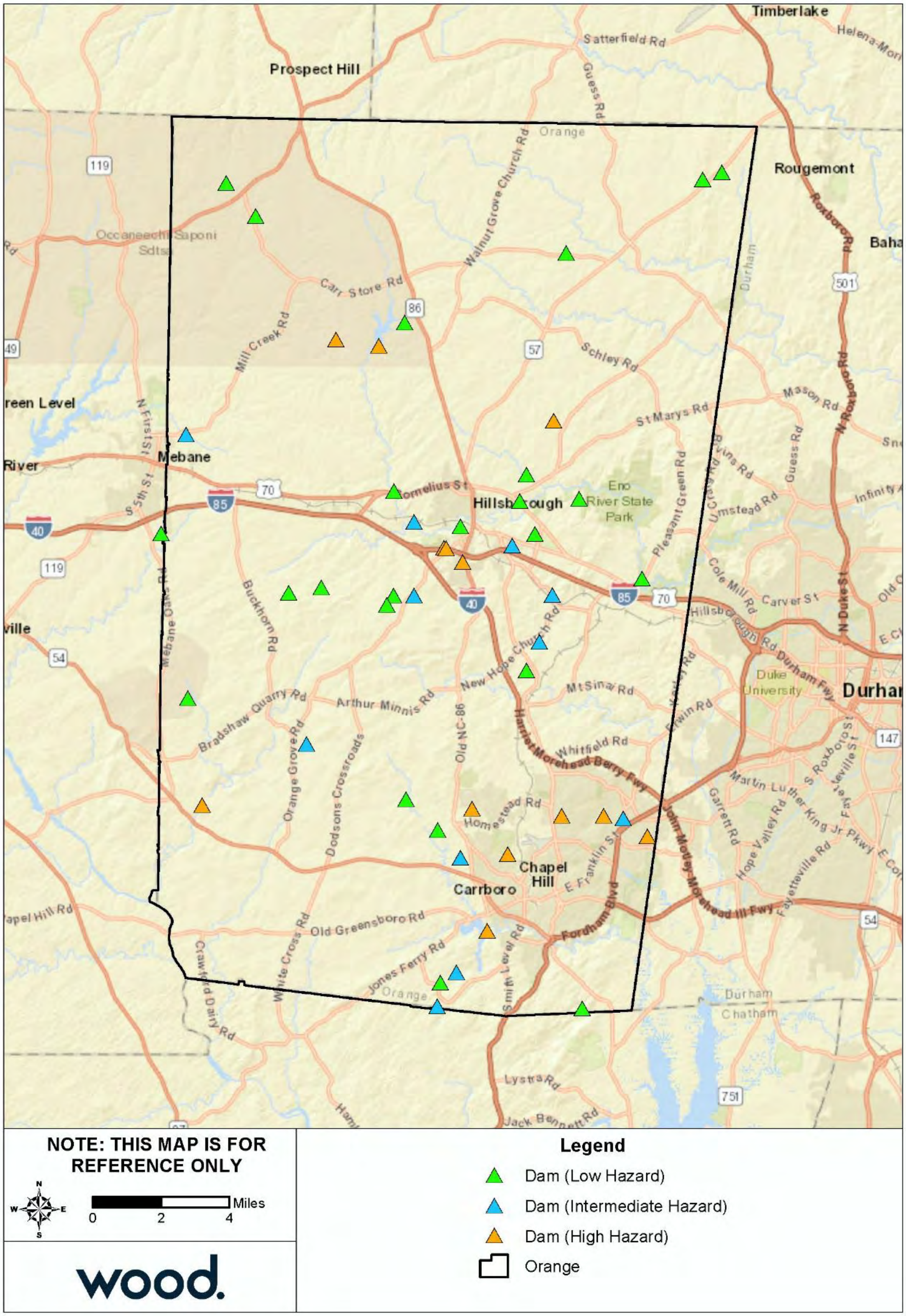
Source: North Carolina Dam Inventory, July 2018

Figure 4.6 – Dam Locations in Durham County



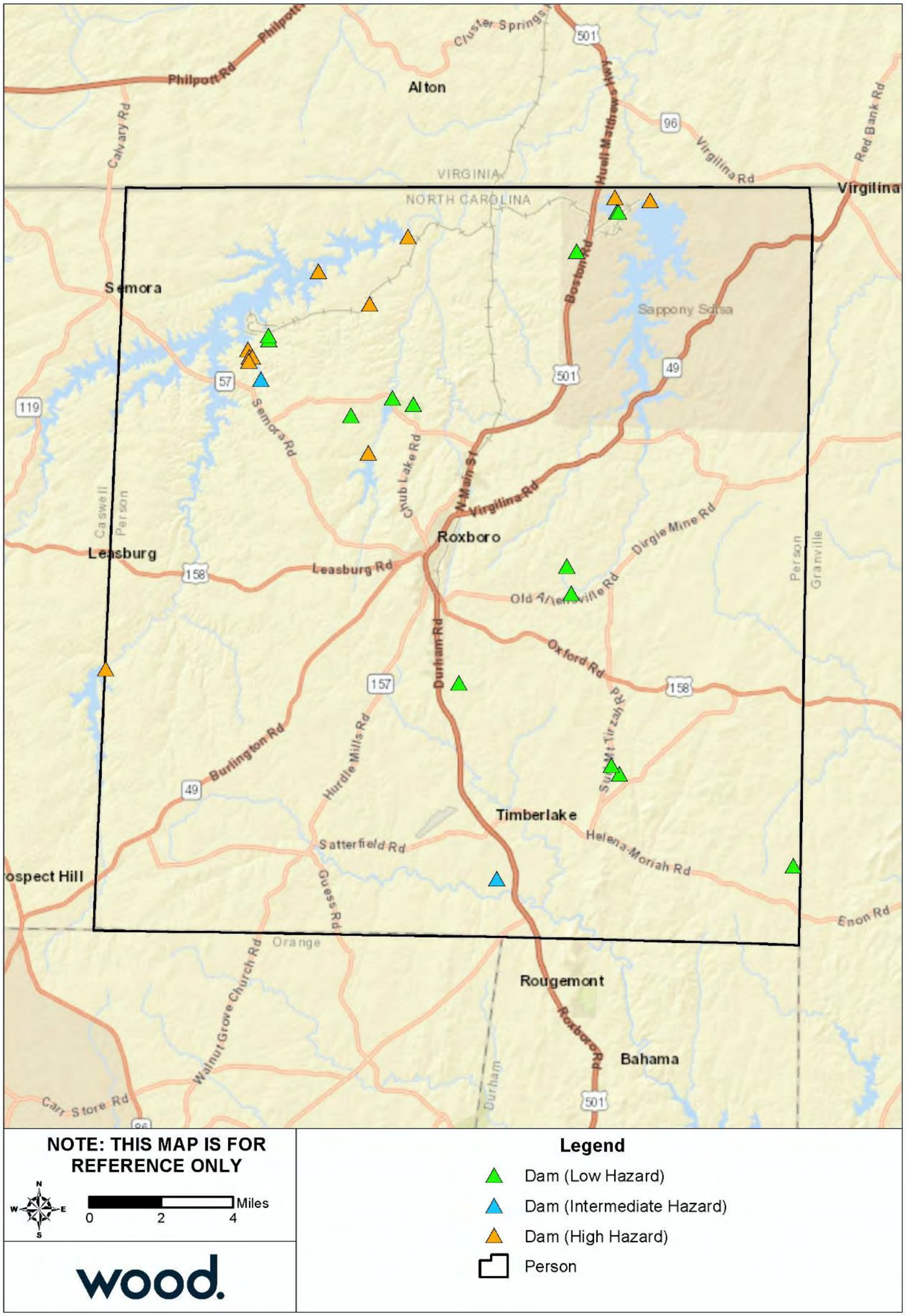
Source: North Carolina Dam Inventory, July 2018

Figure 4.7 – Dam Locations in Orange County



Source: North Carolina Dam Inventory, July 2018

Figure 4.8 – Dam Locations in Person County



Source: North Carolina Dam Inventory, July 2018

Table 4.15 – High Hazard Dams in Alamance County

Dam Name	NID ID	Condition as of Last Inspection	Max Capacity (Ac-Ft)	Nearest Downstream Location
Alamance County				
Lake Cammack Dam	NC00739	Fair	36,000	Carolina
Forest Lake Dam	NC00748	Poor	235	Haw River
Timber Ridge Lake Dam	NC00742	Fair	288	Saxapahaw
Old Stony Creek Dam	NC00762	Poor	3,600	Hopedale
Tredmont Lake Dam	NC01732	Poor	331	
Back Creek Reservoir	NC04873	Fair	10,645	Haw River
Burlington				
McEwen Estate Dam	NC01734	Fair	142	Alamance
Tate Dam	NC01737	Fair	56	Burlington
Lake Mackintosh Dam	NC04954	Fair	30,825	Alamance
Hudgins Dam	NC05541	Unsatisfactory	10	
Elon				
Somerton Lake Dam	NC05203	Poor	46.89	Burlington
Mebane				
Mill Creek Subdivision Dam	NC05718	Fair	7	Mebane

Source: North Carolina Dam Inventory, July 2018

Table 4.16 – High Hazard Dams in Durham County

Dam Name	NID ID	Condition as of Last Inspection	Max Capacity (Ac-Ft)	Nearest Downstream Location
Durham County				
Lake Michie Dam	NC01027	Satisfactory	18,660	Redwood
Eden Lake Dam	NC01043		140	Orange Factory
Willowhaven Lake Dam #2	NC01050	Satisfactory	58	Durham
Lake Vista Dam	NC01051	Fair	69	Durham
Discovery Lake Dam	NC01666	Satisfactory	336	Haywood
N. Durham Quarry East Dam	NC05165	Satisfactory	134	Bunny Rd at Lick Creek
N. Durham Quarry West Dam	NC05166	Satisfactory	83	Cothran Rd
Durham (City)				
Crystal Lake Dam	NC01021	Satisfactory	100	Durham (Hillandale Rd)
Newcomb Lake Dam	NC01023	Fair	94	Durham (Umstead Rd.)
Lake Elton Dam	NC01037	Satisfactory	155	Parkwood
Lakehurst S/D Dam	NC01039	Satisfactory	145	Farrington
Cole Lake Dam	NC01049	Fair	81	Huckleberry Springs (Fleming Dr)
Van Trine Lake Dam	NC01337			Durham
Dairy Pond Dam	NC02270	Satisfactory	31.2	Durham
Boles Lake Dam	NC05046	Satisfactory	60.2	Durham
Little River Dam	NC05143	Satisfactory	18,000	Falls
Georgiade Dam	NC02273	Not Rated	12	Durham
Stone Throw Apartments Pond Dam	NC02317	Fair	1	
Grove Park Dam	NC02323	Satisfactory	302	

Dam Name	NID ID	Condition as of Last Inspection	Max Capacity (Ac-Ft)	Nearest Downstream Location
Hock Dam	NC05112	Satisfactory	8	William Penn Plaza Rd
Oxford Commons Dam	NC02324	Satisfactory	24	William Penn Plaza Rd
Ridgefield Subdv. SWDP Dam 14	NC05629	Fair	6	Durham
The Streets at Southpoint Mall Dam	NC05653	Satisfactory	51	
Patterson Place Dam	NC05819	Satisfactory	82	
Forest at Duke Dam	NC06117	Satisfactory	-	
Williams Terminal Reservoir Dam	NC06139	Fair	-	Durham
Duke Water Harvesting Pond Dam	NC06146	Satisfactory	70	Durham

Source: North Carolina Dam Inventory, July 2018

Table 4.17 – High Hazard Dams in Orange County

Dam Name	NID ID	Condition as of Last Inspection	Max Capacity (Ac-Ft)	Nearest Downstream Location
Orange County				
Lake Orange Dam	NC00773	Satisfactory	1,640	Hillsborough
Cane Creek Resevoir Dam	NC00779	Satisfactory	19,079	
University Lake Dam	NC00782	Satisfactory	4,836	Carrboro
Hillsborough Water Supply Dam	NC05793	Satisfactory	24,061	Hillsborough (N. Elland Cedar)
Randy Fox Dam	NC05715	Satisfactory	68	Hillsborough
Occoneechee Upper Dam	NC05776	Satisfactory	-	Virginia Cates Rd.
Occoneechee Lower Dam	NC05777	Satisfactory	5	Virginia Cates Rd.
Carrboro				
Hogan Farms Dam	NC00770	Satisfactory	160	Chapel Hill
Spring Valley Dam	NC04994	Satisfactory	22	
Chapel Hill				
Eastwood Lake Dam	NC00781	Satisfactory	330	Chapel Hill
Lake Ellen Dam	NC01537	Fair	120	Chapel Hill
Colony Lake	NC03671	Satisfactory	48	
Hillsborough				
Flint Ridge Dam	NC03663	Poor	22	Hillsborough

Source: North Carolina Dam Inventory, July 2018

Table 4.18 – High Hazard Dams in Person County

Dam Name	NID ID	Condition as of Last Inspection	Max Capacity (Ac-Ft)	Nearest Downstream Location
Person County				
Lake Hyco Dam	NC00656	Poor	77,000	Mcgehees Mill
Roxboro Municipal Lake Dam	NC00658	Satisfactory	4,125	Chub Lake
Roxboro Afterbay Dam	NC00666	Fair	16,800	Denniston
South Hyco Lake Dam (Lake Roxboro)	NC03689	Satisfactory	9,400	
Mayo Lake Dam	NC06002	Fair	-	
Mayo Ash Pond Dam	NC06003	Fair	-	

Dam Name	NID ID	Condition as of Last Inspection	Max Capacity (Ac-Ft)	Nearest Downstream Location
Roxboro West Ash Pond Dam	NC06006	Fair	-	
Roxboro West FGD Settling Pond	NC06008	Fair	-	
Roxboro East FGD Settling Pond	NC06009	Fair	-	
Roxboro FGD Forward Flush Pond	NC06010	Fair	-	
Jimmie Bowes Transmission Line Embankment	NC06016	Satisfactory	-	

Source: North Carolina Dam Inventory, July 2018

Extent

Each state has definitions and methods to determine the hazard potential of a dam. In North Carolina, dams are regulated by the state if they are 25 feet or more in height and impound 50 acre-feet or more. Dams and impoundments smaller than that may fall under state regulation if it is determined that failure of the dam could result in loss of human life or significant damage to property. The height of a dam is from the highest point on the crest of the dam to the lowest point on the downstream toe, and the storage capacity is the volume impounded at the elevation of the highest point on the crest of the dam.

Dam Safety Program engineers determine the "hazard potential" of a dam, meaning the probable damage that would occur if the structure failed, in terms of loss of human life and economic loss or environmental damage. Dams are assigned one of three classes based on the nature of their hazard potential:

- Class A (Low Hazard) includes dams located where failure may damage uninhabited low value non-residential buildings, agricultural land, or low volume roads.
- Class B (Intermediate Hazard) includes dams located where failure may damage highways or secondary railroads, cause interruption of use or service of public utilities, cause minor damage to isolated homes, or cause minor damage to commercial and industrial buildings. Damage to these structures will be considered minor only when they are located in backwater areas not subjected to the direct path of the breach flood wave; and they will experience no more than 1.5 feet of flood rise due to breaching above the lowest ground elevation adjacent to the outside foundation walls or no more than 1.5 feet of flood rise due to breaching above the lowest floor elevation of the structure.
- Class C (High Hazard) includes dams located where failure will likely cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, primary highways, or major railroads.

Table 4.19 – Dam Hazard Classifications

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

Source: NCDEQ

Based on classification criteria, a high hazard dam failure could cause death and/or injury as well as severe property damage and economic impacts within the affected area. Therefore, though the affected area would be negligible in size relative to the entire planning area, the potential impact of a high hazard dam failure is critical.

Impact: 3 – Critical

Spatial Extent: 1 – Negligible

Historical Occurrences

According to the previous Eno-Haw and Person County plans and anecdotal evidence, there are no records of historical dam failures occurrences in or affecting the planning area.

Probability of Future Occurrence

Given the significant presence of high hazard dams in the Eno-Haw Region, failure of a dam is possible. Dam failure has not occurred in the region, however historical events alone do not provide an adequate estimate of potential future occurrence. With heavy rain events becoming more frequent and intense, conditions conducive to dam failure may occur more frequently as well.

Probability: 2 – Possible

Climate Change

Studies have been conducted to investigate the impact of climate change scenarios on dam safety. The safety of dams for the future climate can be based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The results from the studies indicate that the design floods with the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. Studies concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario.

Vulnerability Assessment

Methodologies and Assumptions

Dam inundation areas were not available for the identified dams; therefore, a quantitative vulnerability assessment could not be completed. Vulnerability discussed below is based on anecdotal evidence and theoretical understanding of potential risks.

People

A person's immediate vulnerability to a dam failure is directly associated with the person's distance downstream of the dam as well as proximity to the stream carrying the floodwater from the failure. For dams that have an Emergency Action Plan (EAP), the vulnerability of loss of life for persons in their homes or on their property may be mitigated by following the EAP evacuation procedures; however, the displaced persons may still incur sheltering costs. For persons located on the river (e.g. for recreation) the vulnerability of loss of life is significant.

People are also vulnerable to the loss of the uses of the lake upstream of a dam following failure. Several uses are minor, such as aesthetics or recreational use. However, some lakes serve as drinking water supplies and their loss could disrupt the drinking water supply and present a public health problem.

Property

Vulnerability of the built environment includes damage to the dam itself and any man-made feature located within the inundation area caused by the dam failure. Downstream of the dam, vulnerability includes potential damage to homes, personal property, commercial buildings and property, and government owned buildings and property; destruction of bridge or culvert crossings; weakening of bridge supports through scour; and damage or destruction of public or private infrastructure that cross the stream such as water and sewer lines, gas lines and power lines. Water dependent structures on the lake upstream of the dam, such as docks/piers, floating structures or water intake structures, may be damaged by the rapid reduction in water level during the failure.

Environment

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

Consequence Analysis

Table 4.20 summarizes the potential negative consequences of dam failure.

Table 4.20 – Consequence Analysis – Dam Failure

Category	Consequences
Public	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas.
Responders	Localized impact expected to limit damage to personnel in the inundation area at the time of the incident.
Continuity of Operations (including Continued Delivery of Services)	Damage to facilities/personnel in the area of the incident may require temporary relocation of some operations. Localized disruption of roads and/or utilities may postpone delivery of some services. Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Property, Facilities and Infrastructure	Localized impact to facilities and infrastructure in the inundation area of the incident. Some severe damage possible.
Environment	Localized impact expected to be severe for inundation area and moderate to light for other adversely affected areas. Consequences include erosion, water quality degradation, wildlife displacement or destruction, and habitat destruction.
Economic Condition of the Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage and length of investigation.
Public Confidence in the Jurisdiction's Governance	Localized impact expected to primarily adversely affect only the dam owner and local entities.

Hazard Summary by Jurisdiction

The following table summarizes dam failure hazard risk by jurisdiction. Warning time and duration are inherent to the hazard and remain constant across jurisdictions. Spatial extent of any dam failure will be negligible relative to the planning area. Jurisdictions that have high hazard dams within their boundaries or are the nearest downstream location to a high hazard dam were assigned a probability rating of possible and an impact score of critical. Jurisdictions with no high hazard dams or upstream threats were assigned a probability rating of unlikely and an impact rating of limited.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	2	3	1	4	3	2.4	M
Burlington	2	3	1	4	3	2.4	M
Graham	1	2	1	4	3	1.8	L
Mebane	2	3	1	4	3	2.4	M
Elon	2	3	1	4	3	2.4	M
Green Level	1	2	1	4	3	1.8	L
Haw River	2	3	1	4	3	2.4	M
Ossipee	1	2	1	4	3	1.8	L
Swepsonville	1	2	1	4	3	1.8	L
Alamance	2	3	1	4	3	2.4	M
Durham County	2	3	1	4	3	2.4	M
Durham	2	3	1	4	3	2.4	M
Orange County	2	3	1	4	3	2.4	M
Carrboro	2	3	1	4	3	2.4	M
Chapel Hill	2	3	1	4	3	2.4	M
Hillsborough	2	3	1	4	3	2.4	M
Person County	2	3	1	4	3	2.4	M
Roxboro	1	2	1	4	3	1.8	L

4.5.2 Drought

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Drought	Likely	Minor	Large	More than 24 hrs	More than 1 week	2.5

Hazard Background

Drought is a deficiency in precipitation over an extended period. It is a normal, recurrent feature of climate that occurs in virtually all climate zones. The duration of a drought varies widely. There are cases when drought develops relatively quickly and lasts a very short period of time, exacerbated by extreme heat and/or wind, and there are other cases when drought spans multiple years, or even decades. Studying the paleoclimate record is often helpful in identifying when long-lasting droughts have occurred. Common types of drought are detailed below in Table 4.21.

Table 4.21 – Types of Drought

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

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

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

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

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

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

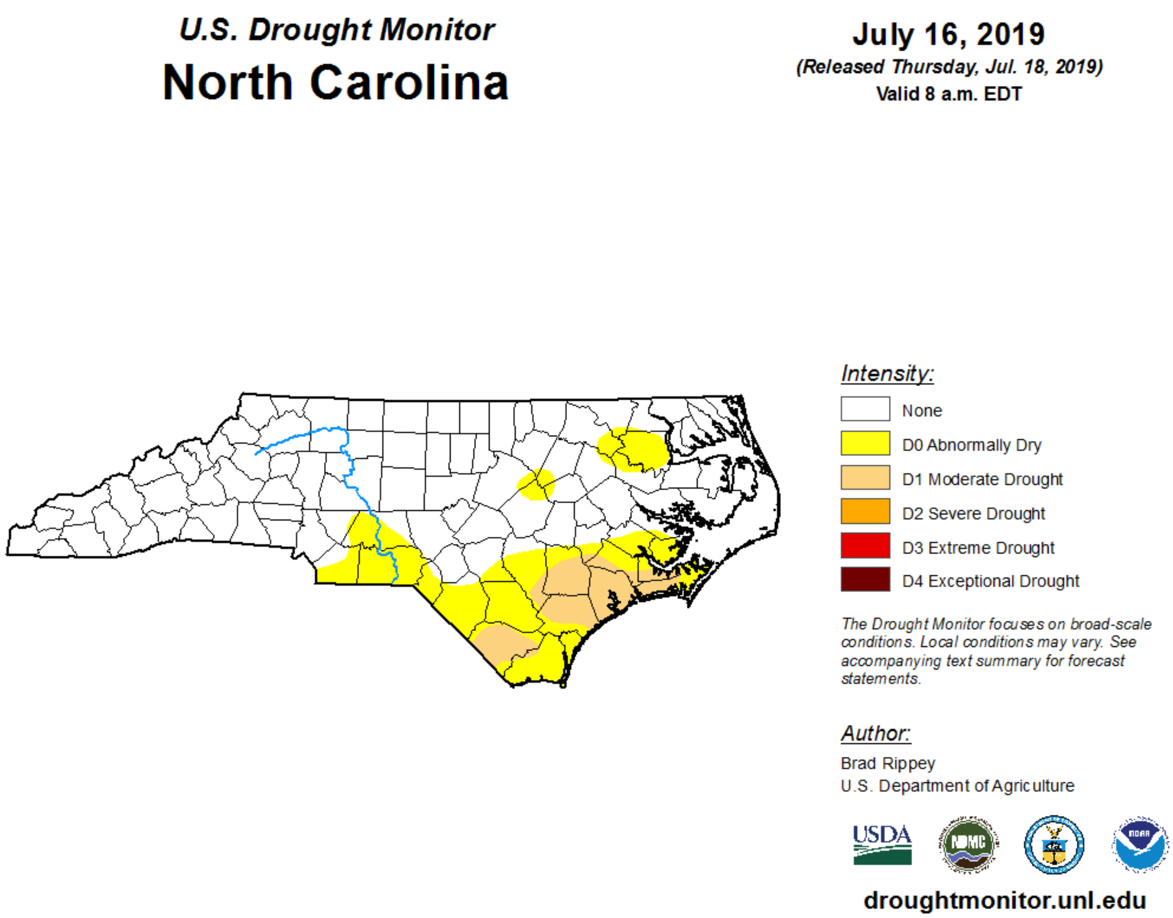
Warning Time: 1 – More than 24 hours

Duration: 4 – More than one week

Location

Drought is a regional hazard that can cover the entire planning area, and in some cases the entire state. The figure below notes the U.S. Drought Monitor's drought ratings for North Carolina as of July 16, 2019; as of that date, the Eno-Haw region was experiencing no impacts of drought.

Figure 4.9 – US Drought Monitor for Week of July 16, 2019



Source: U.S. Drought Monitor

Extent

Drought extent can be defined in terms of intensity, using the U.S. Drought Monitor scale. The Drought Monitor Scale measures drought episodes with input from the Palmer Drought Severity Index, the Standardized Precipitation Index, the Keetch-Byram Drought Index, soil moisture indicators, and other inputs as well as information on how drought is affecting people. Figure 4.10 details the classifications used by the U.S. Drought Monitor. A category of D2 (severe) or higher on the U.S. Drought Monitor Scale can typically result in crop or pasture losses, water shortages, and the need to institute water restrictions.

Figure 4.10 – US Drought Monitor Classifications

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

Source: US Drought Monitor

From late 2007 through mid-2008, North Carolina experienced the worst drought in state history. During this time, portions of all four Eno-Haw Region counties experienced exceptional drought conditions.

Impact: 1 – Minor

Spatial Extent: 4 – Large

Historical Occurrences

U.S. Drought Monitor records drought intensity weekly throughout the country. The North Carolina Department of Environmental Quality (NCDEQ) Division of Water Resources maintains records of Drought Monitor data for the state as far back as January 2000. Table 4.22 presents the number of weeks that each county in the N.E.W. Region spent in drought by intensity over the period from 2000 through 2018, for which the Drought Monitor has records for 973 weeks.

Table 4.22 – Weeks in Drought, 2000-2018

	Weeks in Drought						% of time in Severe Drought or Worse
County	Total	D0	D1	D2	D3	D4	
Alamance	496	247	124	65	22	32	12.2%
Durham	456	200	145	53	25	27	10.8%
Orange	484	230	137	65	22	30	12.0%
Person	436	219	121	47	38	11	9.9%

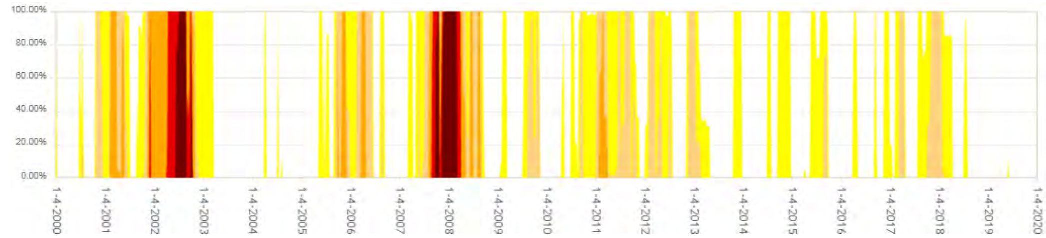
Source: NCDEQ Division of Water Resources, Drought Monitor History

Figure 4.11 through Figure 4.14 shows the historical periods where each county was considered in some level of drought condition. The color key shown in Figure 4.10 indicates the intensity of the drought.

Alamance County

Between 2000 and 2018, Alamance County was in some level of drought 51% of the time.

Figure 4.11 – US Drought Monitor Historical Trends – Alamance County 2000-2018

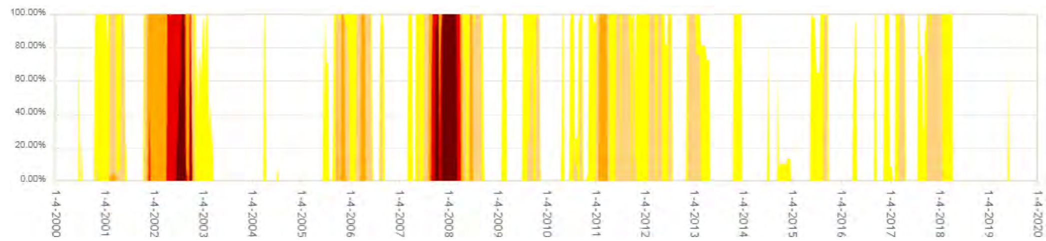


Source: U.S. Drought Monitor

Durham County

Between 2000 and 2018, Durham County was in some level of drought 46.9% of the time.

Figure 4.12 – US Drought Monitor Historical Trends – Durham County 2000-2018

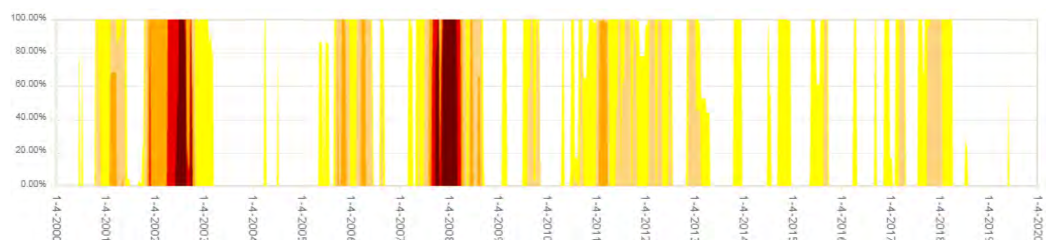


Source: U.S. Drought Monitor

Orange County

Between 2000 and 2018, Orange County was in some level of drought 49.7% of the time.

Figure 4.13 – US Drought Monitor Historical Trends – Orange County 2000-2018

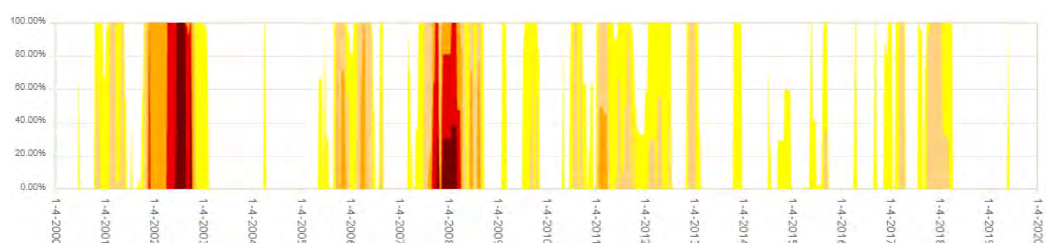


Source: U.S. Drought Monitor

Person County

Between 2000 and 2018, Person County was in some level of drought 47.6% of the time.

Figure 4.14 – US Drought Monitor Historical Trends – Person County 2000-2018



Source: U.S. Drought Monitor

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

According to the National Drought Mitigation Center's Drought Impact Reporter, during the 10-year period from January 2009 through December 2018, 289 drought impacts were noted for the State of North Carolina, of which 19 were reported to affect the Eno-Haw region. Table 4.23 summarizes the number of impacts reported by category and the years impacts were reported for each category. Note that the Drought Impact Reporter assigns multiple categories to each impact.

Table 4.23 – Drought Impacts Reported for Eno-Haw Counties, January 2009 through December 2018

Category	Impacts	Years Reported
Agriculture	2	2010, 2012
Fire	2	2011
Plants & Wildlife	9	2014, 2017
Relief, Response & Restrictions	7	2010, 2011, 2012, 2017
Water Supply & Quality	8	2011, 2012, 2014, 2015, 2017

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

Probability of Future Occurrence

Probability: 3 – Likely

Over the 19-year (973 week) period from 2000 through 2018, the Eno-Haw Region averaged 468 weeks of drought conditions ranging from abnormally dry to exceptional drought. This equates to a 48 percent chance of drought in any given week. Of this time, an average of approximately 109 weeks were categorized as a severe (D2) drought or greater; which equates to an 11 percent chance of severe drought in any given week.

Climate Change

The Fourth National Climate Assessment reports that average and extreme temperatures are increasing across the country and average annual precipitation is decreasing in the Southeast. Heavy precipitation events are becoming more frequent, meaning that there will likely be an increase in the average number of consecutive dry days. As temperature is projected to continue rising, evaporation rates are expected to increase, resulting in decreased surface soil moisture levels. Together, these factors suggest that drought will increase in intensity and duration in the Southeast. The Triangle Regional Resilience Assessment notes that the number of days with extreme temperatures has been increasing in the Triangle, climbing from an average of 18 days over 92°F per year from 1948 to 2012 to a peak of 48 days over 92°F in 2010. The region overall is expected to see longer, more intense periods of drought.

Vulnerability Assessment

Methodologies and Assumptions

Vulnerability to drought in the Eno-Haw region is based on historical occurrences of drought in the planning area and generalized concerns regarding potential drought consequences. Agricultural vulnerability was estimated using data from the 2012 Census of Agriculture and a review of past claims related to drought.

People

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

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

Property

Drought is unlikely to cause damages to the built environment. However, in areas with shrinking and expansive soils, drought may lead to structural damages. Drought may cause severe property loss for the agricultural industry in terms of crop and livestock losses. The USDA's Risk Management Agency (RMA) maintains a database of all paid crop insurance claims. Between 2007-2017, the sum of claims paid for crop damage as a result of drought in the Eno-Haw region was $19,734,491, over 60 percent of these losses were paid out in Person County. The region averaged $1,794,044 in losses every year. Losses were greatest in 2007 for all counties except for Alamance, where losses were greatest in 2011.

Table 4.24 – Crop Losses Resulting from Drought, 2007-2017, Alamance County

Year	Determined Acres	Indemnity Amount
2007	3,299.34	$793,653.00
2008	1,131.12	$273,753.00
2009	1,985.60	$561,311.00
2010	1,909.19	$636,395.00
2011	2,670.08	$1,028,993.00
2012	1,007.26	$179,029.00
2014	698.14	$296,622.90
2015	1,879.76	$507,006.90
2016	730.43	$384,782.90
Total	**15,310.92**	**$4,661,546.70**

Source: USDA Risk Management Agency

Table 4.25 – Crop Losses Resulting from Drought, 2007-2017, Durham County

Year	Determined Acres	Indemnity Amount
2007	980.07	$160,081.00
2008	908.32	$151,673.00
2009	190.67	$25,294.00
2010	412.61	$67,285.00
2011	687.75	$155,180.00
2012	370.58	$52,974.00
2014	150.56	$17,874.16
2015	284.86	$34,739.80
2016	133.05	$24,683.00
Total	**4,118.47**	**$689,783.96**

Source: USDA Risk Management Agency

Table 4.26 – Crop Losses Resulting from Drought, 2007-2017, Orange County

Year	Determined Acres	Indemnity Amount
2007	3,257.97	$654,315.00
2008	1,382.18	$189,012.00
2009	706.36	$126,118.00
2010	2,312.01	$340,313.00

Year	Determined Acres	Indemnity Amount
2011	1,951.83	$339,680.00
2012	1,272.73	$266,205.00
2014	1,039.00	$129,503.35
2015	785.50	$89,972.40
2016	207.01	$82,729.71
Total	**12,914.59**	**$2,217,848.46**

Source: USDA Risk Management Agency

Table 4.27 – Crop Losses Resulting from Drought, 2007-2017, Person County

Year	Determined Acres	Indemnity Amount
2007	15,953.87	$2,395,778.00
2008	12,595.77	$1,837,537.00
2009	4,975.73	$1,045,095.00
2010	9,048.97	$1,621,155.00
2011	6,468.28	$1,262,455.00
2012	3,258.53	$669,129.00
2013	635.49	$50,604.00
2014	1,810.55	$389,822.68
2015	3,723.51	$1,181,568.35
2016	3,699.43	$1,712,168.50
Total	**62,170.13**	**$12,165,312.53**

Source: USDA Risk Management Agency

Environment

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

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

Consequence Analysis

Table 4.28 summarizes the potential negative consequences of drought.

Table 4.28 – Consequence Analysis - Drought

Category	Consequences
Public	Can cause anxiety or depression about economic losses, conflicts over water shortages, reduced incomes, fewer recreational activities, higher incidents of heat stroke, and fatality.
Responders	Impacts to responders are unlikely. Exceptional drought conditions may impact the amount of water immediately available to respond to wildfires.
Continuity of Operations (including Continued Delivery of Services)	Drought would have minimal impacts on continuity of operations due to the relatively long warning time that would allow for plans to be made to maintain continuity of operations.

Category	Consequences
Property, Facilities and Infrastructure	Drought has the potential to affect water supply for residential, commercial, institutional, industrial, and government-owned areas. Drought can reduce water supply in wells and reservoirs. Utilities may be forced to increase rates.
Environment	Environmental impacts include strain on local plant and wildlife; increased probability of erosion and wildfire.
Economic Condition of the Jurisdiction	Farmers may face crop losses or increased livestock costs. Businesses that depend on farming may experience secondary impacts. Extreme drought has the potential to impact local businesses in landscaping, recreation and tourism, and public utilities.
Public Confidence in the Jurisdiction's Governance	When drought conditions persist with no relief, local or State governments must often institute water restrictions, which may impact public confidence.

Hazard Summary by Jurisdiction

The following table summarizes drought hazard risk by jurisdiction. Drought risk is uniform across the planning area. Warning time, duration, and spatial extent are inherent to the hazard and remain constant across jurisdictions. The majority of damages that result from drought are to crops and other agriculture-related activities as well as water-dependent recreation industries. The magnitude of the impacts is typically greater in unincorporated areas due to greater exposure of agriculture. Alamance, Orange, and Person Counties were assigned an impact rating of "limited" because each has over a quarter of their land area in agriculture, as detailed in Section 4.4.4. In developed areas, the magnitude of drought is less severe, with lawns and local gardens affected and potential impacts on local water supplies during severe, prolonged drought.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	3	2	4	1	4	2.8	H
Burlington	3	1	4	1	4	2.5	H
Graham	3	1	4	1	4	2.5	H
Mebane	3	1	4	1	4	2.5	H
Elon	3	1	4	1	4	2.5	H
Green Level	3	1	4	1	4	2.5	H
Haw River	3	1	4	1	4	2.5	H
Ossipee	3	1	4	1	4	2.5	H
Swepsonville	3	1	4	1	4	2.5	H
Alamance	3	1	4	1	4	2.5	H
Durham County	3	1	4	1	4	2.5	H
Durham	3	1	4	1	4	2.5	H
Orange County	3	2	4	1	4	2.8	H
Carrboro	3	1	4	1	4	2.5	H
Chapel Hill	3	1	4	1	4	2.5	H
Hillsborough	3	1	4	1	4	2.5	H
Person County	3	2	4	1	4	2.8	H
Roxboro	3	1	4	1	4	2.5	H

4.5.3 Earthquake

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Earthquake	Unlikely	Minor	Large	Less than 6 hrs	Less than 6 hrs	1.9

Hazard Background

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

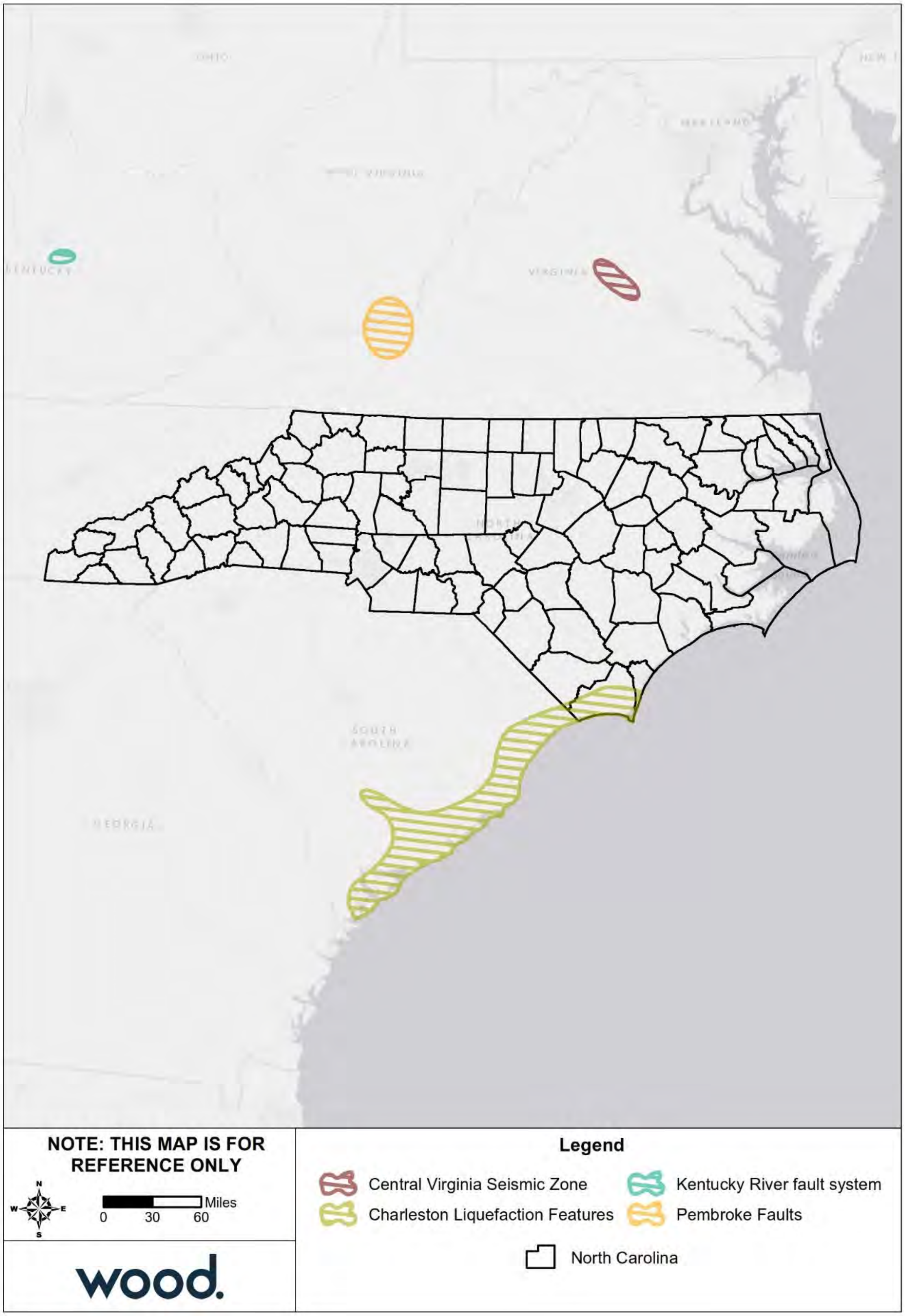
Warning Time: 4 – Less than 6 hours

Duration: 1 – Less than 6 hours

Location

Figure 4.15 reflects the Quaternary faults that present an earthquake hazard for the Eno-Haw region planning area based on data from the USGS Earthquake Hazards Program.

Figure 4.15 – US Quaternary Faults



Source: USGS Earthquake Hazards Program

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

Extent

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude. A detailed description of the Richter Scale is given in Table 4.29. Although the Richter scale is usually used by the news media when reporting the intensity of earthquakes and is the scale most familiar to the public, the scale currently used by the scientific community in the United States is called the Modified Mercalli Intensity (MMI) scale. The MMI scale is an arbitrary ranking based on observed effects. Table 4.30 shows descriptions for levels of earthquake intensity on the MMI scale compared to the Richter scale. Seismic shaking is typically the greatest cause of losses to structures during earthquakes.

Table 4.29 – Richter Scale

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

Source: FEMA

Table 4.30 – Comparison of Richter Scale and Modified Mercalli Intensity (MMI) Scale

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

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

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

As reported in the 2015 Eno-Haw Regional Hazard Mitigation Plan, the largest earthquake to occur within 30 miles of Durham was a 2.7 magnitude in 1978.

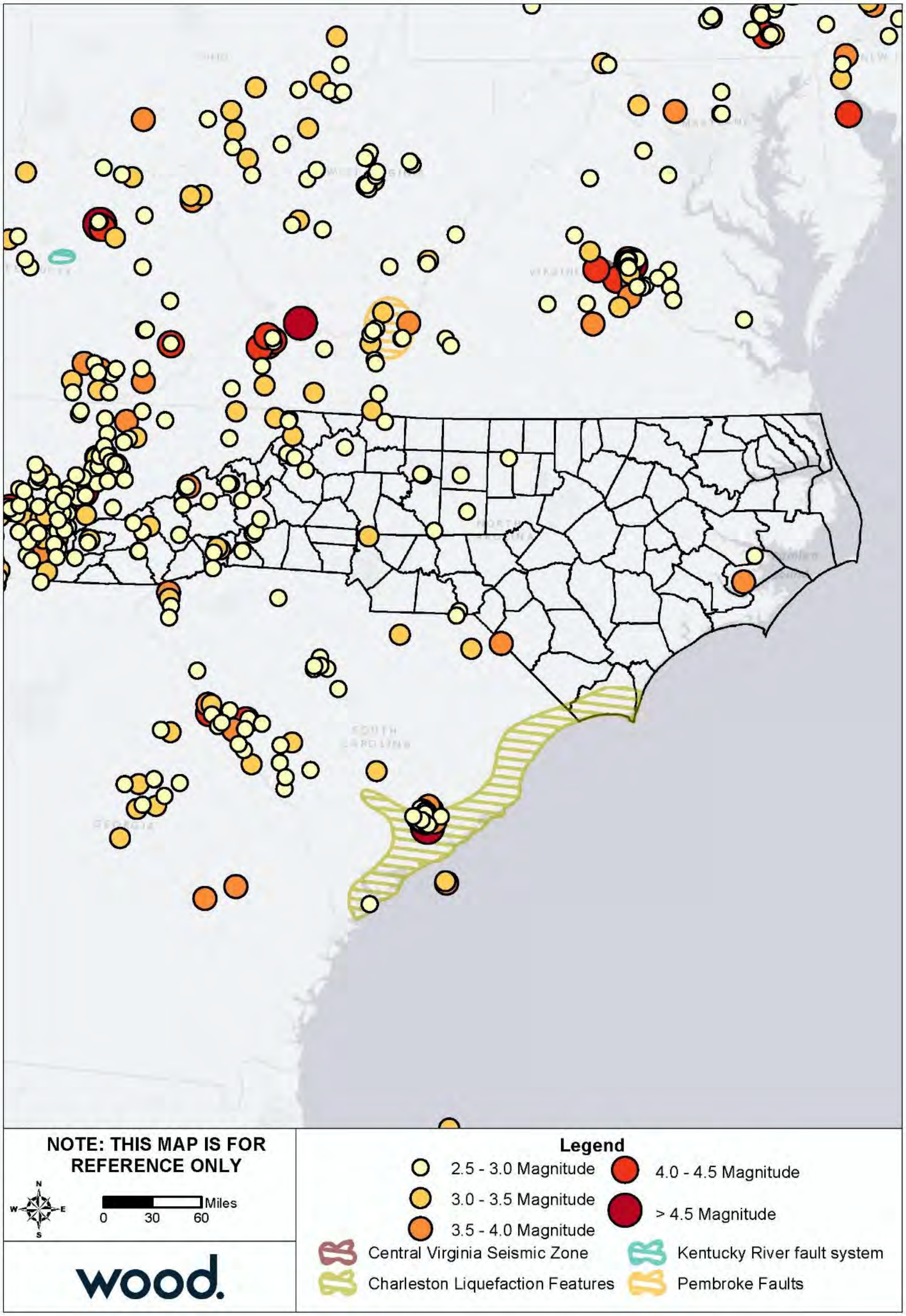
Impact: 1 – Minor

Spatial Extent: 4 – Large

Historical Occurrences

The USGS Earthquake Hazards Program maintains a database of all historical earthquakes of a magnitude 2.5 and greater. These events are illustrated in the following pages. Figure 4.16 shows historical earthquakes by magnitude in relation to North Carolina and the Quaternary Faults identified by USGS. This includes events from 1973 to 2019.

Figure 4.16 – Historical Earthquakes by Magnitude, 1973-2019



Source: USGS Earthquakes Hazard Program

The above map documents all earthquakes that have occurred within North Carolina; however, given the long distances across which earthquake impacts can be felt, these events do not encompass all earthquakes that have affected North Carolina. The USGS Earthquake Hazards Program compiles data on a variety of earthquake metrics, including felt impact. According to USGS records, there have been two earthquakes with a felt impact of III or greater on the MMI scale in North Carolina since 1989; neither of these events caused felt impacts in the Eno-Haw Region.

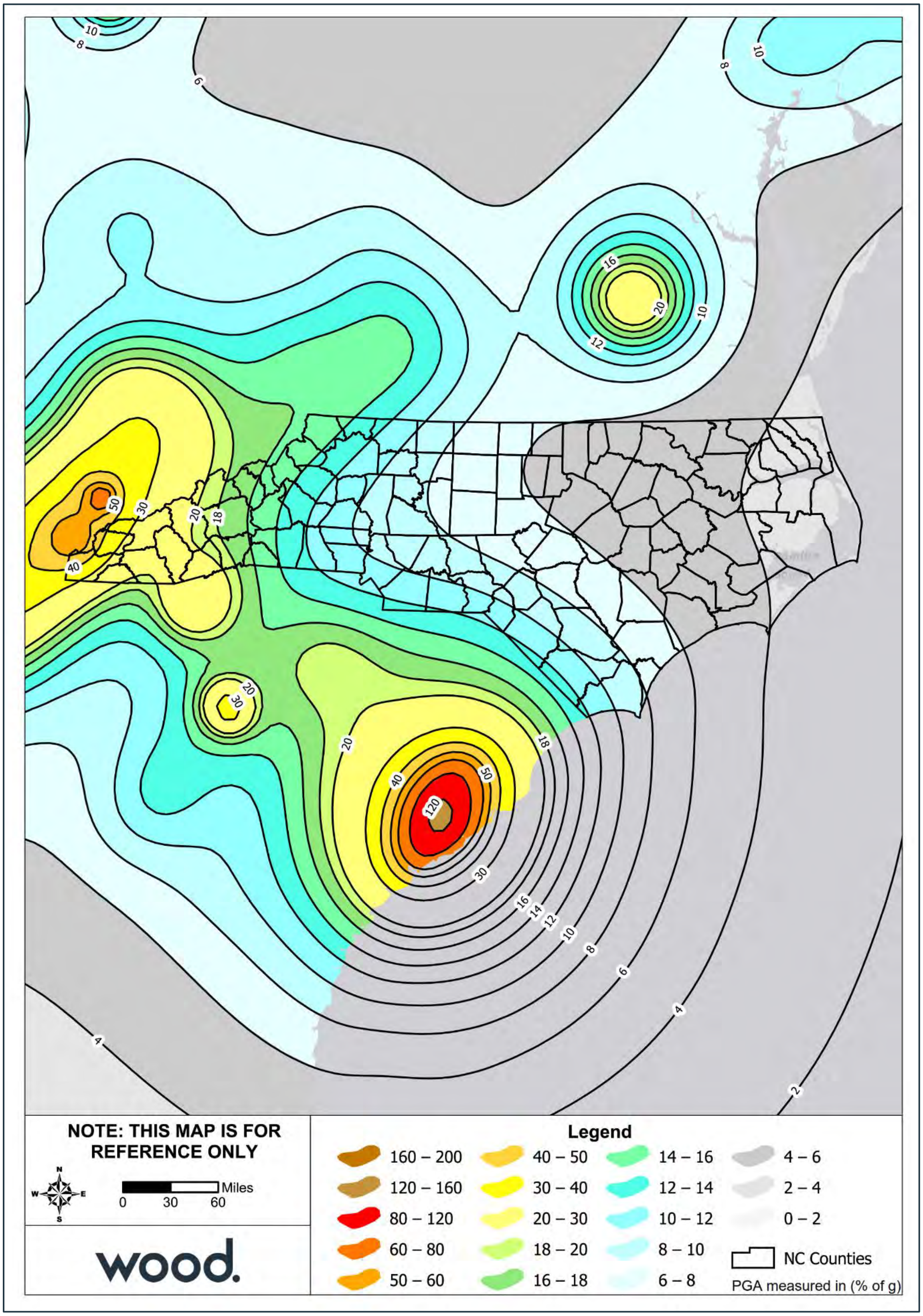
Probability of Future Occurrence

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

Figure 4.17 reflects the seismic hazard for the Eno-Haw Region based on the national USGS map of peak acceleration with two percent probability of exceedance in 50 years. To produce these estimates, the ground motions being considered at a given location are those from all future possible earthquake magnitudes at all possible distances from that location. The ground motion coming from a particular magnitude and distance is assigned an annual probability equal to the annual probability of occurrence of the causative magnitude and distance. The method assumes a reasonable future catalog of earthquakes, based upon historical earthquake locations and geological information on the recurrence rate of fault ruptures. When all the possible earthquakes and magnitudes have been considered, a ground motion value is determined such that the annual rate of its being exceeded has a certain value.

Therefore, for the given probability of exceedance, two percent, the locations shaken more frequently will have larger ground motions. The Eno-Haw Region is located within the light blue and dark gray zones representing a low peak acceleration of 0.04 to 0.08% g. Alamance County is located fully in 0.06 to 0.08% g zone and Durham County is located fully in the 0.04 to 0.06% zone.

Figure 4.17 – Seismic Hazard Information for North Carolina



Source: USGS Earthquake Hazards Program

Based on this data, it can be reasonably assumed that an earthquake event affecting the Eno-Haw Region is unlikely.

Probability: 1 – Unlikely

Climate Change

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

Vulnerability Assessment

People

Earthquake events in the Eno-Haw Region are unlikely to produce more than mild ground shaking; therefore, injury or death is unlikely. Objects falling from shelves generally pose the greatest threat to safety.

Table 4.31 details the population estimated to be at risk from a 250-year earthquake, according to the NCEM IRISK database.

Table 4.31 – Estimated Population Impacted by 250-Year Earthquake

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Alamance County									
Unincorporated Alamance County	43,522	26,322	60.50%	6,358	3,845	60.50%	2,742	1,658	60.50%
City of Burlington	56,075	26,978	48.10%	8,192	3,935	48%	3,533	1,700	48.10%
City of Graham	16,584	7,709	46.50%	2,423	1,126	46.50%	1,045	486	46.50%
City of Mebane	14,590	5,488	37.6%	2,020	760	37.6%	893	336	37.6%
Town of Elon	10,006	5,431	54.30%	1,462	794	54.30%	630	342	54.30%
Town of Green Level	2,368	1,402	59.20%	346	205	59.20%	149	88	59.10%
Town of Haw River	3,773	2,034	53.90%	551	297	53.90%	238	128	53.80%
Town of Ossipee	544	175	32.20%	79	25	31.60%	34	11	32.40%
Town of Swepsonville	1,151	545	47.40%	168	80	47.60%	73	35	47.90%
Village of Alamance	1,462	829	56.70%	214	121	56.50%	92	52	56.50%
Subtotal Alamance	**150,075**	**76,913**	**51.25%**	**21,813**	**11,188**	**51.29%**	**9,429**	**4,836**	**51.29%**
Durham County									
Unincorporated Durham County	38,181	5,057	13.20%	3,725	493	13.20%	2,826	374	13.20%
City of Durham	225,814	21,755	9.63%	22,031	2,122	9.63%	16,715	1,610	9.63%
Subtotal Durham	**263,995**	**26,812**	**10.16%**	**25,756**	**2,615**	**10.15%**	**19,541**	**1,984**	**10.15%**
Orange County									

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Unincorporated Orange County	45,470	12,600	27.70%	4,381	1,214	27.70%	2,342	649	27.70%
Town of Carrboro	20,883	2,991	14.30%	2,012	288	14.30%	1,076	154	14.30%
Town of Chapel Hill	59,351	7,887	13.29%	5,722	760	13.28%	3,117	414	13.28%
Town of Hillsborough	8,467	1,309	15.50%	816	126	15.40%	436	67	15.40%
Subtotal Orange	**134,171**	**24,787**	**18.47%**	**12,931**	**2,388**	**18.47%**	**6,971**	**1,284**	**18.42%**
Person County									
Unincorporated Person County	26,396	8,399	31.80%	4,007	1,275	31.80%	1,584	504	31.80%
City of Roxboro	13,079	3,125	23.90%	1,986	475	23.90%	785	188	23.90%
Subtotal Person	**39,475**	**11,524**	**29.20%**	**5,993**	**1,750**	**29.20%**	**2,369**	**692**	**29.20%**
Total	**587,716**	**140,036**	**23.83%**	**66,493**	**17,941**	**26.98%**	**38,310**	**8,796**	**22.96%**

Source: NCEM Risk Management Tool

Property

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

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

The Eno-Haw Region has not been impacted by an earthquake with more than a moderate intensity, so damage to the built environment is unlikely.

Table 4.32 and Table 4.33 detail the estimated buildings impacted from a 250-year earthquake event and a 500-year earthquake event, respectively.

Table 4.32 – Estimated Buildings Impacted by 250-Year Earthquake Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	15,675	52.9%	$81,369	3,408	11.5%	$72,933	154	0.5%	$14,963	19,237	64.9%	$169,265
City of Burlington	24,403	10,281	42.1%	$88,047	2,373	9.7%	$401,369	208	0.9%	$31,455	12,862	52.7%	$520,871
City of Graham	7,269	3,056	42%	$22,658	525	7.2%	$63,096	131	1.8%	$15,077	3,712	51.1%	$100,830
City of Mebane	5,835	1,996	34.2%	$14,336	458	7.8%	$110,301	38	0.7%	$7,626	2,492	42.7%	$132,263
Town of Elon	2,760	1,321	47.9%	$15,155	142	5.1%	$19,588	160	5.8%	$18,005	1,623	58.8%	$52,748
Town of Green Level	1,177	626	53.2%	$2,188	109	9.3%	$3,923	9	0.8%	$231	744	63.2%	$6,342
Town of Haw River	2,352	1,153	49%	$4,899	167	7.1%	$18,756	18	0.8%	$1,864	1,338	56.9%	$25,519
Town of Ossipee	330	96	29.1%	$446	21	6.4%	$1,134	4	1.2%	$357	121	36.7%	$1,938
Town of Swepsonville	573	257	44.9%	$1,912	24	4.2%	$8,573	4	0.7%	$482	285	49.7%	$10,967
Village of Alamance	798	405	50.8%	$3,650	66	8.3%	$4,202	16	2%	$1,600	487	61%	$9,452
Subtotal Alamance	**75,147**	**34,866**	**46.4%**	**$234,660**	**7,293**	**9.7%**	**$703,875**	**742**	**1%**	**$91,660**	**42,901**	**57.1%**	**$1,030,195**
Durham County													
Unincorporated Durham County	21,038	2,348	11.2%	$13,163	2,796	13.3%	$311,748	214	1%	$30,751	5,358	25.5%	$355,662
City of Durham	75,588	6,329	8.4%	$154,564	5,920	7.8%	$786,180	1,537	2%	$216,209	13,786	18.2%	$1,156,953
Subtotal Durham	**96,626**	**8,677**	**8.98%**	**$167,727**	**8,716**	**9.02%**	**$1,097,928**	**1,751**	**1.81%**	**$246,960**	**19,144**	**19.81%**	**$1,512,615**
Orange County													
Unincorporated Orange County	24,533	5,981	24.4%	$42,913	2,592	10.6%	$92,811	211	0.9%	$39,310	8,784	35.8%	$175,034
Town of Carrboro	5,782	782	13.5%	$25,423	257	4.4%	$26,444	42	0.7%	$8,758	1,081	18.7%	$60,625
Town of Chapel Hill	15,108	1,816	12%	$75,115	560	3.7%	$135,773	499	3.3%	$101,537	2,875	19%	$312,424
Town of Hillsborough	3,883	518	13.3%	$6,208	352	9.1%	$46,427	105	2.7%	$16,571	975	25.1%	$69,206
Subtotal Orange	**49,306**	**9,097**	**18.45%**	**$149,659**	**3,761**	**7.63%**	**$301,455**	**857**	**1.74%**	**$166,176**	**13,715**	**27.82%**	**$617,289**
Person County													
Unincorporated Person County	17,714	4,736	26.7%	$18,274	2,598	14.7%	$40,544	124	0.7%	$22,359	7,458	42.1%	$81,177
City of Roxboro	6,617	1,371	20.7%	$9,591	701	10.6%	$114,968	125	1.9%	$24,517	2,197	33.2%	$149,076
Subtotal Person	**24,331**	**6,107**	**25.1%**	**$27,865**	**3,299**	**13.6%**	**$155,512**	**249**	**1%**	**$46,876**	**9,655**	**39.7%**	**$230,253**
Total	**245,410**	**58,747**	**23.9%**	**$579,911**	**23,069**	**9.4%**	**$2,258,770**	**3,599**	**1.5%**	**$551,672**	**85,415**	**34.8%**	**$3,390,352**

Source: NCEM Risk Management Tool

Table 4.33 – Estimated Buildings Impacted by 500-Year Earthquake Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$1,487,743	3,425	11.6%	$699,048	283	1%	$167,849	29,619	99.9%	$2,354,640
City of Burlington	24,403	21,618	88.6%	$1,535,403	2,401	9.8%	$3,129,356	320	1.3%	$318,481	24,339	99.7%	$4,983,240
City of Graham	7,269	6,575	90.5%	$430,981	530	7.3%	$489,890	155	2.1%	$141,266	7,260	99.9%	$1,062,138
City of Mebane	5,835	5,303	90.9%	$335,334	465	8%	$898,971	64	1.1%	$78,658	5,832	99.9%	$1,312,963
Town of Elon	2,760	2,437	88.3%	$224,678	147	5.3%	$206,677	174	6.3%	$147,561	2,758	99.9%	$578,917
Town of Green Level	1,177	1,057	89.8%	$44,879	109	9.3%	$30,507	10	0.8%	$2,943	1,176	99.9%	$78,329
Town of Haw River	2,352	2,139	90.9%	$98,913	168	7.1%	$147,559	31	1.3%	$18,450	2,338	99.4%	$264,922
Town of Ossipee	330	299	90.6%	$11,303	21	6.4%	$9,436	7	2.1%	$2,891	327	99.1%	$23,629
Town of Swepsonville	573	543	94.8%	$33,133	24	4.2%	$56,274	5	0.9%	$4,672	572	99.8%	$94,079
Village of Alamance	798	714	89.5%	$53,029	66	8.3%	$32,592	17	2.1%	$12,437	797	99.9%	$98,058
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$4,255,396**	**7,356**	**9.8%**	**$5,700,310**	**1,066**	**1.4%**	**$895,208**	**75,018**	**99.8%**	**$10,850,915**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$598,227	2,818	13.4%	$2,564,533	234	1.1%	$288,620	21,020	99.9%	$3,451,381
City of Durham	75,588	67,732	89.6%	$3,926,650	6,071	8%	$7,519,780	1,667	2.2%	$2,039,430	75,470	99.8%	$13,485,861
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$4,524,877**	**8,889**	**9.20%**	**$10,084,313**	**1,901**	**1.97%**	**$2,328,050**	**96,490**	**99.86%**	**$16,937,242**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$1,262,476	2,657	10.8%	$850,353	246	1%	$389,570	24,527	100%	$2,502,398
Town of Carrboro	5,782	5,464	94.5%	$587,987	261	4.5%	$254,468	46	0.8%	$95,233	5,771	99.8%	$937,689
Town of Chapel Hill	15,108	13,922	92.1%	$1,738,894	617	4.1%	$1,215,358	528	3.5%	$1,018,502	15,067	99.7%	$3,972,753
Town of Hillsborough	3,883	3,408	87.8%	$166,724	358	9.2%	$414,627	111	2.9%	$186,994	3,877	99.8%	$768,345
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$3,756,081**	**3,893**	**7.90%**	**$2,734,806**	**931**	**1.89%**	**$1,690,299**	**49,242**	**99.87%**	**$8,181,185**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$509,166	2,613	14.8%	$356,556	156	0.9%	$211,555	17,662	99.7%	$1,077,277
City of Roxboro	6,617	5,754	87%	$208,672	710	10.7%	$841,518	144	2.2%	$210,153	6,608	99.9%	$1,260,343
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$717,838**	**3,323**	**13.7%**	**$1,198,074**	**300**	**1.2%**	**$421,708**	**24,270**	**99.7%**	**$2,337,620**
Total	**245,410**	**217,361**	**88.6%**	**$13,254,192**	**23,461**	**9.6%**	**$19,717,503**	**4,198**	**1.7%**	**$5,335,265**	**245,020**	**99.8%**	**$38,306,962**

Source: NCEM Risk Management Tool

Environment

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

Consequence Analysis

Table 4.34 summarizes the potential negative consequences of earthquake.

Table 4.34 – Consequence Analysis - Earthquake

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

Hazard Summary by Jurisdiction

The following table summarizes earthquake hazard risk by jurisdiction. Earthquake risk is uniform across the planning area.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	1	1	4	4	1	1.9	L
Burlington	1	1	4	4	1	1.9	L
Graham	1	1	4	4	1	1.9	L
Mebane	1	1	4	4	1	1.9	L
Elon	1	1	4	4	1	1.9	L
Green Level	1	1	4	4	1	1.9	L
Haw River	1	1	4	4	1	1.9	L
Ossipee	1	1	4	4	1	1.9	L
Swepsonville	1	1	4	4	1	1.9	L
Alamance	1	1	4	4	1	1.9	L
Durham County	1	1	4	4	1	1.9	L
Durham	1	1	4	4	1	1.9	L
Orange County	1	1	4	4	1	1.9	L
Carrboro	1	1	4	4	1	1.9	L
Chapel Hill	1	1	4	4	1	1.9	L
Hillsborough	1	1	4	4	1	1.9	L
Person County	1	1	4	4	1	1.9	L
Roxboro	1	1	4	4	1	1.9	L

4.5.4 Extreme Heat

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Extreme Heat	Highly Likely	Critical	Large	More than 24 hrs	Less than 1 week	3.3

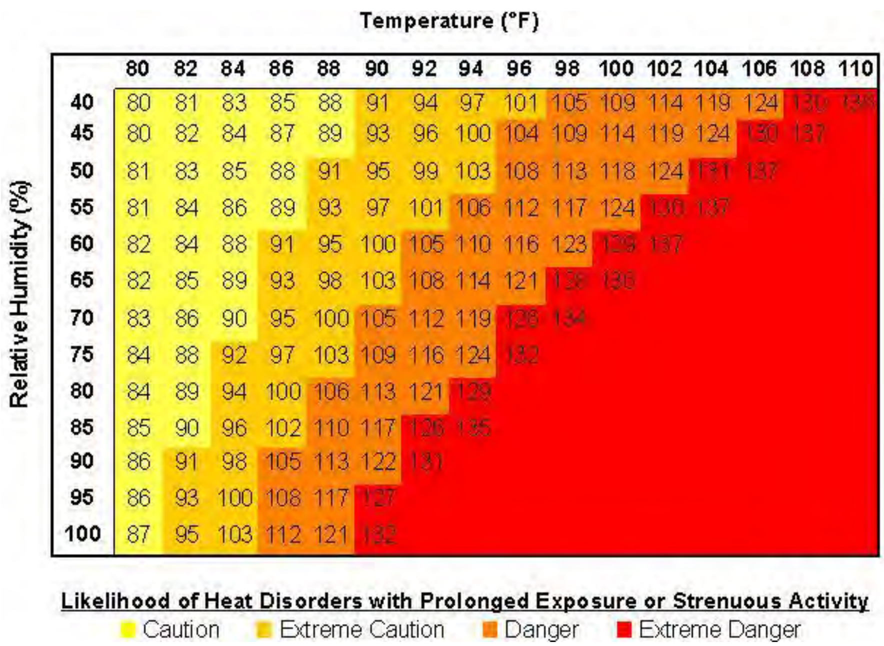
Hazard Background

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

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

Ambient air temperature is one component of heat conditions, with relative humidity being the other. The relationship of these factors creates what is known as the apparent temperature. The Heat Index Chart in Figure 4.18 uses both of these factors to produce a guide for the apparent temperature or relative intensity of heat conditions.

Figure 4.18 – Heat Index Chart



Temperature (°F)

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

Source: National Weather Service (NWS) http://www.nws.noaa.gov/os/heat/heat_index.shtml
Note: Exposure to direct sun can increase Heat Index values by as much as 15°F. The shaded zone above 105°F corresponds to a heat index that may cause increasingly severe heat disorders with continued exposure and/or physical activity.

During these conditions, the human body has difficulties cooling through the normal method of the evaporation of perspiration. Health risks rise when a person is over exposed to heat.

The most dangerous place to be during an extreme heat incident is in a permanent home, with little or no air conditioning. Those at greatest risk for heat-related illness include people 65 years of age and older, young children, people with chronic health problems such as heart disease, people who are obese, people who are socially isolated, and people who are on certain medications, such as tranquilizers, antidepressants, sleeping pills, or drugs for Parkinson's disease. However, even young and healthy individuals are susceptible if they participate in strenuous physical activities during hot weather or are not acclimated to hot weather. Table 4.35 lists typical symptoms and health impacts of exposure to heat.

Table 4.35 – Typical Health Impacts of Extreme Heat

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

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

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

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

Warning Time: 1 – More than 24 hours

Duration: 3 – Less than one week

Location

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

Extent

The extent of extreme heat can be defined by the maximum apparent temperature reached. Apparent temperature is a function of ambient air temperature and relative humidity and is reported as the heat index. The National Weather Service Forecast Office in Raleigh sets the following criteria for heat advisory and excessive heat warning:

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

Table 4.36 notes the highest temperature on record for each county in the Eno-Haw Region.

Table 4.36 – Highest Temperature by County

County	Temperature	Location	Date
Alamance	105°F	Burlington Fire Station #5	06/27/1954
Durham	107°F	Lake Michie	06/30/1959

County	Temperature	Location	Date
Orange	107°F	Chapel Hill 2W	07/19/1902
Person	104°F	Roxboro 7 ESE	07/14/1966

Source: North Carolina Climate Office

Impact: 3 – Critical

Spatial Extent: 4 – Large

Historical Occurrences

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

NCEI records only one incident of heat or excessive heat for the Eno-Haw Region counties. This event occurred in Person County in July 2005 and resulted in the death of a farm worker who had left the farm at 11:30 AM. The heat index was 103°F by 11:00 AM.

The HMPC also noted an additional instance of extreme heat on July 20, 2019, when much of the region was under a heat advisory, with heat indexes reaching up to 110°F. In response to this advisory, many outdoor events were cancelled. Orange County extended the hours of cooling centers throughout the weekend and provided transportation to and from these centers.

Heat index records maintained by the North Carolina Climate Office indicate that the Region regularly experiences heat index temperatures above 100°F. Table 4.37 provides counts of heat index values by threshold recorded from 1999-2018 at the Raleigh-Durham International Airport weather station (KRDU), used as an indicator for the Eno-Haw Region overall. Counts are provided as the number of hours in a given year where the heat index reached or exceeded 100°F. According to this data, the Region averages approximately 87 hours per year with heat index values above 100°F.

Table 4.37 – Historical Heat Index Counts, Raleigh-Durham Airport (KRDU), 1999-2018

Year	Heat Index Value				Total
	100-104°F	105-109°F	110-114°F	≥115°F	
1999	106	45	13	0	164
2000	36	8	0	0	44
2001	36	17	4	1	58
2002	79	16	0	0	95
2003	37	7	0	0	44
2004	25	0	0	0	25
2005	95	17	8	0	120
2006	61	22	2	0	85
2007	76	25	13	0	114
2008	51	5	0	0	56
2009	34	1	0	0	35
2010	123	39	12	1	175
2011	87	33	1	0	121
2012	75	37	16	0	128
2013	11	1	0	0	12
2014	28	3	0	0	31
2015	75	9	0	0	84
2016	108	44	0	0	152

Year	Heat Index Value				Total
	100-104°F	105-109°F	110-114°F	≥115°F	
2017	64	28	1	0	93
2018	95	8	0	0	103
Sum	**1,302**	**365**	**70**	**2**	**1,739**
Average	**65**	**18**	**4**	**0**	**87**

Source: North Carolina Climate Office, Heat Index Climatology Tool

Probability of Future Occurrence

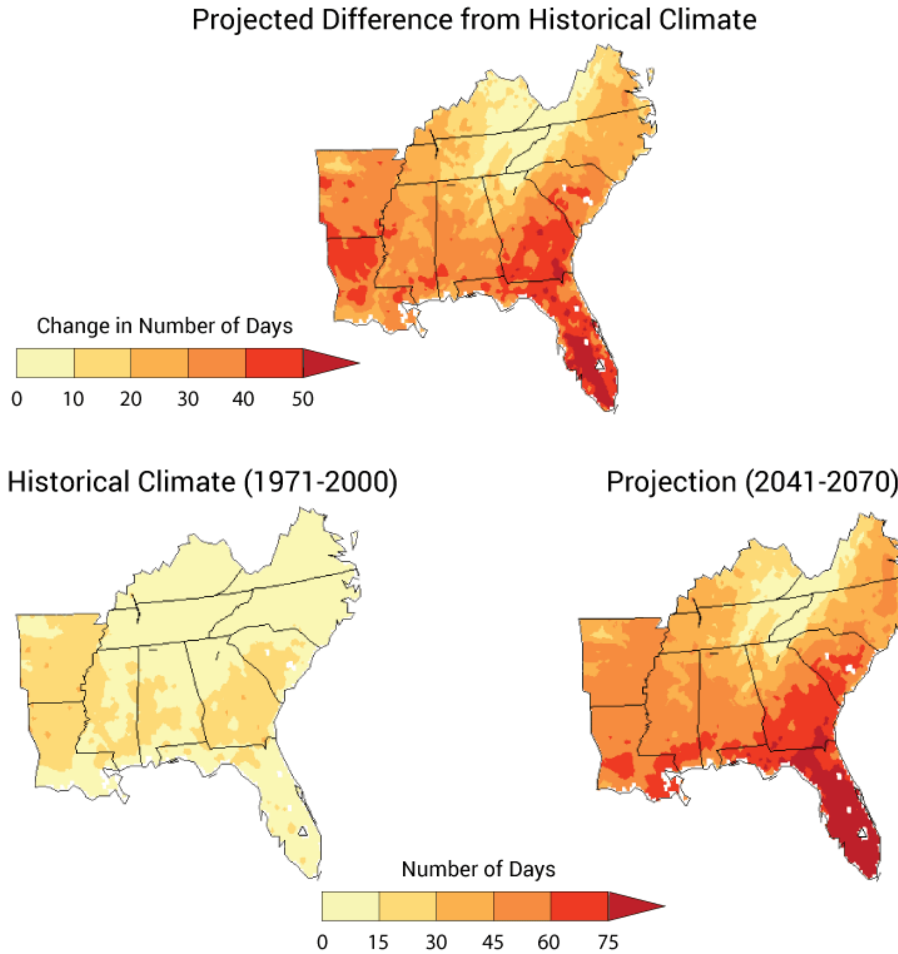
Data was gathered from the North Carolina State Climate Office's Heat Index Climatology Tool using the Raleigh-Durham International Airport weather station as an approximation for the Eno-Haw Region. Based on 20 years of available data, the Region averages 87 hours per year with heat index temperatures above 100°F. Heat index temperatures surpassed 100°F every year, occurring for at least 11 hours per year.

Probability: 4 – Highly Likely

Climate Change

Research shows that average temperatures will continue to rise in the Southeast United States and globally, directly affecting the Eno-Haw Region in North Carolina. Per the Fourth National Climate Assessment, "extreme temperatures are projected to increase even more than average temperatures. Cold waves are projected to become less intense and heat waves more intense." The number of days over 95°F is expected to increase by between 20 and 30 days annually, as shown in Figure 4.19. The Triangle Regional Resilience Partnership Resilience Assessment notes that the number of days with extreme temperatures has been increasing in the Triangle; climbing from an average of 18 days over 92°F per year from 1948 to 2012 to a peak of 48 days over 92°F in 2010.

Figure 4.19 – Projected Change in Number of Days Over 95°F



Source: NOAA NCDC from 2014 National Climate Assessment

Vulnerability Assessment

Methodologies and Assumptions

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

People

Extreme heat can cause heat stroke and even loss of human life. The elderly and the very young are most at risk to the effects of heat. People who are isolated are also more vulnerable to extreme heat. Socially vulnerable populations in areas with a high percentage of developed land and a small tree canopy are most vulnerable to negative health effects related to extreme heat, per the Triangle Regional Resilience Assessment.

Property

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

Extreme heat can also cause significant agricultural losses. Between 2007-2017, the sum of claims paid for crop damage due to heat in the Eno-Haw Region was $3,518,731 or an average of $319,884 in losses every year. Table 4.38 through Table 4.41 summarize the crop losses due to drought reported in the RMA system by county. Person County accounted for the majority of these claims.

Table 4.38 – Crop Losses Resulting from Heat, 2007-2017, Alamance County

Year	Determined Acres	Indemnity Amount
2007	200.31	$180,394.00
2008	43.07	$46,654.00
2009	13.86	$1,394.00
2010	426.79	$146,589.00
2011	293.41	$53,110.00
2012	575.90	$77,791.00
2015	15.50	$25,063.00
2016	54.93	$33,828.40
2017	23.95	$33,696.00
Total	**1,647.72**	**$598,519.40**

Source: USDA Risk Management Agency

Table 4.39 – Crop Losses Resulting from Heat, 2007-2017, Durham County

Year	Determined Acres	Indemnity Amount
2007	16.87	$17,846.00
2008	0.83	$1,595.00
2010	266.25	$75,483.00
2011	25.15	$20,840.00
2012	134.48	$23,462.00
Total	**443.58**	**$139,226.00**

Source: USDA Risk Management Agency

Table 4.40 – Crop Losses Resulting from Heat, 2007-2017, Orange County

Year	Determined Acres	Indemnity Amount
2007	217.13	$97,777.00
2010	116.44	$8,778.00
2011	50.86	$11,799.00
2012	746.96	$175,374.00
Total	**1,131.39**	**$293,728.00**

Source: USDA Risk Management Agency

Table 4.41 – Crop Losses Resulting from Heat, 2007-2017, Person County

Year	Determined Acres	Indemnity Amount
2007	817.90	$626,860.00
2008	294.20	$16,465.00
2010	1,738.90	$587,866.00
2011	89.96	$72,161.00
2012	1,675.60	$444,871.00
2014	103.40	$10,022.00
2015	63.54	$1,646.70

Year	Determined Acres	Indemnity Amount
2016	1,100.67	$661,980.10
2017	517.85	$65,386.00
Total	**6,402.02**	**$2,487,257.80**

Source: USDA Risk Management Agency

Environment

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

Consequence Analysis

Table 4.42 summarizes the potential negative consequences of extreme heat.

Table 4.42 – Consequence Analysis – Extreme Heat

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

Hazard Summary by Jurisdiction

The following table summarizes extreme heat hazard risk by jurisdiction. Extreme heat risk does not vary significantly by jurisdiction. More heavily urbanized areas may experience greater localized temperature extremes due to the urban heat island effect and therefore greater heat risk, but less developed areas may have a greater percentage of individuals working outside and therefore greater exposure to heat.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	4	3	4	1	3	3.3	H
Burlington	4	3	4	1	3	3.3	H
Graham	4	3	4	1	3	3.3	H
Mebane	4	3	4	1	3	3.3	H
Elon	4	3	4	1	3	3.3	H
Green Level	4	3	4	1	3	3.3	H
Haw River	4	3	4	1	3	3.3	H
Ossipee	4	3	4	1	3	3.3	H
Swepsonville	4	3	4	1	3	3.3	H
Alamance	4	3	4	1	3	3.3	H
Durham County	4	3	4	1	3	3.3	H
Durham	4	3	4	1	3	3.3	H
Orange County	4	3	4	1	3	3.3	H

Carrboro	4	3	4	1	3	3.3	H
Chapel Hill	4	3	4	1	3	3.3	H
Hillsborough	4	3	4	1	3	3.3	H
Person County	4	3	4	1	3	3.3	H
Roxboro	4	3	4	1	3	3.3	H

4.5.5 Flood

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Flood	Likely	Limited	Small	6 to 12 hrs	Less than 1 week	2.5

Hazard Background

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

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

Sources and Types of Flooding

Flooding within the Eno-Haw Region can be attributed to two main sources as noted below.

Riverine Flooding: During heavy rainfall events, the primary riverine flooding sources in the Eno-Haw Region are as follows, per each county's effective Flood Insurance Study:

- **Alamance County:** Cane Creek (South) Tributary, Eastside Creek, Michaels Branch, Steelhouse Branch, Willowbrook Creek
- **Durham County:** The County is more prone to flooding by small streams than flooding by a major river. The principle flood problems occur on the smaller tributaries, where, due to urban development pressures, there has been commercial and residential construction in the floodplains of these tributaries. However, local flooding from the Eno River has also occurred.
- **Orange County:** Eno River, North and South Forks Little River, New Hope Creek, Morgan Creek, Bolin Creek, and other streams.
- **Person County:** Flat River, the North Flat River, the South Flat River, Marlowes Creek and smaller creeks and tributaries.

These rivers and their tributaries are susceptible to overflowing their banks during and following excessive precipitation events. Though less common, riverine flood events (such as the "1%-annual-chance flood") will cause significantly more damage and economic disruption for the area than incidences of localized stormwater flooding.

Flash Flooding: A flash flood occurs when water levels rise at an extremely fast rate as a result of intense rainfall over a brief period, possibly from slow-moving intense thunderstorms and sometimes combined with rapid snowmelt, ice jam release, frozen ground, saturated soil, or impermeable surfaces. Ice jam flooding is a form of flash flooding that occurs when ice breaks up in moving waterways, and then stacks on itself where channels narrow. This creates a natural dam, often causing flooding within minutes of the dam formation. Flash flooding can happen in Special Flood Hazard Areas (SFHAs) as delineated by the National Flood Insurance Program (NFIP) and can also happen in areas not associated with floodplains. Flash flood hazards caused by surface water runoff are most common in urbanized areas, where greater population density generally equates to more impervious surface (e.g., pavement and buildings) which increases the amount of surface water generated.

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

In certain areas, aging storm sewer systems are not designed to carry the capacity currently needed to handle the increased storm runoff. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns.

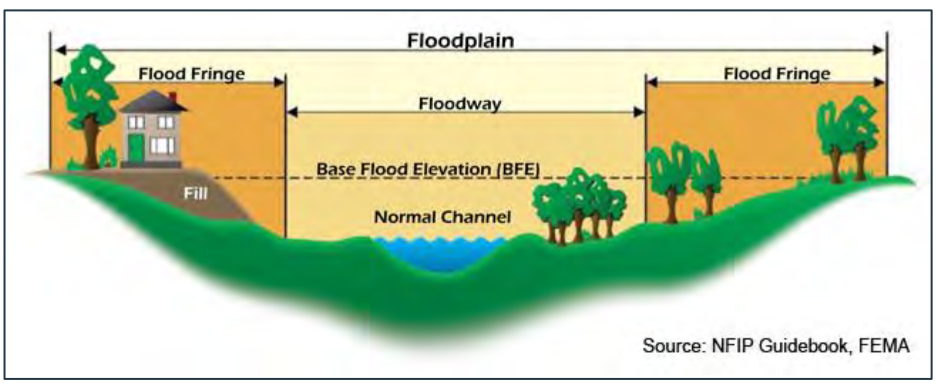
Localized flooding may be caused by the following issues:

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

Flooding and Floodplains

In the case of riverine flooding, the area adjacent to a channel is the floodplain, as shown in Figure 4.20. A floodplain is flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding. It includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows, and the flood fringe, which are areas covered by the flood, but which do not experience a strong current. Floodplains are made when floodwaters exceed the capacity of the main channel or escape the channel by eroding its banks. When this occurs, sediments (including rocks and debris) are deposited that gradually build up over time to create the floor of the floodplain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream.

Figure 4.20 – Characteristics of a Floodplain



In its common usage, the floodplain most often refers to that area that is inundated by the "100-year flood," which is the flood that has a 1% chance in any given year of being equaled or exceeded. The 500-

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

The 1%-annual-chance flood, which is the minimum standard used by most federal and state agencies, is used by the National Flood Insurance Program (NFIP) as the standard for floodplain management and to determine the need for flood insurance. Participation in the NFIP requires adoption and enforcement of a local floodplain management ordinance which is intended to prevent unsafe development in the floodplain, thereby reducing future flood damages. Participation in the NFIP allows for the federal government to make flood insurance available within the community as a financial protection against flood losses. Since floods have an annual probability of occurrence, have a known magnitude, depth and velocity for each event, and in most cases, have a map indicating where they will likely occur, they are in many ways often the most predictable and manageable hazard.

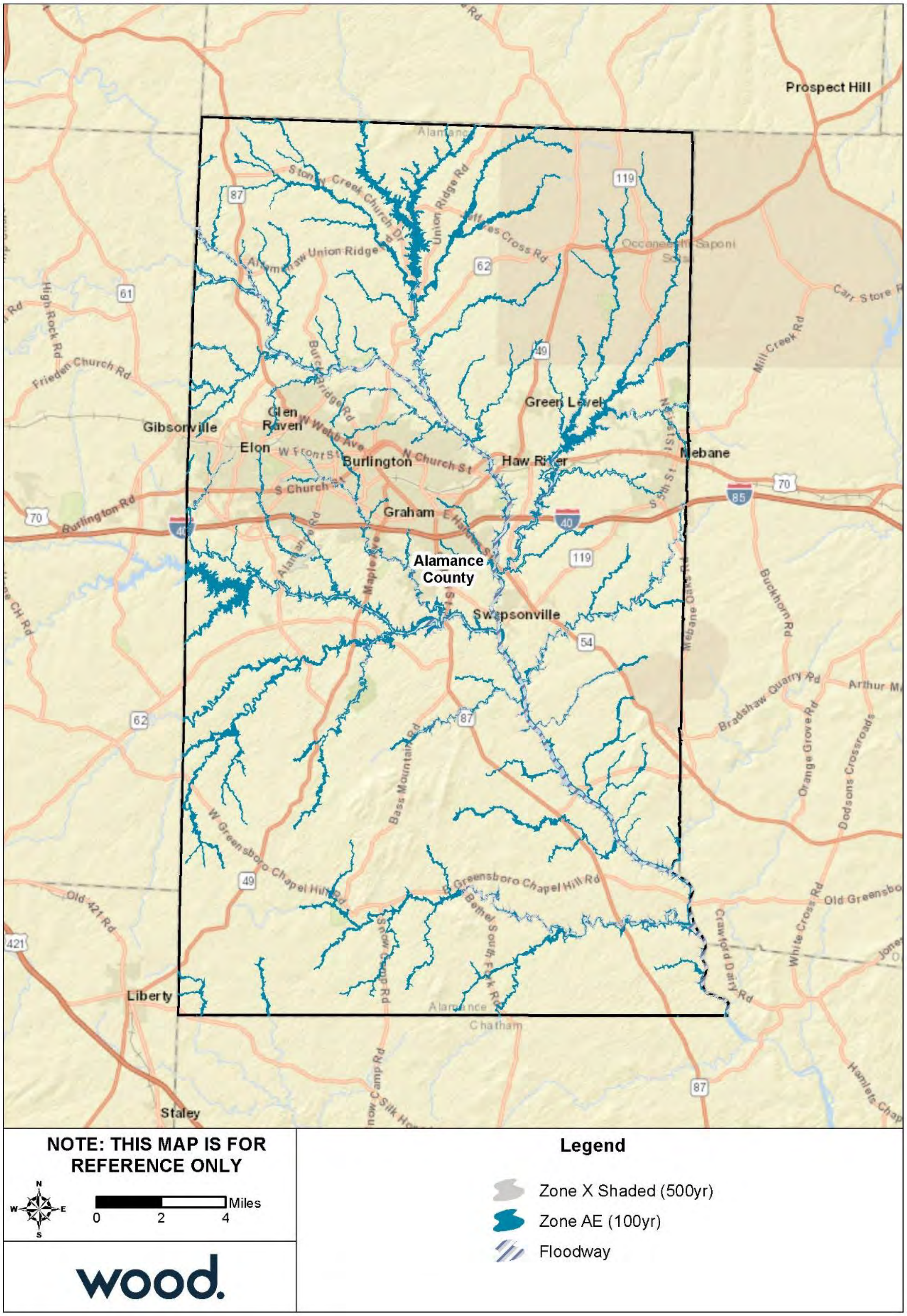
Warning Time: 3 – 6 to 12 hours

Duration: 3 – Less than 1 week

Location

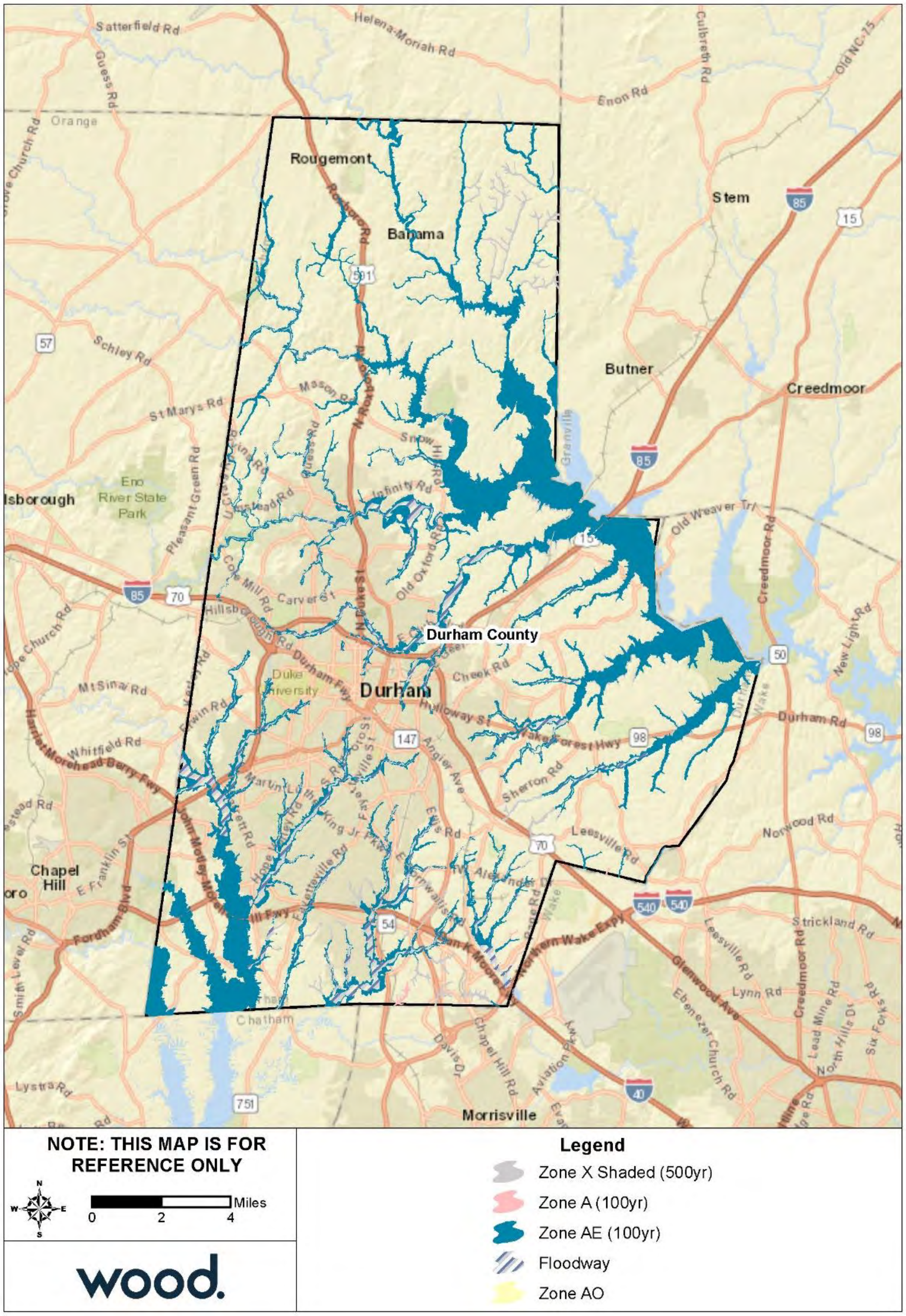
Figure 4.21 through Figure 4.24 reflect the effective mapped flood insurance zones for the Eno-Haw Region by county.

Figure 4.21 – FEMA Flood Hazard Areas in Alamance County



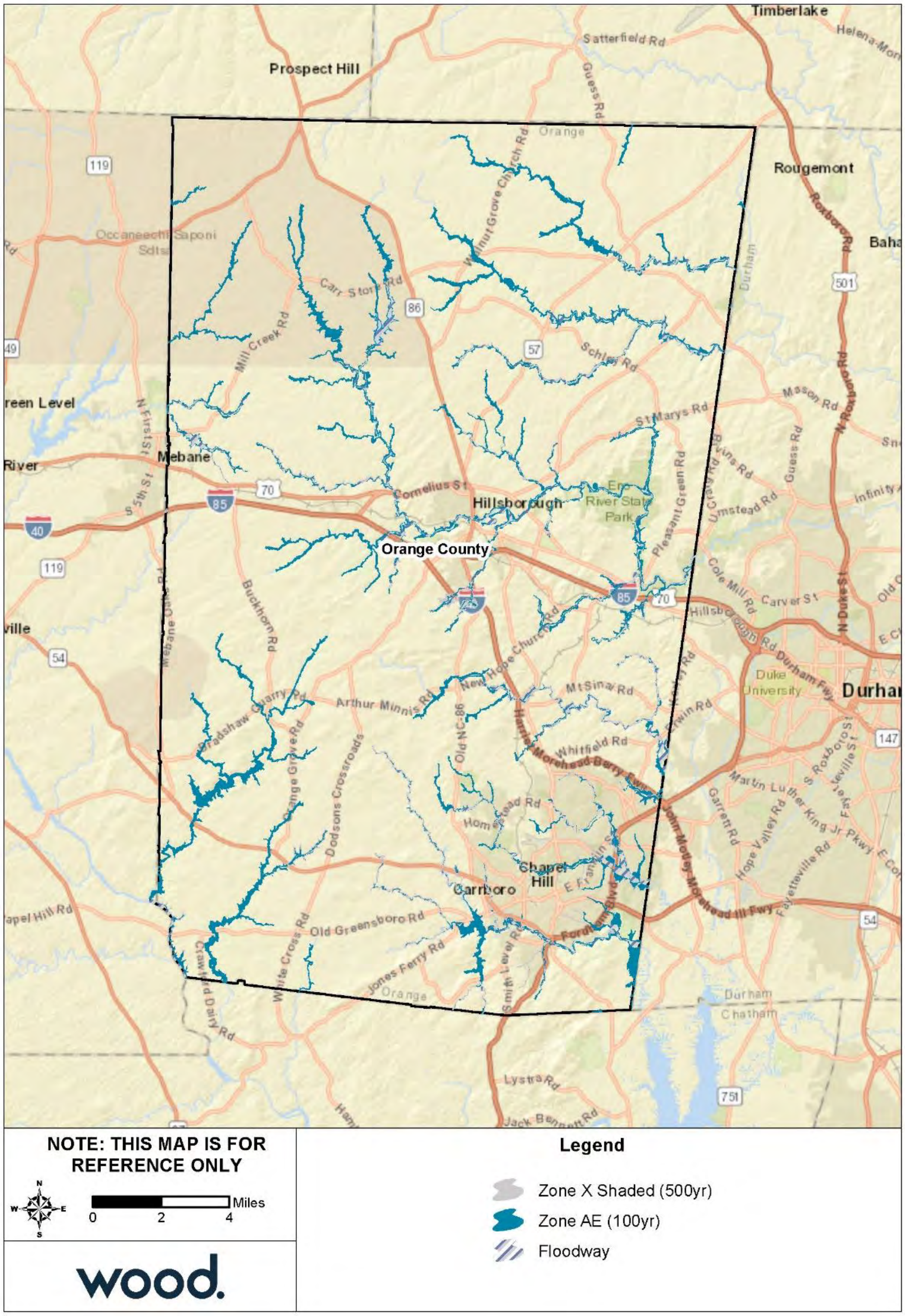
Source: FEMA Effective DFIRM retrieved from North Carolina Flood Risk Information System

Figure 4.22 – FEMA Flood Hazard Areas in Durham County



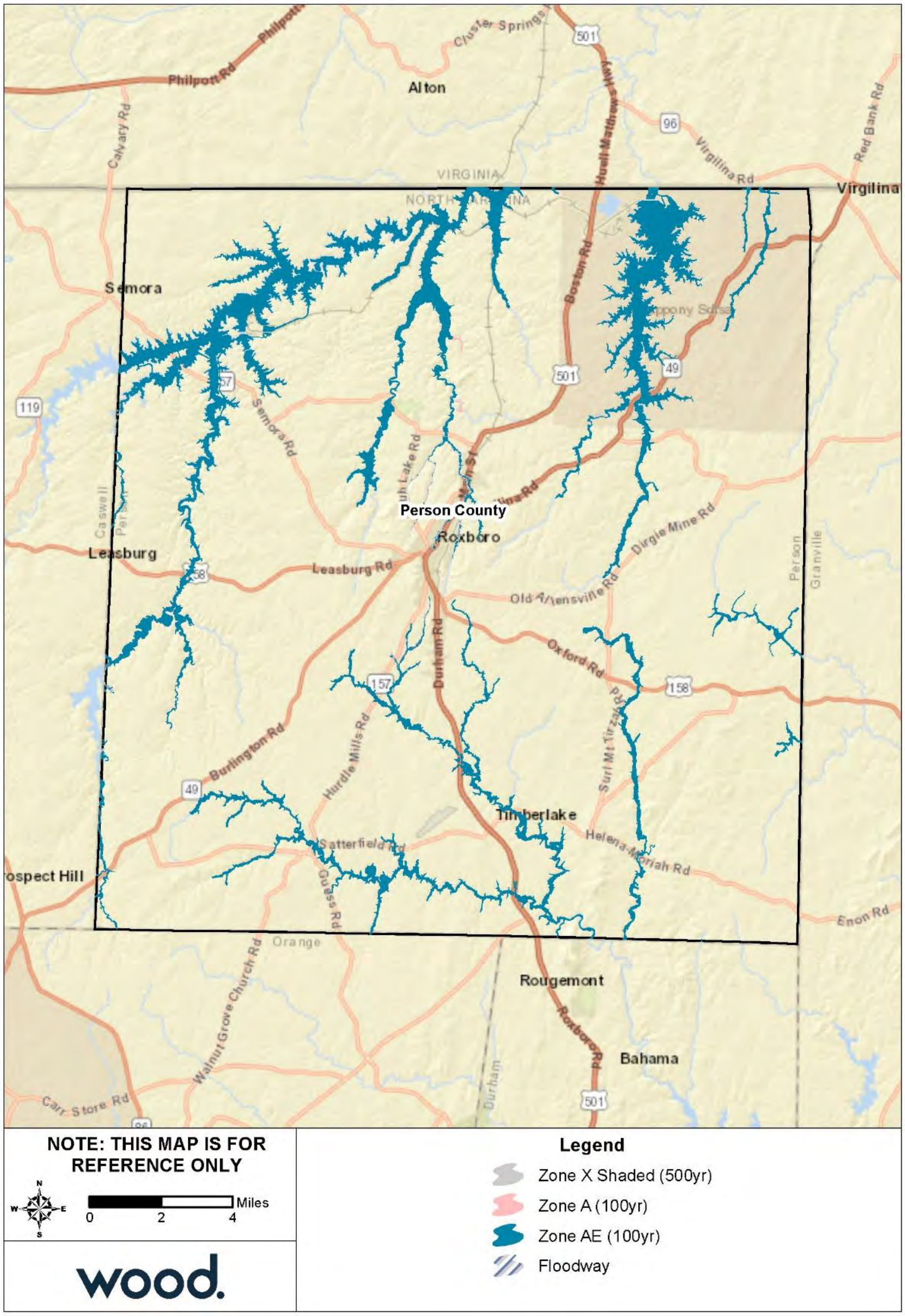
Source: FEMA Effective DFIRM retrieved from North Carolina Flood Risk Information System

Figure 4.23 – FEMA Flood Hazard Areas in Orange County



Source: FEMA Effective DFIRM retrieved from North Carolina Flood Risk Information System

Figure 4.24 – FEMA Flood Hazard Areas in Person County



Source: FEMA Effective DFIRM retrieved from North Carolina Flood Risk Information System

Extent

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

Regulated floodplains are illustrated on inundation maps called Flood Insurance Rate Maps (FIRMs). It is the official map for a community on which FEMA has delineated both the Special Flood Hazard Areas (SFHAs) and the risk premium zones applicable to the community. SFHAs represent the areas subject to inundation by the 100-year flood event. Structures located within the SFHA have a 26-percent chance of flooding during the life of a standard 30-year mortgage. Flood prone areas were identified within Eno-Haw Region using the Effective FIRMs, with most recent updates and/or revisions dated November 17, 2017 for Alamance and Person counties and October 19, 2018 for Durham and Orange counties. Table 4.43 summarizes the flood insurance zones identified by the Digital FIRM (DFIRM).

Table 4.43 – Mapped Flood Insurance Zones within the Eno-Haw Region

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

Source: FEMA

Table 4.44 provides a summary by county of the Region's total area by flood zone on the effective DFIRM. Only about eight percent of the Region falls within the SFHA. Durham County has the greatest proportion of total area in the SFHA, at just over 13 percent, while Orange County has the smallest relative SFHA at just 4.6 percent of the county's total area.

Table 4.44 – Flood Zone Acreage in the Eno-Haw Region

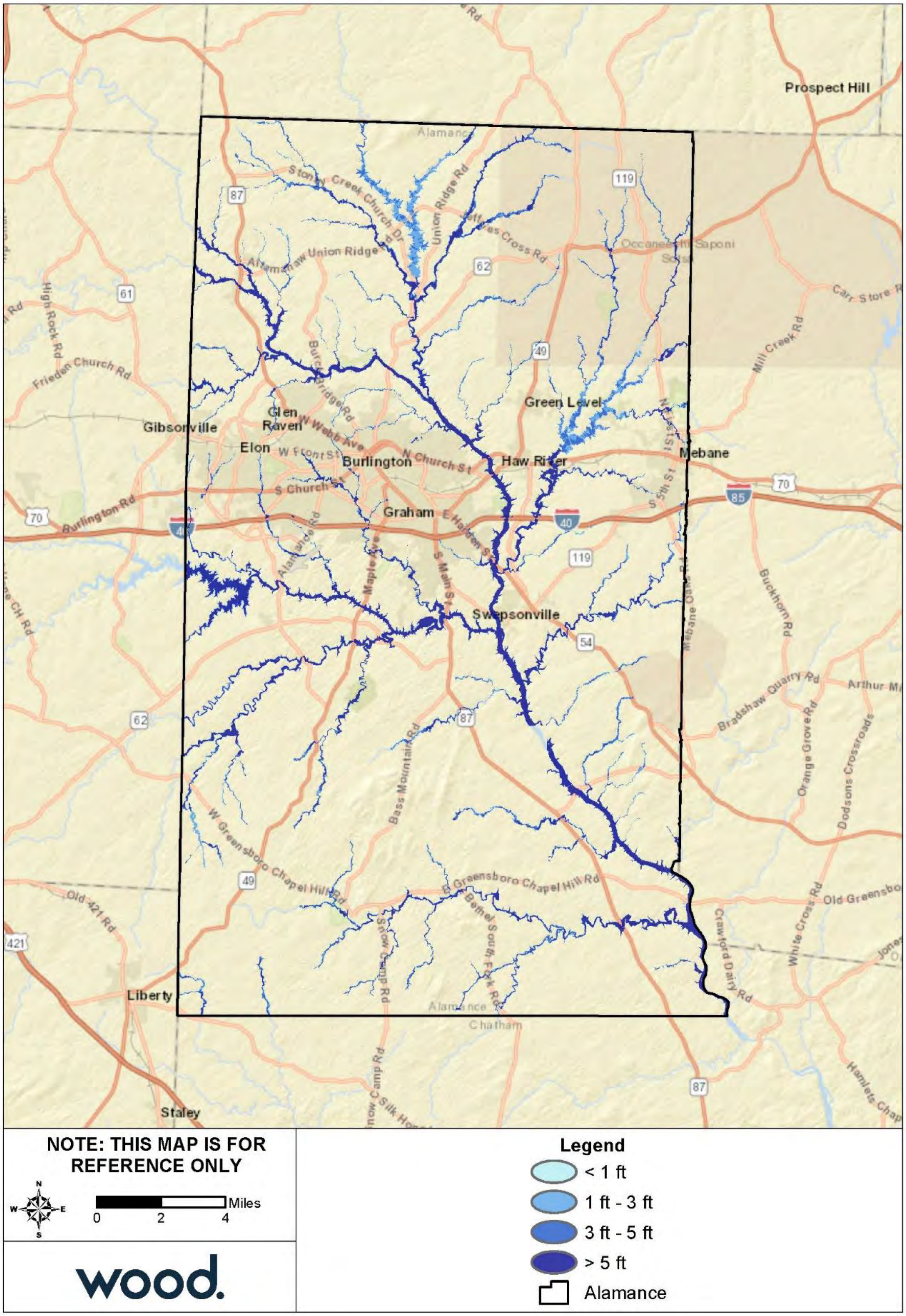
Flood Zone	Acreage	Percent of Total (%)
Alamance		
Zone A	--	--
Zone AE	22,640	7.1%
Zone X (500-year)	1,457	0.5%
Zone X Unshaded	293,202	92.4%

Flood Zone	Acreage	Percent of Total (%)
Subtotal	317,300	--
Durham		
Zone A	81	0%
Zone AE	37,236	13.5%
Zone X (500-year)	1,560	0.6%
Zone X Unshaded	236,907	85.9%
Subtotal	275,702	--
Orange		
Zone A	0	--
Zone AE	12,148	4.6%
Zone X (500-year)	923	0.4%
Zone X Unshaded	249,953	95.0%
Subtotal	263,024	--
Person		
Zone A	26	0%
Zone AE	16,357	6.2%
Zone X (500-year)	102	0%
Zone X Unshaded	246,499	93.7%
Subtotal	262,958	--
Total	**1,118,985**	**--**

Source: FEMA Effective DFIRM

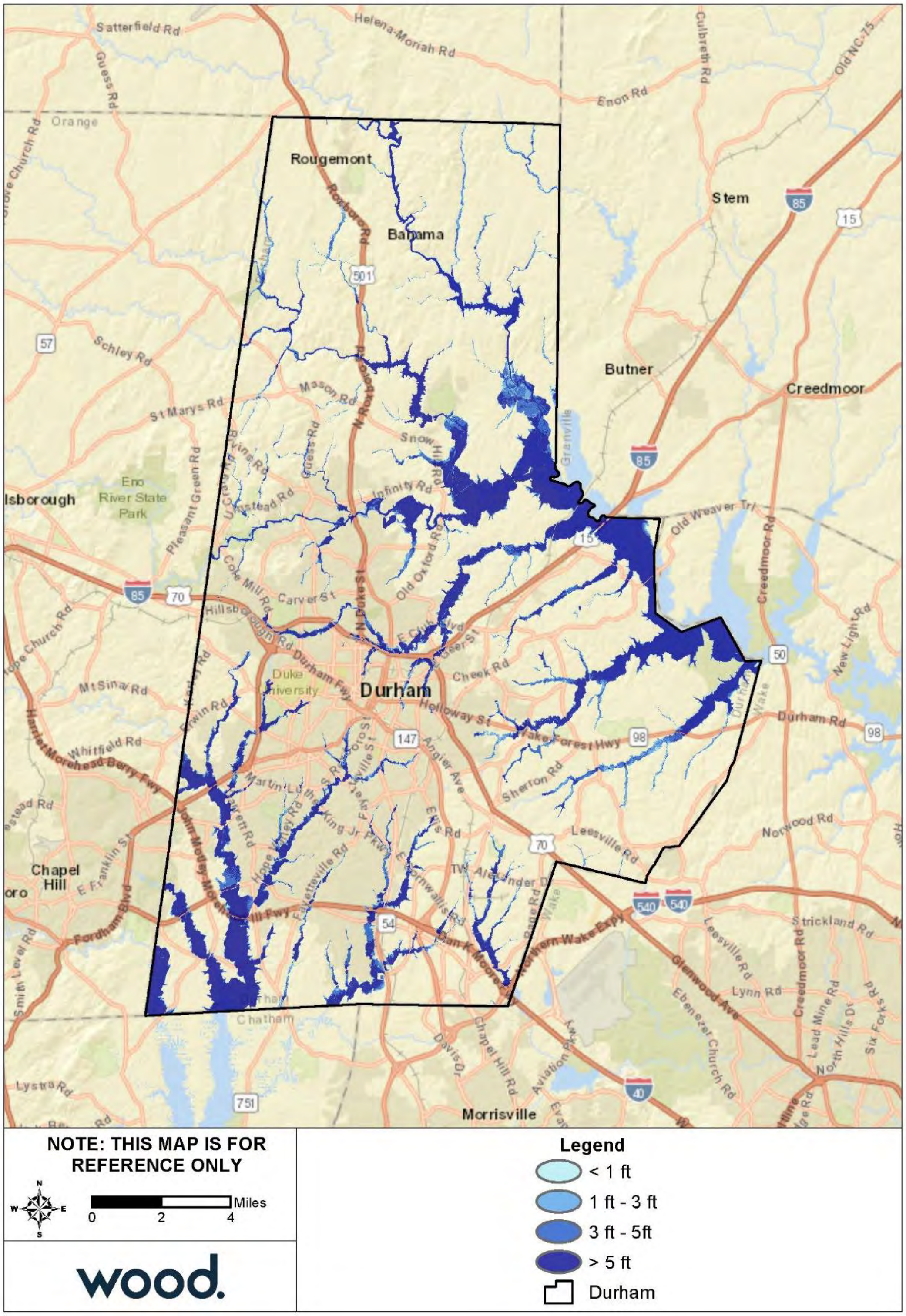
Figure 4.25 through Figure 4.28 show the depth of flooding estimated to occur from a 1% annual chance flood by county.

Figure 4.25 – Flood Depth, 100-Year Floodplain, Alamance County



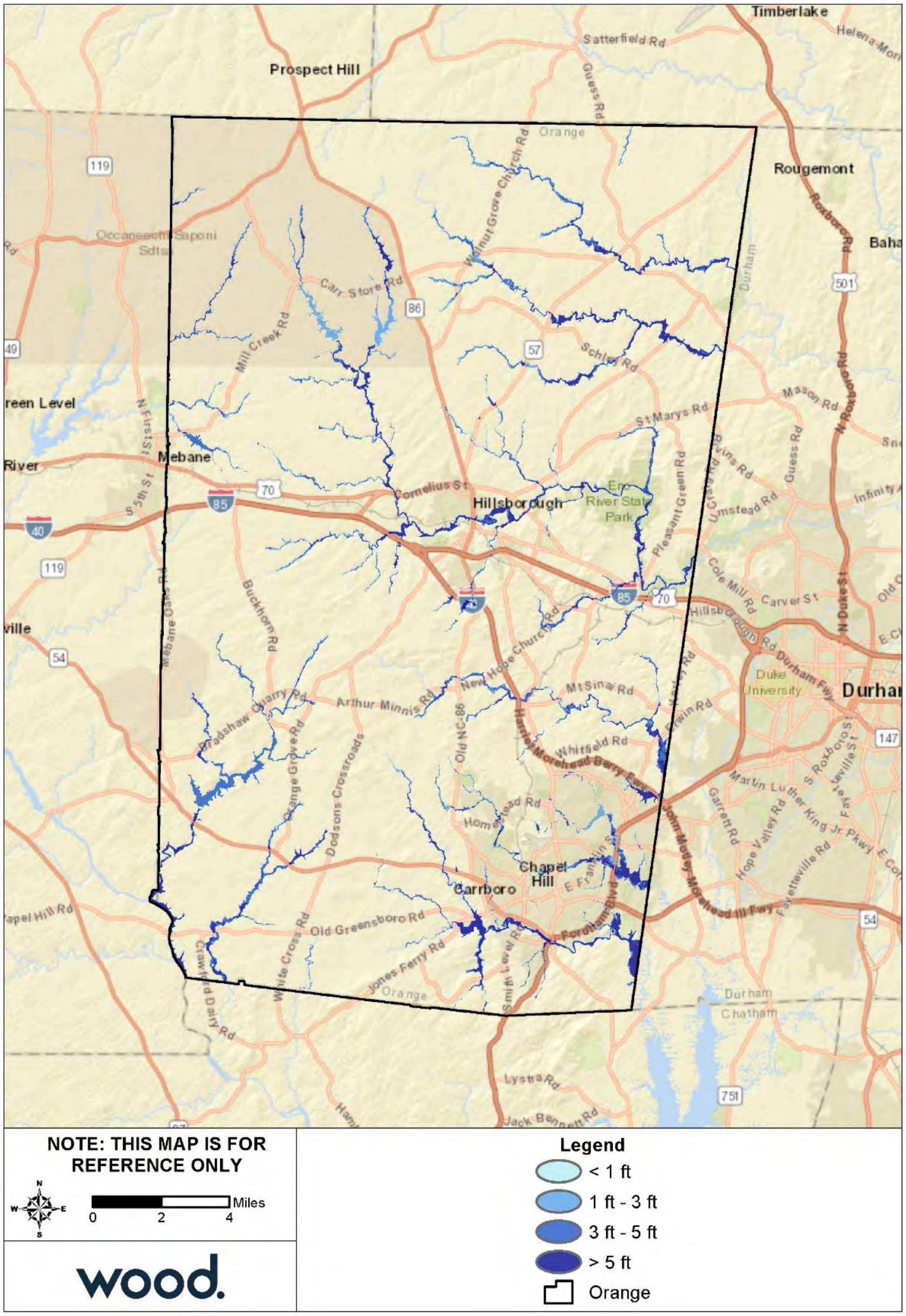
Source: FEMA Effective DFIRM

Figure 4.26 – Flood Depth, 100-Year Floodplain, Durham County



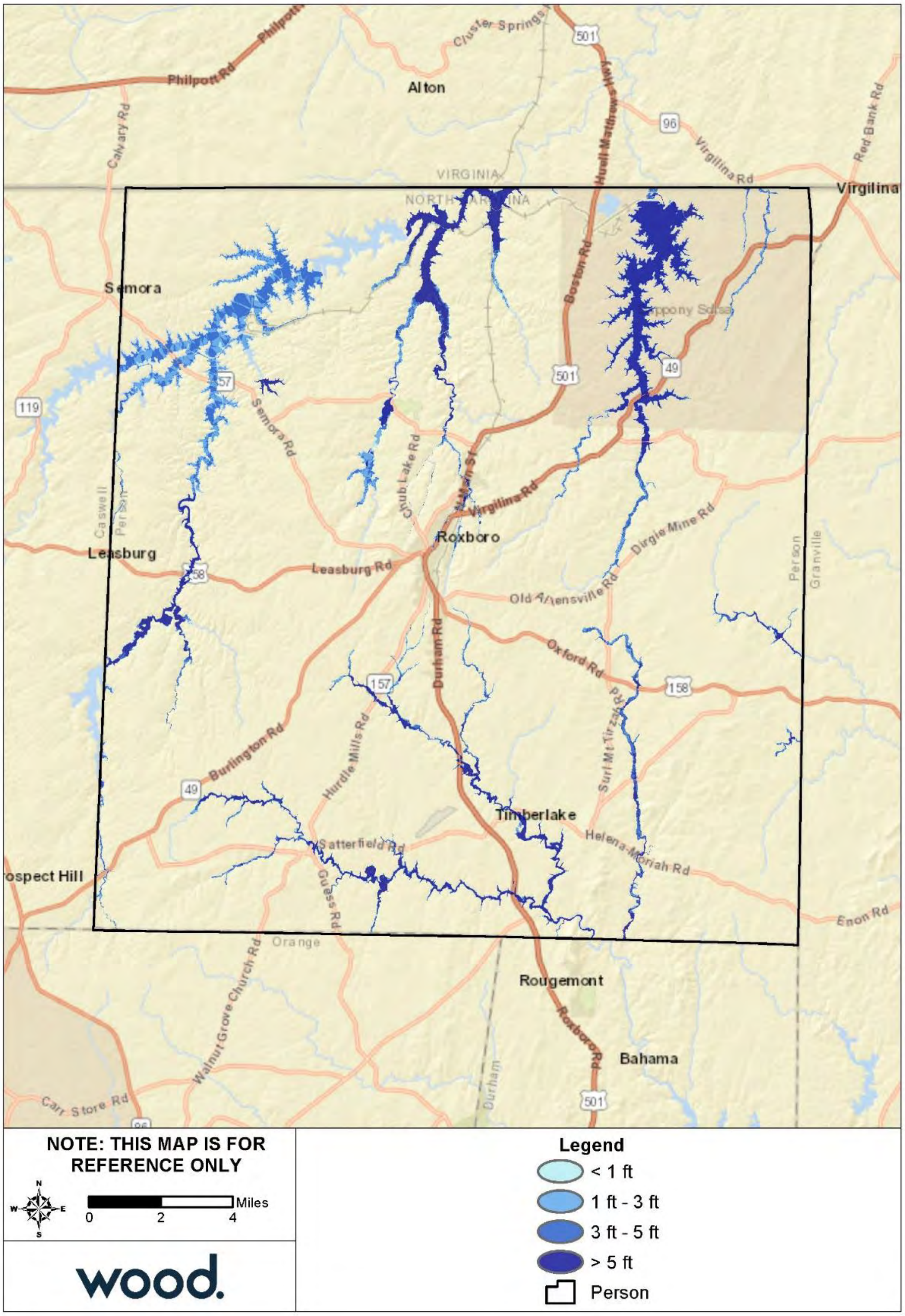
Source: FEMA Effective DFIRM

Figure 4.27 – Flood Depth, 100-Year Floodplain, Orange County



Source: FEMA Effective DFIRM

Figure 4.28 – Flood Depth, 100-Year Floodplain, Person County



Source: FEMA Effective DFIRM

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

Impact: 2 – Limited

Spatial Extent: 2 – Small

Historical Occurrences

According to NCEI Storm Events Database records, 141 flood-related events were reported during the 20-year period from 1999 through 2018, across 74 separate days. These events caused $52,298,000 in property damages, and $15,000,000 in crop damages.

Table 4.45 summarizes these historical occurrences of flooding by county and event type. It should be noted that only those historical occurrences listed in the NCEI database are shown here and that other, unrecorded or unreported events may have occurred within the planning area during this timeframe.

Table 4.45 – NCEI Records of Flooding, 1999-2018

Type	Event Count	Deaths/ Injuries	Reported Property Damage	Reported Crop Damage
Alamance				
Flash Flood	30	0/0	$2,110,000	$0
Flood	5	0/0	$1,070,000	$5,000,000
Durham				
Flash Flood	50	0/0	$425,000	$0
Flood	4	0/0	$11,050,000	$5,000,000
Orange				
Flash Flood	31	0/0	$10,933,000	$0
Flood	2	0/0	$26,400,000	$5,000,000
Person				
Flash Flood	18	0/0	$310,000	$0
Flood	1	0/0	$0	$0
Region Total				
Flash Flood	129	0/0	$13,778,000	$0
Flood	12	0/0	$38,520,000	$15,000,000
Total	**141**	**0/0**	**$52,298,000**	**$15,000,000**

Source: NCEI

Table 4.46 provides a summary of this historical information by location. Many of the events attributed to the county are countywide or cover large portions of the county. Similarly, though some events have associated starting locations identified, the event may have covered a larger area including multiple jurisdictions. Still, this list provides an indication of areas that may be particularly flood prone.

Table 4.46 – Summary of Historical Flood Occurrences by Location, 1999-2018

Location	Event Count	Deaths/Injuries	Property Damage	Crop Damage
Alamance				
Altamaha	2	0/0	$0	$0
Burlington	7	0/0	$0	$0
Countywide	5	0/0	$0	$0
Elon College	3	0/0	$0	$0
Glen Raven	2	0/0	$115,000	$0
Graham	2	0/0	$30,000	$0
Just Xrds	1	0/0	$500,000	$0
Mebane	2	0/0	$1,400,000	$0
Pleasant Grove	1	0/0	$50,000	$0
Saxapahaw	2	0/0	$0	$0
Snow Camp	4	0/0	$1,070,000	$5,000,000
Swepsonville	1	0/0	$0	$0
Union Ridge	1	0/0	$15,000	$0
Subtotal Alamance	**35**	**0/0**	**$3,180,000**	**$5,000,000**
Durham				
Bahama	4	0/0	$100,000	$0
Braggtown	2	0/0	$2,500	$0
Countywide	8	0/0	$0	$0
Durham	12	0/0	$40,000	$0
East Durham	1	0/0	$0	$0
Few	2	0/0	$0	$0
Genlee	1	0/0	$11,050,000	$5,000,000
Gorman	2	0/0	$20,000	$0
Hayes	1	0/0	$0	$0
Hope Valley	8	0/0	$112,500	$0
Huckleberry Spring	2	0/0	$100,000	$0
Lowes Grove	1	0/0	$0	$0
Oak Grove	2	0/0	$0	$0
Orange Factory	1	0/0	$0	$0
Quail Roost	3	0/0	$0	$0
Rougemont	2	0/0	$50,000	$0
Weaver	1	0/0	$0	$0
West Durham	1	0/0	$0	$0
Subtotal Durham	**54**	**0/0**	**$11,475,000**	**$5,000,000**
Orange				
Blackwood	2	0/0	$150,000	$0
Buckhorn	1	0/0	$0	$0
Calvander	2	0/0	$3,000	$0
Carr	1	0/0	$0	$0
Carrboro	1	0/0	$10,000	$0
Chapel Hill	10	0/0	$10,505,000	$0
Countywide	2	0/0	$0	$0
Efland	2	0/0	$250,000	$0
Glenn	1	0/0	$10,000	$0

Location	Event Count	Deaths/Injuries	Property Damage	Crop Damage
Hillsborough	3	0/0	$0	$0
Miles	2	0/0	$0	$0
North Portion	1	0/0	$0	$0
Teer	3	0/0	$26,400,000	$5,000,000
West Hillsborough	1	0/0	$5,000	$0
Subtotal Orange	**33**	**0/0**	**$37,333,000**	**$5,000,000**
Person				
Cavel	1	0/0	$0	$0
Countywide	2	0/0	$0	$0
Cunningham	2	0/0	$0	$0
Dennys Store	1	0/0	$0	$0
Gentrys Store	1	0/0	$0	$0
Gordonton	1	0/0	$50,000	$0
Helena	1	0/0	$0	$0
Hurdle Mills	2	0/0	$0	$0
Longs Store	1	0/0	$250,000	$0
Paynes Tavern	1	0/0	$0	$0
Roxboro	6	0/0	$10,000	$0
Subtotal Person	**19**	**0/0**	**$310,000**	**$0**
Region Total	**143**	**0/0**	**$52,298,000**	**$15,00,000**

Source: NCEI

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

July 23, 2000 – Flooding of streets and buildings was reported countywide, especially in Chapel Hill and Carrboro. The Eastgate Shopping center was damaged, as well as several apartments and homes. A bridge was washed out on Piney Mountain Rd.

July 13, 2003 – Extensive flooding caused evacuations. 30 homes and 6 businesses sustained flood damage, and the wastewater treatment plant was damaged. About a dozen cars were underwater. Highways 70 and 119 were closed along with many other roads.

June 30, 2013 – Heavy rain (4-5 inches) resulted in extensive flooding in the city of Chapel Hill. The first floor of the Town Hall flooded and may be closed for up to a year for repairs. Franklin Street saw widespread flooding, with water above the windows of cars in several locations and some businesses also being impacted. Several buildings on the University of North Carolina had water in them, including the bottom floor of Granville Tower. Another area of the city that experienced flooding was the East Gate Shopping Center, where water entered several businesses and stranded many cars in the parking lot. One hard hit residential area was along Estes Drive near Highway 15-501, where the Camelot Village Condominiums experienced extensive flooding. In fact, 76 out of 116 units flooded. Another residential area that experienced flooding was the Airport Gardens Public Housing Neighborhood, where 18 out of the 26 units flooded. Due to the flooding, the Orange County qualified for state and federal aid. Several areas of Carrboro experienced flooding, including the Rocky Brook Mobile Home Park on Greensboro Street, where residents had to be evacuated due to high water. In fact, 20 out of 31 homes were eventually condemned.

September 17, 2018 – Torrential rainfall of 6 to 10 inches caused widespread flooding across the region, which caused flooding along the Eno and Haw Rivers and other creeks and streams throughout the region.

Additionally, water held in Jordan Lake from rainfall in its headwaters resulted in flooding along the lake into far southeast portions of Orange and Durham counties. Flooding damaged approximately 276 structures throughout Orange County, destroying 1 structure and resulting in $26.4 million in property damage. Flooding damaged approximately 638 structures throughout Durham County, destroying 4 structures and resulting in $11.05 million in property damage. Flooding damaged approximately 202 structures throughout Alamance County, resulting in over $1.07 million in property damage. Numerous roads were closed due to flooding. Numerous homes and businesses were flooded as well. While final losses on crops are not yet tallied, estimates around $5 million or more are possible.

Probability of Future Occurrence

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

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

While exposure to flood hazards vary across jurisdictions, all jurisdictions have at least some area of land in FEMA flood hazard areas. Additionally, flash floods and stormwater flooding can occur outside of mapped SFHAs and historical records indicate that these events are very common in the Region, with an average of 6.45 events reported annually over the last 20 years. Therefore, the probability of flooding is considered likely (between 10% and 100% annual probability) for all jurisdictions.

Probability: 3 – Likely

Climate Change

Per the Fourth National Climate Assessment, frequency and intensity of heavy precipitation events is expected to increase across the country. Additionally, increases in precipitation totals are expected in the Southeast. Therefore, with more rainfall falling in more intense incidents, the region may experience more frequent flash flooding. Increased flooding may also result from more intense tropical cyclone; researchers have noted the occurrence of more intense storms bringing greater rainfall totals, a trend that is expected to continue as ocean and air temperatures rise.

Vulnerability Assessment

Methodologies and Assumptions

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

As a subset of the building vulnerability analysis, exposure of pre-FIRM structures was also estimated. Table 4.47 below provides the NFIP entry date for each participating jurisdiction, which was used to determine which buildings were constructed pre-FIRM. Pre-FIRM structures are those built prior to the community's first FIRM and thus before the adoption of flood protection building standards. These structures are therefore assumed to be at greater risk to the flood hazard.

To estimate the number of pre-FIRM structures in each community using year built data, if the NFIP entry date for a given community was between January and June, buildings constructed the same year as the entry date were considered to be post-FIRM (e.g., if the NFIP entry date is 02/01/1991, buildings constructed in 1990 and before were considered pre-FIRM. Buildings constructed from 1991 to the present were counted as post-FIRM.). If the NFIP entry date was between July and December, then the following year was applied for the year built cut-off (e.g., if the NFIP entry date was 12/18/2007, buildings constructed in the year 2007 and before were counted as pre-FIRM, 2008 and newer were post-FIRM).

Table 4.47 – NFIP Entry Dates

Jurisdiction	NFIP Entry Date
Alamance County	
Alamance County (Unincorporated)	12/1/1981
Alamance	12/17/1987
Burlington	4/1/1981
Elon	6/5/1989
Graham	11/19/1980
Green Level	12/22/1998
Haw River	11/5/1980
Mebane	11/5/1980
Ossipee	Non-participating
Swepsonville	12/1/1981
Durham County	
Durham County (Unincorporated)	2/15/1979
Durham	1/3/1979
Orange County	
Orange County (Unincorporated)	3/6/1981
Carrboro	6/25/1976
Chapel Hill	4/17/1978
Hillsborough	5/15/1980
Person County (Unincorporated)	9/14/1990
Roxboro	3/25/1991

Source: Federal Emergency Management Agency

Effective FEMA DFIRM data was used for the flood hazard areas. Flood zones used in the analysis consist of Zone AE (1-percent-annual-chance flood), Zone AE Floodway, and the 0.2-percent-annual-chance flood hazard area.

People

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

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

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

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

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

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

Floods can also result in fatalities. Though there are no deaths or injuries as a result of flood reported for the Region in NCEI records, these impacts can occur. Individuals face particularly high risk when driving through flooded streets.

Table 4.48 details the population at risk from the 1% annual chance flood event, according to data from the NCEM IRISK database. Note that development and population growth have occurred since the original analysis for the IRISK dataset was performed, therefore actual population at risk is likely higher.

Table 4.48 – Population Impacted by the 100-Year Flood Event

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	%		Number	%		Number	%
Alamance									
Alamance County (Unincorporated Area)	43,522	92	0.20%	6,358	13	0.20%	2,742	6	0.20%
City of Burlington	56,075	525	0.90%	8,192	77	0.90%	3,533	33	0.90%
City of Graham	16,584	222	1.30%	2,423	32	1.30%	1,045	14	1.30%
City of Mebane	14,590	44	0.30%	2,020	6	0.30%	893	3	0.34%
Town of Elon	10,006	86	0.90%	1,462	13	0.90%	630	5	0.80%
Town of Gibsonville	2,368	0	0%	346	0	0%	149	0	0%
Town of Green Level	3,773	34	0.90%	551	5	0.90%	238	2	0.80%
Town of Haw River	544	0	0%	79	0	0%	34	0	0%
Town of Ossipee	1,151	0	0%	168	0	0%	73	0	0%
Town of Swepsonville	1,462	2	0.10%	214	0	0%	92	0	0%
Village of Alamance	**150,075**	**1,005**	**0.67%**	**21,813**	**146**	**0.67%**	**9,429**	**63**	**0.67%**
Durham									
Durham County (Unincorporated Area)	38,181	322	0.84%	3,725	31	0.83%	2,826	24	0.85%
City of Durham	225,814	2,186	1%	22,031	213	1%	16,715	162	1%
Orange									
Orange County (Unincorporated Area)	45,470	80	0.20%	4,381	8	0.20%	2,342	4	0.20%

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	%		Number	%		Number	%
Town of Carrboro	20,883	199	1%	2,012	19	0.90%	1,076	10	0.90%
Town of Chapel Hill	59,351	914	1.54%	5,722	88	1.54%	3,117	48	1.54%
Town of Hillsborough	8,467	10	0.10%	816	1	0.10%	436	1	0.20%
Person									
Person County (Unincorporated Area)	26,396	9	0%	4,007	1	0%	1,584	1	0.10%
City of Roxboro	13,079	41	0.30%	1,986	6	0.30%	785	2	0.30%
Region Total	**587,716**	**4,766**	**0.81%**	**66,493**	**513**	**0.77%**	**38,310**	**291**	**0.76%**

Source: NCEM Risk Management Tool

Property

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

Table 4.49 details the property at risk from the 1% annual chance flood event, according to data from the NCEM IRISK database. As with population vulnerability data, actual property at risk is likely higher due to the amount of development that has occurred since the original analysis for the IRISK dataset was performed.

Table 4.49 – Buildings Impacted by the 100-Year Flood Event

Jurisdiction	All Buildings	Number of Pre-FIRM Buildings at Risk		Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance															
Alamance County (Unincorporated Area)	29,650	38	0.10%	55	0.20%	$363,953	6	0%	$230,681	0	0%	$0	61	0.20%	$594,634
City of Burlington	24,403	192	0.80%	201	0.80%	$646,943	15	0.10%	$167,698	2	0%	$18,193	218	0.90%	$832,834
City of Graham	7,269	29	0.40%	88	1.20%	$199,197	1	0%	$1,246	0	0%	$0	89	1.20%	$200,443
City of Mebane	5,835	0	0%	16	0.30%	$53,658	1	0%	$1,960	0	0%	$0	17	0.30%	$55,618
Town of Elon	2,760	20	0.70%	21	0.80%	$40,705	0	0%	$0	0	0%	$0	21	0.80%	$40,705
Town of Green Level	1,177	0	0%	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Haw River	2,352	17	0.70%	19	0.80%	$110,767	3	0.10%	$29,139	0	0%	$0	22	0.90%	$139,907
Town of Ossipee	330	0	0%	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Swepsonville	573	0	0%	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Village of Alamance	798	1	0.10%	1	0.10%	$339	0	0%	$0	0	0%	$0	1	0.10%	$339
Durham															
City of Durham	75,588	480	0.60%	651	0.90%	$7,217,149	64	0.10%	$5,812,077	6	0%	$228,083	721	1%	$13,257,310
Durham County (Unincorporated Area)	21,038	63	0.30%	152	0.70%	$853,878	13	0.10%	$2,191,130	2	0%	$14,030	167	0.80%	$3,059,038
Orange															
Orange County (Unincorporated Area)	24,533	8	0%	38	0.20%	$171,926	2	0%	$29,200	0	0%	$0	40	0.20%	$201,126
Town of Carrboro	5,782	14	0.20%	52	0.90%	$1,360,258	0	0%	$0	0	0%	$0	52	0.90%	$1,360,258

Jurisdiction	All Buildings	Number of Pre-FIRM Buildings at Risk		Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Town of Chapel Hill	15,108	228	1.50%	216	1.40%	$11,132,018	34	0.20%	$6,204,100	1	0%	$247,944	251	1.70%	$17,584,062
Town of Hillsborough	3,883	5	0.10%	4	0.10%	$5,872	1	0%	$9,528	0	0%	$0	5	0.10%	$15,399
Person															
City of Roxboro	6,617	35	0.50%	18	0.30%	$50,719	15	0.20%	$701,674	2	0%	$18,403	35	0.50%	$770,796
Person County (Unincorporated Area)	17,714	0	0%	5	0%	$12,780	0	0%	$0	0	0%	$0	5	0%	$12,780
Total	**245,410**	**1,130**	**0.50%**	**1,537**	**0.60%**	**$22,220,162**	**155**	**0.10%**	**$15,378,433**	**13**	**0%**	**$526,653**	**1,705**	**0.70%**	**$38,125,249**

Source: NCEM Risk Management Tool

The damage estimates for the 1% annual chance flood event total $46,279,356, which equates to a loss ratio of less than 1 percent. The loss ratio is the damage estimate divided by the total potential exposure (i.e., total value of all buildings in the planning area), displayed as a percentage of value at risk. FEMA considers loss ratios greater than 10% to be significant and an indicator a community may have more difficulties recovering from an event.

Table 4.50 provides building counts and estimated damages for Critical Infrastructure and Key Resources (CIKR) buildings across all jurisdictions, by sector for the 100-year flood event. Vulnerability of CIKR as well as High Potential Loss Properties, where applicable, can be found by jurisdiction in each community's annex to this plan.

Table 4.50 – Critical Infrastructure and Key Resources Buildings at Risk to 100-Year Flood by Sector

Sector	Number of Buildings at Risk	Estimated Damages
Banking and Finance	3	$272,662
Commercial Facilities	108	$7,413,171
Communications	1	$283,671
Critical Manufacturing	28	$7,891,080
Energy	8	$342,366
Food and Agriculture	8	$32,092
Government Facilities	7	$469,408
Healthcare and Public Health	7	$724,292
Transportation Systems	15	$2,265,319
Water	16	$6,373,107
Total	**201**	**$26,067,168**

Source: NCEM Risk Management Tool

Repetitive Loss Analysis

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

According to 2020 NFIP records from the FEMA Community Information System, there are a total of 196 repetitive loss properties within the Eno-Haw region, which have produced over $13.1 million in claims payments. There are 26 properties on the list classified as severe repetitive loss properties. A severe repetitive loss property is classified as such if it has four or more separate claim payments of more than $5,000 each (including building and contents payments) or two or more separate claim payments (building only) where the total of the payments exceeds the current value of the property.

Table 4.51 summarizes repetitive loss properties by jurisdiction as identified by FEMA through the NFIP.

Table 4.51 – Repetitive Loss Properties by Jurisdiction

Jurisdiction	Total Number of Properties	Total Number of Losses	Total Number of Severe Repetitive Loss Properties	Total Amount of Claims Payments
Alamance County	9	16	2	$283,480.40
City of Burlington	8	18	2	$322,040.69
City of Graham	1	2	0	$8,880.76
City of Mebane	0	0	0	$0
Town of Elon	1	3	0	$27,590.23
Town of Green Level	0	0	0	$0
Town of Haw River	0	0	0	$0

Jurisdiction	Total Number of Properties	Total Number of Losses	Total Number of Severe Repetitive Loss Properties	Total Amount of Claims Payments
Town of Ossipee	0	0	0	$0
Town of Swepsonville	0	0	0	$0
Village of Alamance	0	0	0	$0
City of Durham	63	92	6	$1,700,609.94
Durham County	9	14	1	$216,197.28
Orange County	4	5	0	$107,362.93
Town of Carrboro	9	10	0	$134,476.19
Town of Chapel Hill	92	154	15	$10,342,665.66
Town of Hillsborough	0	0	0	$0
City of Roxboro	0	0	0	$0
Person County	0	0	0	$0
Total	**196**	**314**	**26**	**$13,143,304.08**

Source: FEMA Community Information System

These repetitive loss properties include primarily residential as well as some commercial property types. These property types are representative of all communities in the plan with repetitive losses.

Environment

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

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

Consequence Analysis

Table 4.52 summarizes the potential detrimental consequences of flood.

Table 4.52 – Consequence Analysis - Flood

Category	Consequences
Public	Localized impact expected to be severe for incident areas and moderate to light for other adversely affected areas.
Responders	First responders are at risk when attempting to rescue people from their homes. They are subject to the same health hazards as the public. Flood waters may prevent access to areas in need of response or the flood may prevent access to the critical facilities themselves which may prolong response time. Damage to personnel will generally be localized to those in the flood areas at the time of the incident and is expected to be limited.
Continuity of Operations (including Continued Delivery of Services)	Floods can severely disrupt normal operations, especially when there is a loss of power. Damage to facilities in the affected area may require temporary relocation of some operations. Localized disruption of roads, facilities, and/or utilities caused by incident may postpone delivery of some services.
Property, Facilities and Infrastructure	Buildings and infrastructure, including transportation and utility infrastructure, may be damaged or destroyed. Impacts are expected to be localized to the area of the incident. Severe damage is possible.

Category	Consequences
Environment	Chemicals and other hazardous substances may contaminate local water bodies. Wildlife and livestock deaths possible. The localized impact is expected to be severe for incident areas and moderate to light for other areas affected by the flood or HazMat spills.
Economic Condition of the Jurisdiction	Local economy and finances will be adversely affected, possibly for an extended period of time. During floods (especially flash floods), roads, bridges, farms, houses and automobiles are destroyed. Additionally, the local government must deploy firemen, police and other emergency response personnel and equipment to help the affected area. It may take years for the affected communities to be re-built and business to return to normal.
Public Confidence in the Jurisdiction's Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery are not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes flood hazard risk by jurisdiction. To account for increased risk of flood due to stormwater and flash flooding, communities with between 2 and 12 flash flood events in the period from 2007-2018 were assigned a probability rating of 3, and communities with over 12 flash flood events during this period were assigned a probability rating of 4. Note that countywide events were not considered in these counts. Communities with 10% or more of their land area in the SFHA were assigned a spatial extent of 3. All other factors do not vary by jurisdiction.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	3	2	2	3	3	2.5	H
Burlington	3	2	2	3	3	2.5	H
Graham	3	2	2	3	3	2.5	H
Mebane	3	2	2	3	3	2.5	H
Elon	3	2	2	3	3	2.5	H
Green Level	3	2	2	3	3	2.5	H
Haw River	3	2	2	3	3	2.5	H
Ossipee	3	2	2	3	3	2.5	H
Swepsonville	3	2	2	3	3	2.5	H
Alamance	3	2	2	3	3	2.5	H
Durham County	3	2	2	3	3	2.5	H
Durham	3	2	2	3	3	2.5	H
Orange County	3	2	2	3	3	2.5	H
Carrboro	3	2	2	3	3	2.5	H
Chapel Hill	3	2	2	3	3	2.5	H
Hillsborough	3	2	2	3	3	2.5	H
Person County	3	2	2	3	3	2.5	H
Roxboro	3	2	2	3	3	2.5	H

4.5.6 Hurricane and Tropical Storm

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Hurricane & Tropical Storm	Likely	Critical	Large	More than 24 hrs	Less than 24 hrs	2.9

Hazard Background

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

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

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

Warning Time: 1 – More than 24 hours

Duration: 2 – Less than 24 hours

Location

Hurricanes and tropical storms can occur anywhere within the Eno-Haw Region. While coastal areas are most vulnerable to hurricanes, the wind and rain impacts of these storms can be felt hundreds of miles inland.

Extent

Hurricane intensity is classified by the Saffir-Simpson Scale (Table 4.53), which rates hurricane intensity on a scale of 1 to 5, with 5 being the most intense.

Table 4.53 – Saffir-Simpson Scale

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

Source: National Hurricane Center

The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds and barometric pressure, which are combined to estimate potential damage. Categories 3, 4, and 5 are classified as “major” hurricanes and, while hurricanes within this range comprise only 20 percent of total tropical cyclone landfalls, they account for over 70 percent of the damage in the United States. Table 4.54 describes the damage that could be expected for each category of hurricane. Damage during hurricanes may also result from spawned tornadoes, storm surge, and inland flooding associated with heavy rainfall that usually accompanies these storms.

Table 4.54 – Hurricane Damage Classifications

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

Source: National Hurricane Center; Federal Emergency Management Agency

Tropical cyclones weaken relatively quickly after making landfall; therefore, the Eno-Haw Region will not typically experience major hurricane force winds, though these occurrences are possible. The strongest storm on record to pass through the region was Hurricane Fran in 1999, which moved through the Region as a Category 1 storm. However, within 50 miles of the Region Fran was a Category 3 storm. Hurricane Hazel in 1954 passed within 50 miles of the Region as a Category 4 storm.

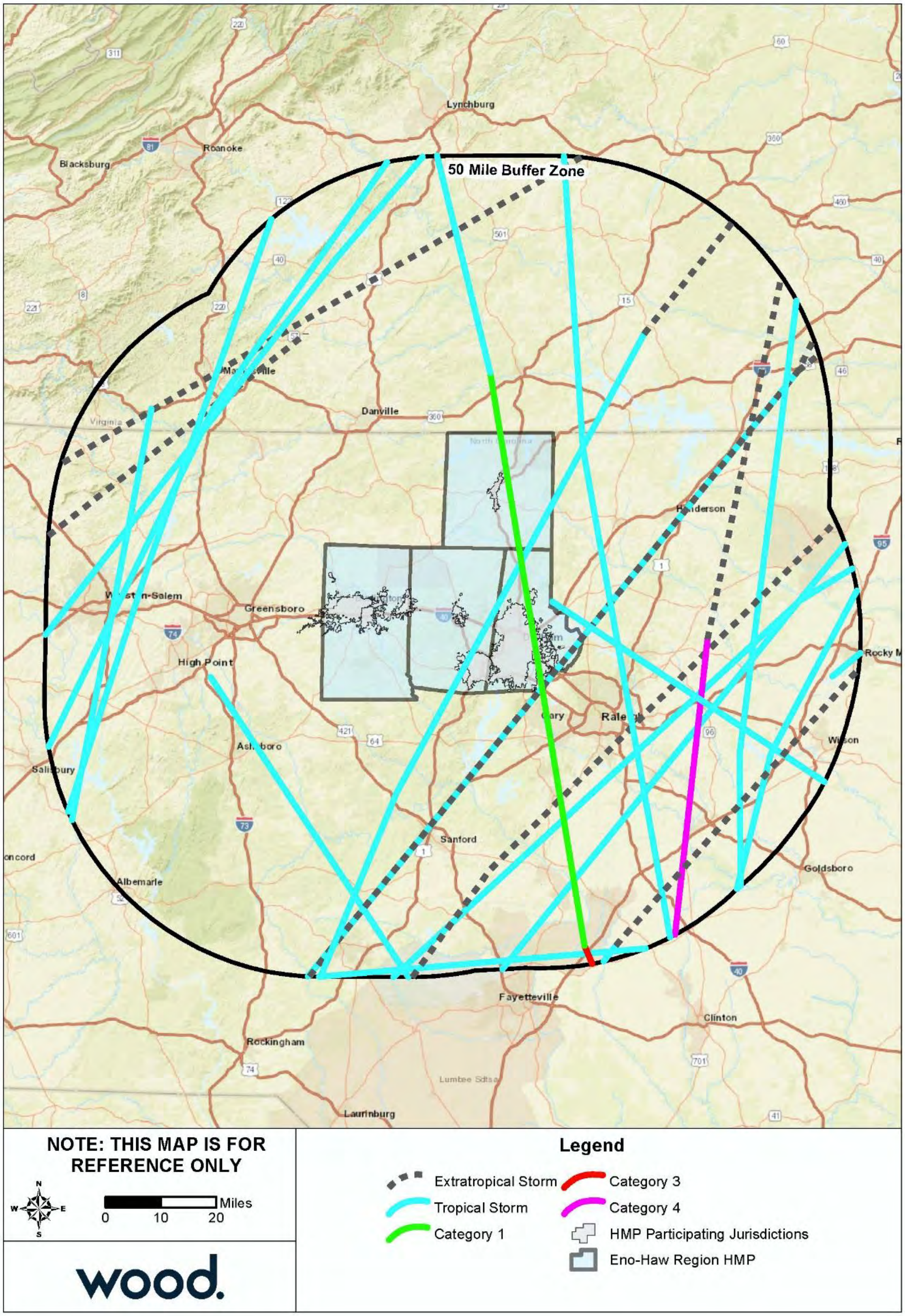
Impact: 3 – Critical

Spatial Extent: 4 – Large

Historical Occurrences

According to the Office of Coastal Management's Tropical Cyclone Storm Segments data, which is a subset of the International Best Track Archive for Climate Stewardship (IBTrACS) dataset, 22 hurricanes and tropical storms passed within 50 miles of the Eno-Haw Region between 1900 and 2016. These storms tracks are shown in Figure 4.29. The date, storm name, storm category, and maximum wind speed of each event are detailed in Table 4.55.

Figure 4.29 – Hurricane and Tropical Storm Tracks within 50 Miles of Eno-Haw Region, 1900-2016



Source: NOAA Office of Coastal Management

Table 4.55 – Hurricane and Tropical Storm Tracks within 50 Miles of Eno-Haw Region, 1900-2016

Date	Storm Name	Max Storm Category*	Max Wind Speed (mph)
6/16/1902	Unnamed	Extratropical Storm	46
10/12/1902	Unnamed	Extratropical Storm	40
9/14/1904	Unnamed	Tropical Storm	69
9/23/1907	Unnamed	Extratropical Storm	40
9/3/1913	Unnamed	Tropical Storm	46
8/4/1915	Unnamed	Tropical Storm	46
9/23/1920	Unnamed	Tropical Storm	40
10/2/1929	Unnamed	Extratropical Storm	58
9/6/1935	Unnamed	Tropical Storm	58
8/2/1944	Unnamed	Tropical Storm	69
10/20/1944	Unnamed	Extratropical Storm	58
9/18/1945	Unnamed	Tropical Storm	58
9/1/1952	Able	Tropical Storm	46
10/15/1954	Hazel	Category 4	132
8/17/1955	Diane	Tropical Storm	63
7/10/1959	Cindy	Tropical Storm	40
9/5/1979	David	Tropical Storm	52
7/25/1985	Bob	Tropical Storm	52
9/6/1996	Fran	Category 3	115
9/5/1999	Dennis	Tropical Storm	40
9/6/2008	Hanna	Tropical Storm	69
6/7/2013	Andrea	Tropical Storm	46

*Reports the most intense category that occurred within 50 miles of the Region, not for the storm event overall.
Source: Office of Coastal Management, 2019. https://marinecadastre.gov/data/

The above list of storms is not an exhaustive list of hurricanes that have affected the Region. Several storms, including Hurricane Floyd and Tropical Storm Hermine passed further than 50 miles away from the Region yet had strong enough wind or rain impacts to affect the county. Additionally, several storms have impacted the planning area since 2016. Storms with hurricane and tropical storm force winds that impacted the Eno-Haw Region from 1999 through 2018 are noted in Table 4.56, as identified by NCEI.

Table 4.56 – Recorded Winds in Eno-Haw Region, 1999-2018

Date	Type	Storm	Deaths/ Injuries	Property Damage	Crop Damage
9/4/1999	Hurricane (Typhoon)	Hurricane Dennis	0/0	$0	$3,000,000
9/15/1999	Hurricane (Typhoon)	Hurricane Floyd	0/0	$3,000,000,000*	$5,000,000,000*
9/18/2003	Hurricane (Typhoon)	Hurricane Isabel	0/0	$309,000	$0
9/14/2018	Tropical Storm	Hurricane Florence	0/0	$0	$25,000
10/11/2018	Tropical Storm	Tropical Storm Michael	0/0	$1,700,000	$0
		Total	**0/0**	**$3,002,009,000**	**$5,003,025,000**

Source: NCEI
*Note: Damage estimates provided by NCEI for Hurricane Floyd are for the entire state; however, counties within the Raleigh warning area were thought to have sustained more than half the state total.

Hurricane Dennis (1999) – The Triangle received from 6 to 8 inches of rain with Chapel Hill peaking out at 12 inches. The I-40 corridor of counties also got dumped on with totals in the 6 to 10 inch range. This water caused considerable urban and lowland flooding. Several main stem rivers also went into flood.

The winds with the remnants of Dennis were generally not a significant problem. There were many old, larger trees uprooted and widespread limb damage was reported. However, the wind and rain combination caused considerable crop damage.

Hurricane Florence (2018) – A ridge of high pressure over eastern North America stalled Florence's forward motion a few miles off the southeast North Carolina coast on September 13th. Hurricane Florence made landfall near Wrightsville Beach early on September 15 and weakened further as it moved slowly inland. Despite making landfall as a weakened Category 1 hurricane, Florence still produced 40 to 70 mph wind gusts, enough wind speed to uproot trees and cause widespread power outages throughout the Carolinas. As the storm moved inland, from September 15 to 17, heavy rain of 10 to 25 inches caused widespread inland flooding, inundating cities such as Fayetteville, Smithfield, Goldsboro, Durham, and Chapel Hill, and causing major river flooding on main-stem rivers such as the Neuse, Cape Fear, and Little River. Most major roads and highways in the area experienced some flooding, with large stretches of I-40 and I-95 remaining impassable for days after the storm had passed. The storm also spawned tornadoes in several places along its path. There were 3 direct and 6 indirect deaths attributed to the storm with in the Raleigh Weather Forecast Office County Warning Area.

Tropical Storm Michael (2018) – Tropical Storm Michael moved through North Carolina on Thursday, October 11th. Michael brought heavy rain and strong damaging winds to central North Carolina. While heavy rainfall of 3 to 6 inches produced minor flash flooding across the area, it was high wind gusts of 40 to 60 mph that caused the biggest problems, knocking down score of trees, leading to blocked roadways and thousands without power. In the Eno-Haw Region, tropical storm wind gusts downed numerous trees, caused widespread power outages, and produced a variety of damage to homes and structures. At the peak of the storm, total peak outages were around 33,000 customers in Alamance County, 22,000 in Orange County, and 20,000 in Durham County.

Probability of Future Occurrence

Probability: 3 – Likely

In the 20-year period from 1999 through 2018, five hurricanes and tropical storms have impacted the Eno-Haw Region, which equates to a 25 percent annual probability of hurricane winds impacting the county. This probability does not account for impacts from hurricane rains, which may also be severe. Two additional storms passed within 50 miles of the Region during this period; these storms did not have significant wind impacts but may have brought heavy rains. Overall, the probability of a hurricane or tropical storm impacting the Region is likely.

Climate Change

One of the primary factors contributing to the origin and growth of tropical storm and hurricanes systems is water temperature. Per the Fourth National Climate Assessment, "There is growing evidence that the tropics have expanded poleward by about 70 to 200 miles in each hemisphere since satellite measurements began in 1979, with an accompanying shift of the subtropical dry zones, midlatitude jets, and both midlatitude and tropical cyclone tracks." It is unclear as of yet whether these changes can be attributed to climate change, but current climate science suggests cyclones would become more frequent and intense as water temperatures warm. In addition to occurring with greater frequency, intense hurricanes are also expected to produce greater amounts of rainfall. The 2017 hurricane season is considered an indicator of these potential changes.

Vulnerability Assessment

Methodologies and Assumptions

Property at risk to hurricanes was estimated using data from the North Carolina Emergency Management (NCEM) IRISK database, which was compiled in NCEM's Risk Management Tool. The vulnerability data displayed below is for wind-related damages. Hurricanes may also cause substantial damages from heavy rains and subsequent flooding, which is addressed in Section 4.5.5 Flood.

People

The very young, the elderly and disabled individuals are more vulnerable to harm from hurricanes, as are those who are unable to evacuate for medical reasons, including special-needs patients and those in hospitals and nursing homes. Many of these patients are either oxygen-dependent, insulin-dependent, or in need of intensive or ongoing treatment. For all affected populations, the stress from disasters such as a hurricane can result in immediate and long-term physical and emotional health problems among victims.

People exposed to the elements are also more vulnerable to wind hazards. The availability of sheltered locations, such as buildings constructed using wind-resistant materials and public storm shelters, reduces the exposure of the population. Individuals in mobile home housing are particularly susceptible to wind hazards. According to the 2017 American Community Survey (ACS), 19,000 occupied housing units (7.5%) in the Eno-Haw Region are classified as "mobile homes or other types of housing." Based on an estimated average of 2.4 persons per household from the 2017 ACS, there are approximately 45,000 people in the Region living in mobile homes. Table 4.57 details the number of mobile home units in each jurisdiction.

Table 4.57 – Mobile Home Units in the Eno-Haw Region, 2017

County	Occupied Mobile Home Units	Total Occupied Housing Units	Percent of Occupied Housing
Alamance County	**8,705**	**69,049**	**12.6%**
Unincorporated Alamance County	6,576	25,462	25.8%
Burlington	781	24,471	3.2%
Graham	586	6,581	8.9%
Mebane	84	6,138	1.4%
Elon	46	3,108	1.5%
Green Level	325	824	39.4%
Haw River	230	1,126	20.4%
Ossipee	45	211	21.3%
Swepsonville	30	694	4.3%
Alamance	2	434	0.5%
Durham County	**1,826**	**130,691**	**1.4%**
Unincorporated Durham County	922	17,125	5.4%
Durham	904	113,566	0.8%
Orange County	**4,328**	**56,941**	**7.6%**
Unincorporated Orange County	3,875	22,840	17.0%
Carrboro	69	9,585	0.7%
Chapel Hill	218	21,685	1.0%
Hillsborough	166	2,831	5.9%
Person County	**4,141**	**18,371**	**22.5%**
Unincorporated Person County	3,579	14,231	25.1%
Roxboro	562	4,140	13.6%

Source: American Community Survey 2013-2017 5-Year Estimates
Unincorporated area counts are estimated by subtracting incorporated areas from the county total.

Property

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

Hurricanes and tropical storms can also cause agricultural damages. For the Eno-Haw Region, USDA RMA reports losses of $37,689 from 2007-2017 due to hurricane and cyclone, which equates to an average annual loss of $3,426. Table 4.58 summarizes these crop losses reported in the RMA system.

Table 4.58 – Crop Losses Resulting from Hurricane and Cyclone, 2007-2017

County	Total Affected Acres	Total Indemnity Paid	Average Indemnity Amount
Alamance	32.58	$13,227.00	$4,409.00
Orange	20.40	$6,356.00	$6,356.00
Person	10.40	$18,106.00	$9,053.00
Region Total	**11.50**	**$37,689.00**	**$6,606.00**

Source: USDA Risk Management Agency

The damage estimates for the 100-year hurricane wind event total $165,377,598, which equates to a loss ratio of less than 1 percent. These damage estimates account for only wind impacts and actual damages would likely be higher due to flooding. Therefore, the Region would likely experience a higher overall loss ratio from the 100-year hurricane event and face difficulty recovering from such an event.

Table 4.59 through Table 4.63 detail the estimated building damages from varying magnitudes of hurricane events.

Table 4.59 – Estimated Buildings Impacted by 25-Year Hurricane Wind Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,587	86.3%	$1,517,967	3,425	11.6%	$93,888	283	1%	$30,176	29,295	98.8%	$1,642,032
City of Burlington	24,403	21,461	87.9%	$1,510,650	2,401	9.8%	$293,499	320	1.3%	$44,561	24,182	99.1%	$1,848,710
City of Graham	7,269	6,512	89.6%	$381,793	530	7.3%	$38,766	155	2.1%	$17,058	7,197	99%	$437,617
City of Mebane	5,835	5,194	89%	$374,873	465	8%	$117,083	64	1.1%	$14,644	5,723	98.1%	$506,600
Town of Elon	2,760	2,432	88.1%	$208,948	147	5.3%	$23,513	174	6.3%	$17,521	2,753	99.7%	$249,981
Town of Green Level	1,177	1,049	89.1%	$54,664	109	9.3%	$5,043	10	0.8%	$414	1,168	99.2%	$60,121
Town of Haw River	2,352	2,121	90.2%	$122,845	168	7.1%	$8,549	31	1.3%	$2,738	2,320	98.6%	$134,131
Town of Ossipee	330	297	90%	$17,195	21	6.4%	$1,204	7	2.1%	$448	325	98.5%	$18,847
Town of Swepsonville	573	526	91.8%	$41,834	24	4.2%	$11,554	5	0.9%	$1,142	555	96.9%	$54,530
Village of Alamance	798	711	89.1%	$41,010	66	8.3%	$1,302	17	2.1%	$1,398	794	99.5%	$43,710
Subtotal Alamance	**75,147**	**65,890**	**87.7%**	**$4,271,779**	**7,356**	**9.8%**	**$594,401**	**1,066**	**1.4%**	**$130,100**	**74,312**	**98.9%**	**$4,996,279**
Durham County													
Unincorporated Durham County	21,038	17,863	84.9%	$1,306,795	2,818	13.4%	$394,394	234	1.1%	$49,206	20,915	99.4%	$1,750,395
City of Durham	75,588	66,993	88.6%	$5,934,692	6,071	8%	$1,288,346	1,667	2.2%	$370,777	74,731	98.9%	$7,593,815
Subtotal Durham	**96,626**	**84,856**	**87.82%**	**$7,241,487**	**8,889**	**9.20%**	**$1,682,740**	**1,901**	**1.97%**	**$419,983**	**95,646**	**98.99%**	**$9,344,210**
Orange County													
Unincorporated Orange County	24,533	21,439	87.4%	$1,770,536	2,657	10.8%	$171,290	246	1%	$103,055	24,342	99.2%	$2,044,881
Town of Carrboro	5,782	5,450	94.3%	$729,711	261	4.5%	$76,279	46	0.8%	$65,644	5,757	99.6%	$871,634
Town of Chapel Hill	15,108	3,405	87.7%	$313,667	358	9.2%	$42,195	111	2.9%	$44,105	3,874	99.8%	$399,967
Town of Hillsborough	3,883	518	13.3%	$6,208	352	9.1%	$46,427	105	2.7%	$16,571	975	25.1%	$69,206
Subtotal Orange	**49,306**	**30,812**	**62.49%**	**$2,820,122**	**3,628**	**7.36%**	**$336,191**	**508**	**1.03%**	**$229,375**	**34,948**	**70.88%**	**$3,385,688**
Person County													
Unincorporated Person County	17,714	14,626	82.6%	$1,380,564	2,613	14.8%	$79,184	156	0.9%	$60,127	17,395	98.2%	$1,519,875
City of Roxboro	6,617	5,742	86.8%	$537,648	710	10.7%	$104,442	144	2.2%	$45,812	6,596	99.7%	$687,902
Subtotal Person	**24,331**	**20,368**	**83.7%**	**$1,918,212**	**3,323**	**13.7%**	**$183,626**	**300**	**1.2%**	**$105,939**	**23,991**	**98.6%**	**$2,207,777**
Total	**245,410**	**215,293**	**87.7%**	**$18,874,641**	**23,461**	**9.6%**	**$2,945,820**	**4,198**	**1.7%**	**$1,108,496**	**242,952**	**99%**	**$22,928,955**

Source: NCEM Risk Management Tool

Table 4.60 – Estimated Buildings Impacted by 50-Year Hurricane Wind Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,610	86.4%	$1,789,093	3,425	11.6%	$130,010	283	1%	$38,710	29,318	98.9%	$1,957,812
City of Burlington	24,403	21,461	87.9%	$1,510,650	2,401	9.8%	$293,499	320	1.3%	$44,561	24,182	99.1%	$1,848,710
City of Graham	7,269	6,512	89.6%	$381,793	530	7.3%	$38,766	155	2.1%	$17,058	7,197	99%	$437,617
City of Mebane	5,835	5,194	89%	$374,873	465	8%	$117,083	64	1.1%	$14,644	5,723	98.1%	$506,600
Town of Elon	2,760	2,432	88.1%	$208,948	147	5.3%	$23,513	174	6.3%	$17,521	2,753	99.7%	$249,981
Town of Green Level	1,177	1,049	89.1%	$54,664	109	9.3%	$5,043	10	0.8%	$414	1,168	99.2%	$60,121
Town of Haw River	2,352	2,121	90.2%	$122,845	168	7.1%	$8,549	31	1.3%	$2,738	2,320	98.6%	$134,131
Town of Ossipee	330	297	90%	$17,195	21	6.4%	$1,204	7	2.1%	$448	325	98.5%	$18,847
Town of Swepsonville	573	526	91.8%	$41,834	24	4.2%	$11,554	5	0.9%	$1,142	555	96.9%	$54,530
Village of Alamance	798	711	89.1%	$41,010	66	8.3%	$1,302	17	2.1%	$1,398	794	99.5%	$43,710
Subtotal Alamance	**75,147**	**65,913**	**87.7%**	**$4,542,905**	**7,356**	**9.8%**	**$630,523**	**1,066**	**1.4%**	**$138,634**	**74,335**	**98.9%**	**$5,312,059**
Durham County													
Unincorporated Durham County	21,038	17,962	85.4%	$4,475,661	2,818	13.4%	$1,151,975	234	1.1%	$159,541	21,014	99.9%	$5,787,176
City of Durham	75,588	67,732	89.6%	$21,431,914	6,071	8%	$4,529,119	1,667	2.2%	$1,323,180	75,470	99.8%	$27,284,213
Subtotal Durham	**96,626**	**84,856**	**87.82%**	**$7,241,487**	**8,889**	**9.20%**	**$1,682,740**	**1,901**	**1.97%**	**$419,983**	**95,646**	**98.99%**	**$9,344,210**
Orange County													
Unincorporated Orange County	24,533	21,602	88.1%	$3,884,109	2,657	10.8%	$364,999	246	1%	$172,678	24,505	99.9%	$4,421,786
Town of Carrboro	5,782	5,464	94.5%	$2,558,836	261	4.5%	$341,439	46	0.8%	$288,628	5,771	99.8%	$3,188,903
Town of Chapel Hill	15,108	13,922	92.1%	$8,698,323	617	4.1%	$822,592	528	3.5%	$1,017,789	15,067	99.7%	$10,538,703
Town of Hillsborough	3,883	3,405	87.7%	$424,422	358	9.2%	$76,275	111	2.9%	$46,923	3,874	99.8%	$547,620
Subtotal Orange	**49,306**	**44,393**	**90.04%**	**$15,565,690**	**3,893**	**7.90%**	**$1,605,305**	**931**	**1.89%**	**$1,526,018**	**49,217**	**99.82%**	**$18,697,012**
Person County													
Unincorporated Person County	17,714	14,626	82.6%	$1,380,564	2,613	14.8%	$79,184	156	0.9%	$60,127	17,395	98.2%	$1,519,875
City of Roxboro	6,617	5,742	86.8%	$537,648	710	10.7%	$104,442	144	2.2%	$45,812	6,596	99.7%	$687,902
Subtotal Person	**24,331**	**20,368**	**83.7%**	**$1,918,212**	**3,323**	**13.7%**	**$183,626**	**300**	**1.2%**	**$105,939**	**23,991**	**98.6%**	**$2,207,777**
Total	**245,410**	**216,368**	**88.2%**	**$47,934,382**	**23,461**	**9.6%**	**$8,100,548**	**4,198**	**1.7%**	**$3,253,312**	**244,027**	**99.4%**	**$59,288,237**

Source: NCEM Risk Management Tool

Table 4.61 – Estimated Buildings Impacted by 100-Year Hurricane Wind Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,610	86.4%	$1,789,093	3,425	11.6%	$130,010	283	1%	$38,710	29,318	98.9%	$1,957,812
City of Burlington	24,403	21,461	87.9%	$1,510,650	2,401	9.8%	$293,499	320	1.3%	$44,561	24,182	99.1%	$1,848,710
City of Graham	7,269	6,512	89.6%	$381,793	530	7.3%	$38,766	155	2.1%	$17,058	7,197	99%	$437,617
City of Mebane	5,835	5,194	89%	$374,873	465	8%	$117,083	64	1.1%	$14,644	5,723	98.1%	$506,600
Town of Elon	2,760	2,432	88.1%	$208,948	147	5.3%	$23,513	174	6.3%	$17,521	2,753	99.7%	$249,981
Town of Green Level	1,177	1,049	89.1%	$54,664	109	9.3%	$5,043	10	0.8%	$414	1,168	99.2%	$60,121
Town of Haw River	2,352	2,121	90.2%	$122,845	168	7.1%	$8,549	31	1.3%	$2,738	2,320	98.6%	$134,131
Town of Ossipee	330	297	90%	$17,195	21	6.4%	$1,204	7	2.1%	$448	325	98.5%	$18,847
Town of Swepsonville	573	526	91.8%	$41,834	24	4.2%	$11,554	5	0.9%	$1,142	555	96.9%	$54,530
Village of Alamance	798	711	89.1%	$41,010	66	8.3%	$1,302	17	2.1%	$1,398	794	99.5%	$43,710
Subtotal Alamance	**75,147**	**65,913**	**87.7%**	**$4,542,905**	**7,356**	**9.8%**	**$630,523**	**1,066**	**1.4%**	**$138,634**	**74,335**	**98.9%**	**$5,312,059**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$10,744,559	2,818	13.4%	$3,484,762	234	1.1%	$457,730	21,020	99.9%	$14,687,051
City of Durham	75,588	67,732	89.6%	$54,054,072	6,071	8%	$14,961,703	1,667	2.2%	$4,475,993	75,470	99.8%	$73,491,768
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$64,798,631**	**8,889**	**9.20%**	**$18,446,465**	**1,901**	**1.97%**	**$4,933,723**	**96,490**	**99.86%**	**$88,178,819**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$10,744,116	2,657	10.8%	$1,183,862	246	1%	$568,397	24,527	100%	$12,496,375
Town of Carrboro	5,782	5,464	94.5%	$6,312,753	261	4.5%	$1,150,600	46	0.8%	$854,587	5,771	99.8%	$8,317,940
Town of Chapel Hill	15,108	13,922	92.1%	$21,129,165	617	4.1%	$3,009,976	528	3.5%	$3,703,606	15,067	99.7%	$27,842,747
Town of Hillsborough	3,883	3,408	87.8%	$1,046,140	358	9.2%	$155,091	111	2.9%	$138,551	3,877	99.8%	$1,339,782
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$39,232,174**	**3,893**	**7.90%**	**$5,499,529**	**931**	**1.89%**	**$5,265,141**	**49,242**	**99.87%**	**$49,996,844**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$4,680,293	2,613	14.8%	$268,918	156	0.9%	$216,901	17,662	99.7%	$5,166,112
City of Roxboro	6,617	5,754	87%	$1,770,266	710	10.7%	$412,257	144	2.2%	$178,831	6,608	99.9%	$2,361,354
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$6,450,559**	**3,323**	**13.7%**	**$681,175**	**300**	**1.2%**	**$395,732**	**24,270**	**99.7%**	**$7,527,466**
Total	**245,410**	**217,361**	**88.6%**	**$126,862,827**	**23,461**	**9.6%**	**$27,297,853**	**4,198**	**1.7%**	**$11,216,917**	**245,020**	**99.8%**	**$165,377,598**

Source: NCEM Risk Management Tool

Table 4.62 – Estimated Buildings Impacted by 300-Year Hurricane Wind Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$33,160,510	3,425	11.6%	$6,483,967	283	1%	$1,822,163	29,619	99.9%	$41,466,641
City of Burlington	24,403	21,618	88.6%	$30,834,890	2,401	9.8%	$12,800,367	320	1.3%	$2,679,425	24,339	99.7%	$46,314,682
City of Graham	7,269	6,575	90.5%	$8,234,848	530	7.3%	$2,200,394	155	2.1%	$1,140,007	7,260	99.9%	$11,575,249
City of Mebane	5,835	5,303	90.9%	$8,843,654	465	8%	$5,169,882	64	1.1%	$660,516	5,832	99.9%	$14,674,052
Town of Elon	2,760	2,437	88.3%	$4,528,752	147	5.3%	$1,698,642	174	6.3%	$998,717	2,758	99.9%	$7,226,111
Town of Green Level	1,177	1,057	89.8%	$1,044,769	109	9.3%	$210,188	10	0.8%	$40,438	1,176	99.9%	$1,295,394
Town of Haw River	2,352	2,139	90.9%	$2,728,522	168	7.1%	$350,117	31	1.3%	$153,101	2,338	99.4%	$3,231,741
Town of Ossipee	330	299	90.6%	$307,230	21	6.4%	$99,388	7	2.1%	$15,674	327	99.1%	$422,292
Town of Swepsonville	573	543	94.8%	$833,748	24	4.2%	$457,462	5	0.9%	$29,685	572	99.8%	$1,320,896
Village of Alamance	798	714	89.5%	$916,534	66	8.3%	$112,489	17	2.1%	$72,462	797	99.9%	$1,101,485
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$91,433,457**	**7,356**	**9.8%**	**$29,582,896**	**1,066**	**1.4%**	**$7,612,188**	**75,018**	**99.8%**	**$128,628,543**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$28,552,841	2,818	13.4%	$10,587,535	234	1.1%	$1,498,459	21,020	99.9%	$40,638,835
City of Durham	75,588	67,732	89.6%	$134,627,064	6,071	8%	$43,654,889	1,667	2.2%	$13,158,313	75,470	99.8%	$191,440,266
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$163,179,905**	**8,889**	**9.20%**	**$54,242,424**	**1,901**	**1.97%**	**$14,656,772**	**96,490**	**99.86%**	**$232,079,101**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$36,985,891	2,657	10.8%	$5,170,896	246	1%	$2,988,282	24,527	100%	$45,145,069
Town of Carrboro	5,782	5,464	94.5%	$16,504,977	261	4.5%	$2,826,506	46	0.8%	$1,705,569	5,771	99.8%	$21,037,051
Town of Chapel Hill	15,108	13,922	92.1%	$52,706,532	617	4.1%	$9,162,755	528	3.5%	$10,466,470	15,067	99.7%	$72,335,758
Town of Hillsborough	3,883	3,408	87.8%	$6,263,186	358	9.2%	$1,860,930	111	2.9%	$989,004	3,877	99.8%	$9,113,119
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$112,460,586**	**3,893**	**7.90%**	**$19,021,087**	**931**	**1.89%**	**$16,149,325**	**49,242**	**99.87%**	**$147,630,997**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$25,609,387	2,613	14.8%	$2,017,581	156	0.9%	$1,870,455	17,662	99.7%	$29,497,423
City of Roxboro	6,617	5,754	87%	$10,323,182	710	10.7%	$4,616,560	144	2.2%	$1,747,326	6,608	99.9%	$16,687,068
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$35,932,569**	**3,323**	**13.7%**	**$6,634,141**	**300**	**1.2%**	**$3,617,781**	**24,270**	**99.7%**	**$46,184,491**
Total	**245,410**	**217,361**	**88.6%**	**$403,006,517**	**23,461**	**9.6%**	**$109,480,548**	**4,198**	**1.7%**	**$42,036,066**	**245,020**	**99.8%**	**$554,523,132**

Source: NCEM Risk Management Tool

Table 4.63 – Estimated Buildings Impacted by 700-Year Hurricane Wind Event

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$94,272,463	3,425	11.6%	$18,047,917	283	1%	$5,059,879	29,619	99.9%	$117,380,259
City of Burlington	24,403	21,618	88.6%	$84,166,459	2,401	9.8%	$38,513,551	320	1.3%	$7,622,960	24,339	99.7%	$130,302,971
City of Graham	7,269	6,575	90.5%	$22,373,018	530	7.3%	$7,115,467	155	2.1%	$3,388,298	7,260	99.9%	$32,876,783
City of Mebane	5,835	5,303	90.9%	$26,014,943	465	8%	$13,227,786	64	1.1%	$1,810,433	5,832	99.9%	$41,053,162
Town of Elon	2,760	2,437	88.3%	$13,297,174	147	5.3%	$4,578,421	174	6.3%	$3,062,159	2,758	99.9%	$20,937,754
Town of Green Level	1,177	1,057	89.8%	$2,864,467	109	9.3%	$539,952	10	0.8%	$128,133	1,176	99.9%	$3,532,553
Town of Haw River	2,352	2,139	90.9%	$8,242,257	168	7.1%	$1,186,380	31	1.3%	$397,558	2,338	99.4%	$9,826,195
Town of Ossipee	330	299	90.6%	$818,587	21	6.4%	$285,184	7	2.1%	$41,749	327	99.1%	$1,145,519
Town of Swepsonville	573	543	94.8%	$2,460,882	24	4.2%	$1,265,495	5	0.9%	$86,248	572	99.8%	$3,812,625
Village of Alamance	798	714	89.5%	$2,404,949	66	8.3%	$327,395	17	2.1%	$219,007	797	99.9%	$2,951,351
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$256,915,199**	**7,356**	**9.8%**	**$85,087,548**	**1,066**	**1.4%**	**$21,816,424**	**75,018**	**99.8%**	**$363,819,172**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$82,605,462	2,818	13.4%	$29,439,410	234	1.1%	$4,371,221	21,020	99.9%	$116,416,092
City of Durham	75,588	67,732	89.6%	$399,885,839	6,071	8%	$128,990,087	1,667	2.2%	$37,609,907	75,470	99.8%	$566,485,833
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$482,491,301**	**8,889**	**9.20%**	**$158,429,497**	**1,901**	**1.97%**	**$41,981,128**	**96,490**	**99.86%**	**$682,901,925**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$100,677,530	2,657	10.8%	$11,431,191	246	1%	$6,547,506	24,527	100%	$118,656,228
Town of Carrboro	5,782	5,464	94.5%	$51,932,481	261	4.5%	$6,251,671	46	0.8%	$2,954,468	5,771	99.8%	$61,138,620
Town of Chapel Hill	15,108	13,922	92.1%	$156,317,237	617	4.1%	$26,750,005	528	3.5%	$28,013,943	15,067	99.7%	$211,081,185
Town of Hillsborough	3,883	3,408	87.8%	$18,467,270	358	9.2%	$5,493,604	111	2.9%	$2,463,959	3,877	99.8%	$26,424,833
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$327,394,518**	**3,893**	**7.90%**	**$49,926,471**	**931**	**1.89%**	**$39,979,876**	**49,242**	**99.87%**	**$417,300,866**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$77,634,827	2,613	14.8%	$4,888,642	156	0.9%	$5,169,015	17,662	99.7%	$87,692,484
City of Roxboro	6,617	5,754	87%	$32,040,587	710	10.7%	$13,113,608	144	2.2%	$5,186,820	6,608	99.9%	$50,341,015
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$109,675,414**	**3,323**	**13.7%**	**$18,002,250**	**300**	**1.2%**	**$10,355,835**	**24,270**	**99.7%**	**$138,033,499**
Total	**245,410**	**217,361**	**88.6%**	**$1,176,476,432**	**23,461**	**9.6%**	**$311,445,766**	**4,198**	**1.7%**	**$114,133,263**	**245,020**	**99.8%**	**$1,602,055,462**

Source: NCEM Risk Management Tool

Environment

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

Consequence Analysis

Table 4.64 summarizes the potential negative consequences of hurricanes and tropical storms.

Table 4.64 – Consequence Analysis – Hurricane and Tropical Storm

Category	Consequences
Public	Impacts include injury or death, loss of property, outbreak of diseases, mental trauma and loss of livelihoods. Power outages and flooding are likely to displace people from their homes. Water can become polluted such that if consumed, diseases and infection can be easily spread. Residential, commercial, and public buildings, as well as critical infrastructure such as transportation, water, energy, and communication systems may be damaged or destroyed, resulting in cascading impacts on the public.
Responders	Localized impact expected to limit damage to personnel in the inundation area at the time of the incident.
Continuity of Operations (including Continued Delivery of Services)	Damage to facilities/personnel from flooding or wind may require temporary relocation of some operations. Operations may be interrupted by power outages. Disruption of roads and/or utilities may postpone delivery of some services. Regulatory waivers may be needed locally. Fulfillment of some contracts may be difficult. Impact may reduce deliveries.
Property, Facilities and Infrastructure	Structural damage to buildings may occur; loss of glass windows and doors by high winds and debris; loss of roof coverings, partial wall collapses, and other damages requiring significant repairs are possible in a major (category 3 to 5) hurricane.
Environment	Hurricanes can devastate wooded ecosystems and remove all the foliation from forest canopies, and they can change habitats so drastically that the indigenous animal populations suffer as a result. Specific foods can be taken away as high winds will often strip fruits, seeds and berries from bushes and trees. Secondary impacts may occur; for example, high winds and debris may result in damage to an above-ground fuel tank, resulting in a significant chemical spill.
Economic Condition of the Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damages. Intangible impacts also likely, including business interruption and additional living expenses.
Public Confidence in the Jurisdiction's Governance	Likely to impact public confidence due to possibility of major event requiring substantial response and long-term recovery effort.

Hazard Summary by Jurisdiction

The following table summarizes hurricane and tropical storm hazard risk by jurisdiction. Most aspects of hurricane risk do not vary substantially by jurisdiction; however, impacts may be greater in more highly developed areas with greater amounts of impervious surface and higher exposure in terms of both property and population density. Additionally, mobile home units are more vulnerable to wind damage. Mobile home units comprise over 10 percent of the occupied housing in unincorporated Alamance County, unincorporated Orange County, unincorporated Person County, Green Level, Haw River, Ossipee, and Roxboro; therefore, these jurisdictions may face more severe impacts from wind.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	3	4	4	1	2	3.2	H
Burlington	3	3	4	1	2	2.9	H
Graham	3	3	4	1	2	2.9	H
Mebane	3	3	4	1	2	2.9	H
Elon	3	3	4	1	2	2.9	H
Green Level	3	4	4	1	2	3.2	H
Haw River	3	4	4	1	2	3.2	H
Ossipee	3	4	4	1	2	3.2	H
Swepsonville	3	3	4	1	2	2.9	H
Alamance	3	3	4	1	2	2.9	H
Durham County	3	3	4	1	2	2.9	H
Durham	3	3	4	1	2	2.9	H
Orange County	3	4	4	1	2	3.2	H
Carrboro	3	3	4	1	2	2.9	H
Chapel Hill	3	3	4	1	2	2.9	H
Hillsborough	3	3	4	1	2	2.9	H
Person County	3	4	4	1	2	3.2	H
Roxboro	3	4	4	1	2	3.2	H

4.5.7 Landslide

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Landslide	Unlikely	Minor	Negligible	6 to 12 hours	Less than 6 hrs	1.2

Hazard Background

A landslide is the downhill movement of masses of soil and rock, driven by gravity. Landslides occur when susceptible rock, earth, or debris moves down a slope under the force of gravity and water. They can be triggered by natural changes, such as heavy rains, snow melt, fires, and earthquakes; and human-caused changes, such as slope or drainage modifications. Landslides may be very small or very large and can move at slow to very high speeds.

There are several types of landslides: rock falls, rock topple, slides, and flows. Rock falls are rapid movements of bedrock, which result in bouncing or rolling. A topple is a section or block of rock that rotates or tilts before falling to the slope below. Slides are movements of soil or rock along a distinct surface of rupture, which separates the slide material from the more stable underlying material. Mudflows, sometimes referred to as mudslides, mudflows, lahars or debris avalanches, are fast-moving rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as heavy rainfall or rapid snowmelt, changing the soil into a flowing river of mud or "slurry." Slurry can flow rapidly down slopes or through channels and can strike with little or no warning at avalanche speeds. Slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way. As the flows reach flatter ground, the mudflow spreads over a broad area where it can accumulate in thick deposits.

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompany these events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly.

Areas that are generally prone to landslide hazards include previous landslide areas, the bases of steep slopes, the bases of drainage channels, and developed hillsides where leach-field septic systems are used. Areas that are typically considered safe from landslides include areas that have not moved in the past, relatively flat-lying areas away from sudden changes in slope, and areas at the top or along ridges set back from the tops of slopes.

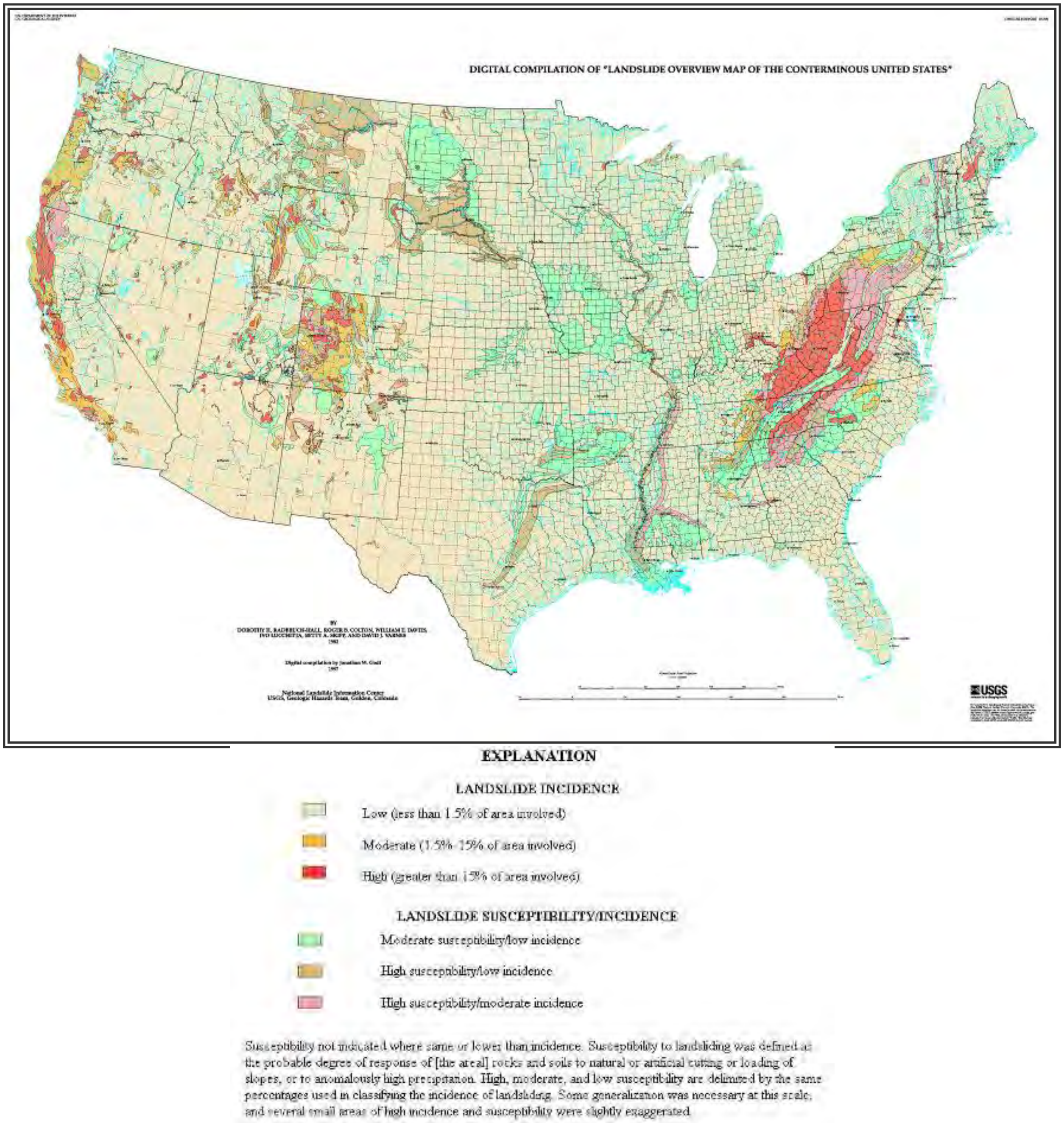
Warning Time: 3 – 6 to 12 hours

Duration: 1 – Less than 6 hours

Location

The U.S. Geological Survey (USGS) has produced landslide susceptibility and incidence mapping of the U.S., as shown in Figure 4.30. The USGS determines susceptibility based on the probable degree of response to cutting or loading of slopes or to anomalously high precipitation. Incidence is measured by the rate of past occurrences. According to the USGS definition and mapping, most of the region faces moderate susceptibility with low to moderate incidence of landslide.

Figure 4.30 – Landslide Incidence and Susceptibility



Source: USGS

Extent

Landslide extent can be defined by susceptibility and incidence, which are defined and depicted in Figure 4.30. Event magnitude is also dependent on topography; landslide risk is higher in areas with steeper slopes. Given the gentle topography of most of the region, the magnitude of any landslides in the planning area would be minor.

Impact: 1 – Minor

Spatial Extent: 1 – Negligible

Historical Occurrences

According to the region's previous plan, there are no records of historical occurrences of significant landslides in the planning area. The North Carolina Geologic Survey does not have any record of past landslide events in the planning area.

The HMPC noted a landslide that occurred in Chapel Hill on September 17, 2018 during Hurricane Florence when a landslide occurred on an embankment off of East Franklin Street, spilling significant debris onto the Bolin Creek Trail.

Probability of Future Occurrence

Given the moderate susceptibility rating and lack of historical occurrences, the probability of a significant landslide event is unlikely. It is possible, that a minor event may occur in the future, but it would be unlikely to produce significant damages.

Probability: 1 – Unlikely

Climate Change

Per the Fourth National Climate Assessment, frequency and intensity of heavy precipitation events is expected to increase across the country. Additionally, increases in precipitation totals are expected in the Southeast. Increased flooding may also result from more intense tropical cyclone; researchers have noted the occurrence of more intense storms bringing greater rainfall totals, a trend that is expected to continue as ocean and air temperatures rise. More rainfall falling in more intense incidents could contribute to an increase in landslide events.

Vulnerability Assessment

People

People are unlikely to sustain serious physical harm as a result of landslides in the Eno-Haw Region. Impacts would be relatively minor and highly localized. An individual using an impacted structure or infrastructure at the time of a landslide event may sustain minor injuries.

Property

Landslides in the Piedmont are infrequent and occur in small, highly localized instances relative to the general area of risk. Additionally, these events are generally small scale in terms of the magnitude of impacts. As a result, it is difficult to estimate the property at risk to landslide. On average, a landslide event in the planning area may cause minor to moderate property damage to one or more buildings or cause localized damage to infrastructure. A landslide event may also result in the need for debris removal.

Environment

Because landslides are essentially a mass movement of sediment, they may result in changes to terrain, damage to trees in the slide area, changes to drainage patterns, and increases in sediment loads in nearby waterways. Landslides in the Eno-Haw Region are unlikely to cause any more severe impacts.

Consequence Analysis

Table 4.65 summarizes the potential negative consequences of landslide.

Table 4.65 – Consequence Analysis - Landslide

Category	Consequences
Public	Any impacts to the public are expected to be minor. Individuals may sustain injuries if they are in an affected structure or using affected infrastructure when the event occurs.
Responders	Impacts to responders are unlikely. Personnel responsible for debris cleanup or roadway closures may face increased risk.
Continuity of Operations (including Continued Delivery of Services)	Landslide is unlikely to affect continuity of operations.
Property, Facilities and Infrastructure	Buildings and infrastructure may incur minor damages as a result of landslide; however, vulnerability in the Region is low.
Environment	Environmental impacts are expected to be minimal. Landslide may cause terrain and drainage changes and may temporarily increase sediment loads in nearby waterways.
Economic Condition of the Jurisdiction	Economic impacts are not expected.
Public Confidence in the Jurisdiction's Governance	Any landslide occurring in the Region is unlikely to be severe and would not be expected to affect public confidence.

Hazard Summary by Jurisdiction

The following table summarizes landslide hazard risk by jurisdiction. Given the lack of historical records and the limited data on susceptibility, risk was considered uniform across the planning area.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	1	1	1	3	1	1.2	L
Burlington	1	1	1	3	1	1.2	L
Graham	1	1	1	3	1	1.2	L
Mebane	1	1	1	3	1	1.2	L
Elon	1	1	1	3	1	1.2	L
Green Level	1	1	1	3	1	1.2	L
Haw River	1	1	1	3	1	1.2	L
Ossipee	1	1	1	3	1	1.2	L
Swepsonville	1	1	1	3	1	1.2	L
Alamance	1	1	1	3	1	1.2	L
Durham County	1	1	1	3	1	1.2	L
Durham	1	1	1	3	1	1.2	L
Orange County	1	1	1	3	1	1.2	L
Carrboro	1	1	1	3	1	1.2	L
Chapel Hill	1	1	1	3	1	1.2	L
Hillsborough	1	1	1	3	1	1.2	L
Person County	1	1	1	3	1	1.2	L
Roxboro	1	1	1	3	1	1.2	L

4.5.8 Severe Weather (Thunderstorm Winds, Lightning & Hail)

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Severe Weather: Hail	Highly Likely	Minor	Small	Less than 6 hrs	Less than 6 hours	2.4
Severe Weather: Lightning	Highly Likely	Minor	Negligible	Less than 6 hrs	Less than 6 hours	2.2
Severe Weather: Thunderstorm Winds	Highly Likely	Limited	Large	Less than 6 hrs	Less than 6 hours	3.1

Hazard Background

Thunderstorm Winds

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

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

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

Warning Time: 4 – Less than six hours

Duration: 1 – Less than six hours

Lightning

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

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

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

Warning Time: 4 – Less than six hours

Duration: 1 – Less than six hours

Hail

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

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

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

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

Warning Time: 4 – Less than six hours

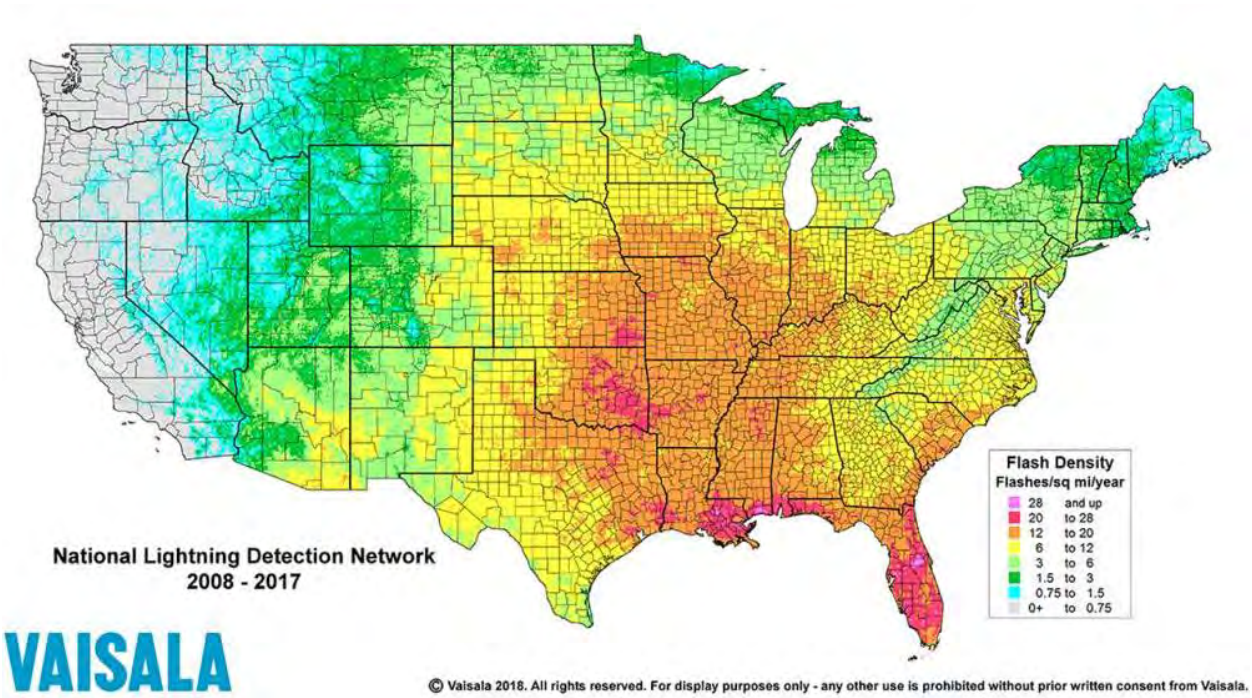
Duration: 1 – Less than six hours

Location

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

According to the Vaisala flash density map, shown in Figure 4.31, the Eno-Haw Region is located in an area that experiences 3 to 12 lightning flashes per square mile per year. It should be noted that future lightning occurrences may exceed these figures.

Figure 4.31 – Lightning Flash Density (2008-2017)



Source: Vaisala

Extent

Thunderstorm Winds

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

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

The strongest recorded thunderstorm wind event in the Eno-Haw Region occurred on May 25, 2000 with a measured gust of 70 mph on the western side of the city of Burlington and gusts of 60 mph elsewhere across the region. The event caused two injuries.

Impact: 2 – Limited

Spatial Extent: 4 – Large

Lightning

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

Table 4.66 – Lightning Activity Level Scale

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

Source: National Weather Service

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

Impact: 1 – Minor

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

Spatial Extent: 1 – Negligible

Hail

The National Weather Service classifies hail by diameter size, and corresponding everyday objects to help relay scope and severity to the population. Table 4.67 indicates the hailstone measurements utilized by the National Weather Service.

Table 4.67 – Hailstone Measurement Comparison Chart

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

Average Diameter	Corresponding Household Object
3.00 inch	Teacup
4.00 inch	Grapefruit
4.5 inch	Softball

Source: National Weather Service

The Tornado and Storm Research Organization (TORRO) has further described hail sizes by their typical damage impacts. Table 4.68 describes typical intensity and damage impacts of the various sizes of hail.

Table 4.68 – Tornado and Storm Research Organization Hailstorm Intensity Scale

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

Source: Tornado and Storm Research Organization (TORRO), Department of Geography, Oxford Brookes University
Notes: In addition to hail diameter, factors including number and density of hailstones, hail fall speed and surface wind speeds affect severity.

The average hailstone size recorded between 1999 and 2018 in the Haw-Eno Region was a little over 1" in diameter; the largest hailstone recorded was 2.5", recorded on June 23, 2016. Very little damage was reported due to hail in the region. The worst instance occurred on July 1, 2012 in Person County. The hail damaged 300 acres of tobacco causing $2,000,000 worth of damage.

Impact: 1 – Minor

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

Spatial Extent: 2 – Small

Historical Occurrences

Thunderstorm Winds

Between January 1, 1999 and December 31, 2018, the NCEI recorded 493 separate incidents of thunderstorm winds, occurring on 214 separate days. These events caused $2,279,250 in recorded property damage, 5 injuries and 2 fatalities. The recorded gusts averaged 50.4 mph, with the highest gusts recorded at 70 mph. Gusts of 70 mph were recorded three times in the region, twice during a storm on May 25, 2000. Of these events, 139 caused reported property damage. Wind gusts with property damage recorded averaged $4,600 in damage, with three gusts causing over a reported $250,000 in damage each (at Elon College on July 27, 2012, in Huckleberry Spring on February 24, 2016 and in Quail Roost on June 13, 2013). These incidents are recorded below:

Table 4.69 – Recorded Thunderstorm Winds with Property Damages in Eno-Haw Region, 1999-2018

Location	Date	Time	Wind Speed (mph)	Fatalities	Injuries	Property Damage
Roxboro	6/2/2006	1458	50	0	0	$65,000
Roxboro	4/8/2010	2000	50	0	0	$1,000
Oak Grove	5/22/2010	1710	50	0	0	$4,000
Hillsborough	5/28/2010	2106	50	0	0	$50,000
Few	5/28/2010	2100	50	0	0	$10,000
Triple Springs	6/13/2010	1458	50	0	0	$2,000
Brooksdale	6/13/2010	1501	50	0	0	$2,000
Durham	6/23/2010	1255	50	0	0	$15,000
Cheeks Crossroads	7/13/2010	1935	50	0	0	$3,000
Elon College	7/17/2010	1010	50	0	0	$20,000
Snow Camp	7/17/2010	1315	50	0	1	$2,000
Hyco	7/25/2010	1903	50	0	0	$10,000
Swepsonville	8/5/2010	1415	50	0	0	$30,000
Mebane	8/5/2010	1700	50	0	0	$15,000
Roseville	8/5/2010	1620	50	0	0	$10,000
Snow Camp	11/16/2010	2245	50	0	0	$10,000
Burlington Airport	4/5/2011	203	52	0	0	$75,000
Durham	4/5/2011	236	50	0	0	$25,000
Occoneechee	4/27/2011	1210	50	0	0	$5,000
Timberlake	5/13/2011	1825	50	0	0	$500
Carr	6/18/2011	1705	50	0	0	$500
Chapel Hill Williams Airport	5/9/2012	1457	50	0	0	$2,500
Mebane	6/1/2012	1400	50	0	0	$110,000
Surf	6/1/2012	1505	50	0	0	$20,000
Glenn	6/1/2012	1544	50	0	0	$10,000
West Durham	6/29/2012	2202	50	0	0	$10,000
Surf	6/29/2012	2125	50	0	0	$5,000
Saxapahaw	6/29/2012	2155	50	0	0	$4,000
Cavel	7/1/2012	1305	50	0	0	$3,000
Mc Gehees Mill	7/1/2012	1258	50	0	0	$2,000
Schley	7/5/2012	1255	50	0	0	$5,000
Schley	7/5/2012	1257	50	0	0	$5,000
Hyco	7/19/2012	1515	50	0	0	$1,000
Union Ridge	7/21/2012	1730	50	0	0	$1,000
Bahama	7/23/2012	1714	50	0	0	$3,000
Graham	7/23/2012	1618	50	0	0	$2,000
Chapel Hill	7/24/2012	1426	50	0	0	$20,000
Chapel Hill	7/24/2012	1426	50	0	0	$10,000
Snow Camp	7/24/2012	1358	50	0	0	$5,000
Chapel Hill	7/24/2012	1425	50	0	0	$4,000

Location	Date	Time	Wind Speed (mph)	Fatalities	Injuries	Property Damage
Snow Camp	7/24/2012	1345	50	0	0	$2,000
Snow Camp	7/24/2012	1350	50	0	0	$2,000
Teer	7/24/2012	1410	50	0	0	$2,000
Elon College	7/27/2012	1635	50	0	0	$313,000
Triple Springs	9/2/2012	1403	50	0	0	$750
West Durham	9/8/2012	1645	50	0	0	$750
Hillsborough	1/30/2013	2218	50	0	0	$1,500
Hurdle Mills	1/30/2013	2245	50	0	0	$1,000
Orange Factory	4/19/2013	1740	50	0	0	$1,500
Quail Roost	6/13/2013	1610	61	0	0	$250,000
Snow Camp	6/13/2013	1554	50	0	0	$200,000
Ceffo	6/13/2013	1548	50	0	0	$10,000
Chapel Hill	6/13/2013	1615	61	1	0	$3,000
Helena	6/26/2013	1652	50	0	0	$1,000
Quail Roost	6/28/2013	1645	50	0	0	$2,500
Chapel Hill	6/30/2013	1422	50	0	0	$5,000
Kimesville	7/2/2013	950	50	0	0	$10,000
Altamahaw	7/28/2013	2205	50	0	0	$1,000
Hope Valley	1/11/2014	1350	50	0	0	$5,000
Chapel Hill Williams Airport	1/11/2014	1340	50	0	0	$1,000
Hope Valley	3/12/2014	1730	50	1	0	$8,000
Mt Tirzah	5/15/2014	1752	50	0	0	$1,000
Calvander	5/27/2014	1457	50	0	0	$1,000
Durham	6/11/2014	1406	50	0	0	$25,000
Hope Valley	6/11/2014	1644	50	0	0	$10,000
Snow Camp	6/11/2014	1645	50	0	0	$2,000
Graham	6/11/2014	1715	50	0	0	$2,000
Schley	6/11/2014	1725	50	0	0	$2,000
West Hillsboro	6/19/2014	1556	50	0	0	$10,000
Durham	6/19/2014	1615	50	0	0	$8,000
Occoneechee	7/15/2014	1500	50	0	0	$5,000
Huckleberry Spring	8/12/2014	1710	50	0	0	$1,000
Ceffo	6/17/2015	1854	50	0	0	$25,000
Roxboro	6/20/2015	1824	50	0	0	$2,500
Chapel Hill	6/26/2015	2223	50	0	0	$2,000
Carr	6/30/2015	1749	50	0	0	$10,000
Kimesville	7/8/2015	1851	50	0	0	$25,000
Union Ridge	7/13/2015	1946	50	0	0	$10,000
Chapel Hill Williams Airport	7/21/2015	1750	50	0	0	$5,000
Oak Grove	7/23/2015	925	50	0	0	$1,000
Hurdle Mills Airport	8/11/2015	1633	50	0	0	$1,250
Sutphin	9/10/2015	1618	50	0	0	$5,000
Huckleberry Spring	2/24/2016	1600	70	0	0	$250,000
Chapel Hill	2/24/2016	1550	50	0	0	$3,000
Hyco Jct	4/28/2016	1730	50	0	0	$1,000
Altamahaw	5/12/2016	1826	50	0	0	$5,000
Woodsdale	6/5/2016	1741	50	0	0	$10,000

Location	Date	Time	Wind Speed (mph)	Fatalities	Injuries	Property Damage
Bethel Hill	6/5/2016	1750	50	0	0	$7,500
Gentrys Store	6/5/2016	1747	50	0	0	$2,500
Triple Springs	6/5/2016	1751	50	0	0	$2,500
Cedar Grove	6/29/2016	1739	50	0	0	$2,500
Hillsborough	7/8/2016	1953	50	0	0	$5,000
Few	7/15/2016	1550	50	0	1	$150,000
Burlington Airport	7/15/2016	1740	50	0	0	$10,000
Buckhorn	7/31/2016	1912	50	0	0	$10,000
Just Xrds	7/31/2016	1740	50	0	0	$5,000
Longs Store	9/1/2016	1247	50	0	0	$10,000
Longs Store	2/25/2017	1500	50	0	0	$1,000
Hope Valley	5/5/2017	335	50	0	0	$10,000
Mt Tirzah	5/5/2017	340	50	0	0	$2,500
Hopedale	5/5/2017	300	50	0	0	$1,000
West Durham	5/11/2017	2012	50	0	0	$100,000
Fairntosh	5/19/2017	1642	50	0	0	$3,000
Schley	5/19/2017	1624	50	0	0	$2,000
Occoneechee	5/25/2017	1158	50	0	0	$2,000
Mangum Store	6/16/2017	1918	50	0	0	$750
Cedar Grove	6/19/2017	2035	50	0	0	$4,000
Concord	7/13/2017	1703	50	0	0	$4,000
Elon College	7/13/2017	1650	50	0	0	$2,000
Cedar Grove	7/13/2017	1701	50	0	0	$1,000
Chapel Hill	7/23/2017	1645	50	0	0	$3,000
Burlington	4/15/2018	1646	50	0	0	$5,000
Hurdle Mills	4/15/2018	1725	50	0	0	$2,000
Mc Dade	4/15/2018	1715	50	0	0	$1,000
Chapel Hill	4/15/2018	1725	50	0	0	$1,000
Triple Springs	5/6/2018	1835	50	0	0	$2,500
Blackwood	5/21/2018	1435	50	0	0	$2,000
Union Ridge	5/21/2018	1608	50	0	0	$1,000
Calvander	6/10/2018	2240	50	0	0	$25,000
West Durham	6/10/2018	2246	50	0	0	$1,000
Genlee	6/10/2018	2305	50	0	0	$1,000
Roseville	6/21/2018	2229	50	0	0	$4,000
Gorman	6/24/2018	1925	50	0	0	$4,000
Calvander	7/4/2018	1820	50	0	0	$2,500
Chapel Hill	7/4/2018	1821	50	0	0	$1,500
Rougemont	7/6/2018	1525	50	0	0	$10,000
Rougemont	7/6/2018	1540	50	0	0	$5,000
Cedar Grove	7/6/2018	1450	50	0	0	$2,500
Hillsborough	7/6/2018	1500	50	0	0	$1,500
Longs Store	7/11/2018	1625	50	0	0	$2,500
Mt Tirzah	7/22/2018	2042	50	0	0	$10,000
Ceffo	7/22/2018	2056	50	0	0	$10,000
Durham	7/22/2018	2005	50	0	0	$5,000
Hope Valley	8/2/2018	1438	50	0	0	$1,000
Alamance	8/7/2018	1840	50	0	0	$10,000
Occoneechee	8/7/2018	1900	50	0	0	$5,000

Location	Date	Time	Wind Speed (mph)	Fatalities	Injuries	Property Damage
Etland	8/8/2018	1609	50	0	0	$250
Swepsonville	8/8/2018	1609	50	0	0	$250
Hope Valley	8/8/2018	1645	50	0	0	$ 250
Total				0	0	**$2,279,250**

Source: NCEI

During this time period, 17 events also caused crop damage totaling $189,000. These incidents are recorded below:

Table 4.70 – Recorded Wind Events with Crop Damages in the Eno-Haw Region, 1999-2018

Location	Date	Time	Wind Speed (mph)	Fatalities	Injuries	Crop Damage
Altamahaw	7/13/2005	1815	50	0	0	$150,000
Burlington Airport	7/15/2016	1740	50	0	0	$10,000
Durham (Zone)	4/16/2007	854	42	0	0	$5,000
Person (Zone)	4/16/2007	904	37	0	0	$5,000
Orange (Zone)	4/16/2007	930	46	0	0	$5,000
Alamance (Zone)	4/16/2007	1052	47	0	0	$5,000
Longs Store	2/25/2017	1500	50	0	0	$2,000
Hillsborough	5/11/2017	1955	50	0	0	$2,000
Person (Zone)	11/22/2006	800	35	0	0	$1,000
Durham (Zone)	11/22/2006	1000	35	0	0	$1,000
Orange (Zone)	11/22/2006	1000	32	0	0	$1,000
Alamance (Zone)	11/22/2006	1000	30	0	0	$1,000
Allensville	6/23/2006	1930	50	0	0	$1,000
Total				**2**	**2**	**$189,000**

Source: NCEI

In addition to recorded thunderstorm wind events, NCEI reports 67 high wind and strong wind events during this same period that caused $1,293,150 in property damage. Of all 560 wind events during this period, there were eight incidents that directly caused deaths or injuries. These incidents are recorded below:

Table 4.71 – Recorded Wind Events with Injuries and/or Fatalities, 1999-2018

Location	Event Type	Date	Wind Speed (mph)	Fatalities	Injuries	Property Damage
Orange County	Strong Wind	12/9/2009	40	0	2	$30,000
Chapel Hill	Thunderstorm Wind	5/25/2000	60	0	2	$0
Hillborough	Thunderstorm Wind	6/1/2002	50	0	1	$0
Snow Camp	Thunderstorm Wind	7/17/2010	50	0	1	$2,000
Chapel Hill	Thunderstorm Wind	6/13/2013	61	1	0	$3,000
Hope Valley	Thunderstorm Wind	3/12/2014	50	1	0	$8,000
Durham County	Strong Wind	4/9/2016	37	1	1	$30,000
Few	Thunderstorm Wind	7/15/2006	50	0	1	$150,000
			Total	**3**	**8**	**$223,000**

Source: NCEI

Lightning

According to NCEI data, there were 25 lightning strikes reported between 1999 and 2018. Of these, 18 strikes caused recorded property damage totaling over $3 million and 4 strikes directly caused 4 fatalities and 5 injuries. No injuries or crop damage was recorded by these strikes. It should be noted that lightning events recorded by the NCEI are only those that are reported; it is certain that additional lightning incidents have occurred in the Eno-Haw Region. Table 4.72 details NCEI-recorded lightning strikes from 1999 through 2018.

Table 4.72 – Recorded Lightning Strikes in the Eno-Haw Region, 1999-2018

Location	Date	Time	Fatalities	Injuries	Property Damage
Durham	3/21/1999	1400	0	0	$20,000
Carrboro	8/14/1999	1500	0	1	$0
Roxboro	4/8/2000	1530	0	0	$110,000
Chapel Hill	7/2/2002	1515	0	0	$880,000
Burlington	7/4/2002	1815	0	3	$0
Mebane	7/4/2002	1827	0	0	$20,000
Snow Camp	7/22/2003	1830	0	0	$100,000
Cedar Grove	8/22/2003	1600	1	0	$0
Hillsborough	6/11/2006	435	1	0	$0
Roxboro	7/13/2006	1900	0	0	$100,000
Durham	3/27/2007	2200	0	0	$10,000
Chapel Hill	12/11/2008	1205	0	0	$1,500,000
Huckleberry Spring	5/28/2010	2100	0	0	$20,000
Mebane	6/2/2010	1645	0	0	$25,000
Graham	6/15/2010	1845	1	1	$0
Fairntosh	8/5/2010	1740	0	0	$3,000
Graham	8/18/2010	0	0	0	$7,000
Gorman	6/10/2011	2209	1	0	$0
Union Ridge	9/6/2011	1230	0	0	$75,000
Few	3/20/2012	2233	0	0	$100,000
Cedar Grove	7/5/2012	1325	0	0	$5,000
Hesters Store	6/13/2013	1605	0	0	$10,000
Few	7/5/2015	2000	0	0	$30,000
Occoneechee	7/5/2017	2035	0	0	$10,000
Genlee	7/5/2018	1730	0	1	$0
		Total	**4**	**5**	**$3,025,000**

Source: NCEI

The following are a selection of narrative descriptions recorded in NCEI for lightning events that occurred in Eno-Haw Region:

June 11, 2006 – Tree fell on Interstate 85 near mile marker 168 when lightning struck a tree. One fatality when a motorcyclist struck the down tree.

December 11, 2008 – Lightning struck a home in Chapel Hill and caught fire. The house burned to the ground when the lightning got into the gas lines of the home.

May 28, 2010 – A lightning strike caused an electrical failure at a pump station near Durham, North Carolina. The electrical failure allowed 18,000 gallons of sewage to spill into the Eno River.

June 15, 2010 – A 19 year old male was struck by lightning and killed while taking shelter under a tree. It was not raining at the time.

June 10, 2011 – A 45 year old male died when he was struck by lightning while feeding his livestock.

Eighteen of the 25 incidents recorded by the NCEI included property damage, which was mostly recorded as fire damage ignited by lightning. The highest rate of property damage recorded for a single incident was $1,500,000.

Hail

NCEI records 229 separate hail incidents across 131 days between January 1, 1999 and December 31, 2018 in the Eno-Haw Region. Of these, three events were reported to have caused property damage, two caused crop damage and none caused death or injury. The largest diameter hail recorded in the Eno-Haw Region was in Person County on June 23, 2016; the average hail size in all storms was a little over one inch in diameter.

Table 4.73 – Summary of Hail Occurrences by County

Location	Number of Occurrences	Average Hail Diameter
Alamance	57	1.02”
Durham	70	1.03”
Orange	41	1.04”
Person	61	1.10”

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

April 17, 2000 – Golfball sized hail reported at intersection of Highway 98 and Miami Blvd.

March 28, 2007 - A back-door cold front combined with moderate to strong instability from afternoon heating...produced severe storms across northern portions of the piedmont. Minor flooding from heavy rainfall and hail blocking street drains.

July 27, 2007 – Pea size hail resulted in the total loss of 6 acres of tobacco crop.

July 1, 2012 – Large hail to the size of golf balls completely destroyed 300 acres of tobacco, with other surrounding areas experiencing a 30 to 50 percent loss. An upper level disturbance moved across central North Carolina during the late afternoon into the evening and interacted with a moist and unstable atmosphere to produce scattered showers and thunderstorms. Some of the thunderstorms became severe and produced damaging winds.

April 28, 2016 – Quarter sized to golf ball sized hail fell along a one mile swath along highway 54 near the intersection of Orange Grove Road in Teer. The hail covered the road and was approximately half an inch deep, causing the road to be closed for a short period of time.

June 23, 2016 – Golf ball to tennis ball size hail fell along a swath from the Virginia state line to Bethel Hill.

Probability of Future Occurrence

Based on historical occurrences recorded by NCEI of 493 wind events over the 20-year period from 1999 through 2018, the Eno-Haw Region averages nearly 25 thunderstorm wind events per year. Over this same period, 25 lightning events were reported as having caused death, injury, or property damage, which equates to an average of 1.25 damaging lightning strikes per year.

The average hail storm in the Eno-Haw Region occurs in late afternoon and has a hail stone with a diameter of an inch. Over the 20-year period from 1999 through 2018, the Eno-Haw Region experienced 229 reported hail incidents; this averages over eleven reported incidents per year somewhere in the planning area, or a 100% chance that the region will experience a hail incident each year.

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

Probability: 4 – Highly Likely

Climate Change

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

Vulnerability Assessment

Methodologies and Assumptions

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

People

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

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

The availability of sheltered locations such as basements, buildings constructed using hail-resistant materials and methods, and public storm shelters, all reduce the exposure of the population. Individuals who work outdoors may face increased risk. Residents living in mobile homes are also more vulnerable to hail events due to the lack of shelter locations and the vulnerability of the housing unit to damages. According to the 2017 American Community Survey (ACS), 19,000 occupied housing units (7.5%) in the Eno-Haw Region are classified as "mobile homes or other types of housing." Based on an estimated average of 2.4 persons per household from the 2017 ACS, there are approximately 45,000 people in the Region living in mobile homes. See Table 4.57 in Section 4.5.6 for details on the number of mobile home units in each jurisdiction.

Since 1999, the NCEI records four fatalities and five injuries attributed to lightning in the Eno-Haw Region. NCEI records three fatalities and eight injuries attributed to wind events in the Eno-Haw Region. There are no injuries or fatalities attributed to hail.

Property

Property damage caused by lightning usually occurs in one of two ways – either by direct damages through fires ignited by lightning, or by secondary impacts due to power loss. According to data collected on lightning strikes in Eno-Haw Region, the vast majority of recorded property damage was due to structure fires.

NCEI records lightning impacts over 20 years (1999-2018), with $3,025,000 in property damage recorded (no incidents were recorded in 2001, 2004, 2005, 2009, 2014, or 2016). Historically, this has resulted in $216,000 in property impacts annually in the Eno-Haw Region. The average impact from lightning per incident in the Eno-Haw Region is $168,000.

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

During a 20-year span between January 1, 1999 and December 31, 2018 in the Eno-Haw Region, NCEI reported $60,500 in property damage as a direct result of hail. This averages to $3,025 per year in reported damages due to hail, though it should be noted that $60,000 in recorded damage was all due to one storm.

According to a National Insurance Crime Bureau (NICB) study of insurance claims from the Insurance Services Office (ISO) ClaimSearch database, between 2014 and 2016, North Carolina saw 45,274 separate hail damage claims.

It should be noted that property damage due to hail is usually insured loss, with damages covered under most major comprehensive insurance plans. Because of this, hail losses are notoriously underreported by the NCEI. It is difficult to find an accurate repository of hail damages in the Eno-Haw Region, thus the NCEI is still used to form a baseline.

When strong enough, wind events can cause significant direct damage to buildings and infrastructure. NCEM's IRISK database estimates damages from increasing magnitudes of wind events, detailed in Table 4.74 through Table 4.77. Note that these tables sum the total estimated damage should every exposed property in each jurisdiction be impacted by an event of the given magnitude. Therefore, these tables are not an approximation of the total damages that would occur from an event of each magnitude because a thunderstorm wind event would not uniformly impact the entire Region. These tables should only be used to understand potential damages relative to storms of varying degrees of severity.

Table 4.74 – Estimated Buildings Impacted by 50-Year Thunderstorm Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.40%	$9,113,652	3,425	11.60%	$1,085,154	283	1%	$297,999	29,619	99.90%	$10,496,804
City of Burlington	24,403	21,618	88.60%	$8,912,208	2,401	9.80%	$2,164,023	320	1.30%	$438,268	24,339	99.70%	$11,514,499
City of Graham	7,269	6,575	90.50%	$2,351,862	530	7.30%	$309,603	155	2.10%	$172,340	7,260	99.90%	$2,833,806
City of Mebane	5,835	5,303	90.90%	$2,350,875	465	8%	$1,001,728	64	1.10%	$121,817	5,832	99.90%	$3,474,420
Town of Elon	2,760	2,437	88.30%	$1,219,936	147	5.30%	$288,850	174	6.30%	$153,287	2,758	99.90%	$1,662,072
Town of Green Level	1,177	1,057	89.80%	$313,206	109	9.30%	$40,743	10	0.80%	$5,621	1,176	99.90%	$359,570
Town of Haw River	2,352	2,139	90.90%	$707,757	168	7.10%	$53,849	31	1.30%	$27,653	2,338	99.40%	$789,258
Town of Ossipee	330	299	90.60%	$95,720	21	6.40%	$16,014	7	2.10%	$2,907	327	99.10%	$114,641
Town of Swepsonville	573	543	94.80%	$234,417	24	4.20%	$98,357	5	0.90%	$5,274	572	99.80%	$338,048
Village of Alamance	798	714	89.50%	$270,376	66	8.30%	$16,528	17	2.10%	$11,541	797	99.90%	$298,445
Subtotal Alamance	**75,147**	**66,596**	**88.60%**	**$25,570,009**	**7,356**	**9.80%**	**$5,074,849**	**1,066**	**1.40%**	**$1,236,707**	**75,018**	**99.80%**	**$31,881,563**
Durham County													
Unincorporated Durham County	21,038	17,968	85.40%	$8,260,081	2,818	13.40%	$2,151,962	234	1.10%	$297,186	21,020	99.90%	$10,709,230
City of Durham	75,588	67,732	89.60%	$34,842,622	6,071	8%	$8,383,949	1,667	2.20%	$2,475,611	75,470	99.80%	$45,702,182
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$43,102,703**	**8,889**	**9.20%**	**$10,535,911**	**1,901**	**1.97%**	**$2,772,797**	**96,490**	**99.86%**	**$56,411,412**
Orange County													
Unincorporated Orange County	24,533	21,624	88.10%	$10,956,321	2,657	10.80%	$1,201,269	246	1%	$697,859	24,527	100%	$12,855,449
Town of Carrboro	5,782	5,464	94.50%	$4,096,444	261	4.50%	$657,012	46	0.80%	$525,469	5,771	99.80%	$5,278,925
Town of Chapel Hill	15,108	13,922	92.10%	$13,789,411	617	4.10%	$1,621,761	528	3.50%	$2,013,121	15,067	99.70%	$17,424,293
Town of Hillsborough	3,883	3,408	87.80%	$1,670,389	358	9.20%	$303,111	111	2.90%	$239,835	3,877	99.80%	$2,213,335
Subtotal Orange	**49,306**	**44,418**	**89.20%**	**$30,512,565**	**3,893**	**9.60%**	**$3,783,153**	**931**	**1.20%**	**$3,476,284**	**49,242**	**99.90%**	**$37,772,002**
Person County													
Unincorporated Person County	17,714	14,893	84.10%	$7,263,867	2,613	14.80%	$477,046	156	0.90%	$395,114	17,662	99.70%	$8,136,027
City of Roxboro	6,617	5,754	87%	$2,750,934	710	10.70%	$807,474	144	2.20%	$335,974	6,608	99.90%	$3,894,381
Subtotal Person	**24,331**	**20,647**	**84.90%**	**$10,014,801**	**3,323**	**13.70%**	**$1,284,520**	**300**	**1.20%**	**$731,088**	**24,270**	**99.70%**	**$12,030,408**
Total	**245,410**	**217,361**	**88.60%**	**$109,200,078**	**23,461**	**9.60%**	**$20,678,433**	**4,198**	**1.70%**	**$8,216,876**	**245,020**	**99.80%**	**$138,095,385**

Source: NCEM Risk Management Tool

Table 4.75 – Estimated Buildings Impacted by 100-Year Thunderstorm Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.40%	$9,113,652	3,425	11.60%	$1,085,154	283	1%	$297,999	29,619	99.90%	$10,496,804
City of Burlington	24,403	21,618	88.60%	$8,912,208	2,401	9.80%	$2,164,023	320	1.30%	$438,268	24,339	99.70%	$11,514,499
City of Graham	7,269	6,575	90.50%	$2,351,862	530	7.30%	$309,603	155	2.10%	$172,340	7,260	99.90%	$2,833,806
City of Mebane	5,835	5,303	90.90%	$2,350,875	465	8%	$1,001,728	64	1.10%	$121,817	5,832	99.90%	$3,474,420
Town of Elon	2,760	2,437	88.30%	$1,219,936	147	5.30%	$288,850	174	6.30%	$153,287	2,758	99.90%	$1,662,072
Town of Green Level	1,177	1,057	89.80%	$313,206	109	9.30%	$40,743	10	0.80%	$5,621	1,176	99.90%	$359,570
Town of Haw River	2,352	2,139	90.90%	$707,757	168	7.10%	$53,849	31	1.30%	$27,653	2,338	99.40%	$789,258
Town of Ossipee	330	299	90.60%	$95,720	21	6.40%	$16,014	7	2.10%	$2,907	327	99.10%	$114,641
Town of Swepsonville	573	543	94.80%	$234,417	24	4.20%	$98,357	5	0.90%	$5,274	572	99.80%	$338,048
Village of Alamance	798	714	89.50%	$270,376	66	8.30%	$16,528	17	2.10%	$11,541	797	99.90%	$298,445
Subtotal Alamance	**75,147**	**66,596**	**88.60%**	**$25,570,009**	**7,356**	**9.80%**	**$5,074,849**	**1,066**	**1.40%**	**$1,236,707**	**75,018**	**99.80%**	**$31,881,563**
Durham County													
Unincorporated Durham County	21,038	17,968	85.40%	$8,260,081	2,818	13.40%	$2,151,962	234	1.10%	$297,186	21,020	99.90%	$10,709,230
City of Durham	75,588	67,732	89.60%	$34,842,622	6,071	8%	$8,383,949	1,667	2.20%	$2,475,611	75,470	99.80%	$45,702,182
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$43,102,703**	**8,889**	**9.20%**	**$10,535,911**	**1,901**	**1.97%**	**$2,772,797**	**96,490**	**99.86%**	**$56,411,412**
Orange County													
Unincorporated Orange County	24,533	21,624	88.10%	$10,956,321	2,657	10.80%	$1,201,269	246	1%	$697,859	24,527	100%	$12,855,449
Town of Carrboro	5,782	5,464	94.50%	$4,096,444	261	4.50%	$657,012	46	0.80%	$525,469	5,771	99.80%	$5,278,925
Town of Chapel Hill	15,108	13,922	92.10%	$13,789,411	617	4.10%	$1,621,761	528	3.50%	$2,013,121	15,067	99.70%	$17,424,293
Town of Hillsborough	3,883	3,408	87.80%	$1,670,389	358	9.20%	$303,111	111	2.90%	$239,835	3,877	99.80%	$2,213,335
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$30,512,565**	**3,893**	**7.90%**	**$3,783,153**	**931**	**1.89%**	**$3,476,284**	**49,242**	**99.87%**	**$37,772,002**
Person County													
Unincorporated Person County	17,714	14,893	84.10%	$7,263,867	2,613	14.80%	$477,046	156	0.90%	$395,114	17,662	99.70%	$8,136,027
City of Roxboro	6,617	5,754	87%	$2,750,934	710	10.70%	$807,474	144	2.20%	$335,974	6,608	99.90%	$3,894,381
Subtotal Person	**24,331**	**20,647**	**84.90%**	**$10,014,801**	**3,323**	**13.70%**	**$1,284,520**	**300**	**1.20%**	**$731,088**	**24,270**	**99.70%**	**$12,030,408**
Total	**245,410**	**217,361**	**88.60%**	**$109,200,078**	**23,461**	**9.60%**	**$20,678,433**	**4,198**	**1.70%**	**$8,216,876**	**245,020**	**99.80%**	**$138,095,385**

Source: NCEM Risk Management Tool

Table 4.76 – Estimated Buildings Impacted by 300-Year Thunderstorm Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$29,422,337	3,425	11.6%	$5,994,876	283	1%	$1,637,855	29,619	99.9%	$37,055,069
City of Burlington	24,403	21,618	88.6%	$25,020,142	2,401	9.8%	$10,721,802	320	1.3%	$2,384,927	24,339	99.7%	$38,126,871
City of Graham	7,269	6,575	90.5%	$8,234,848	530	7.3%	$2,200,394	155	2.1%	$1,140,007	7,260	99.9%	$11,575,249
City of Mebane	5,835	5,303	90.9%	$8,843,654	465	8%	$5,169,882	64	1.1%	$660,516	5,832	99.9%	$14,674,052
Town of Elon	2,760	2,437	88.3%	$2,852,773	147	5.3%	$1,002,673	174	6.3%	$558,103	2,758	99.9%	$4,413,549
Town of Green Level	1,177	1,057	89.8%	$1,044,769	109	9.3%	$210,188	10	0.8%	$40,438	1,176	99.9%	$1,295,394
Town of Haw River	2,352	2,139	90.9%	$2,728,522	168	7.1%	$350,117	31	1.3%	$153,101	2,338	99.4%	$3,231,741
Town of Ossipee	330	299	90.6%	$205,256	21	6.4%	$57,523	7	2.1%	$9,343	327	99.1%	$272,122
Town of Swepsonville	573	543	94.8%	$833,748	24	4.2%	$457,462	5	0.9%	$29,685	572	99.8%	$1,320,896
Village of Alamance	798	714	89.5%	$916,534	66	8.3%	$112,489	17	2.1%	$72,462	797	99.9%	$1,101,485
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$80,102,583**	**7,356**	**9.8%**	**$26,277,406**	**1,066**	**1.4%**	**$6,686,437**	**75,018**	**99.8%**	**$113,066,428**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$28,552,841	2,818	13.4%	$10,587,535	234	1.1%	$1,498,459	21,020	99.9%	$40,638,835
City of Durham	75,588	67,732	89.6%	$134,627,064	6,071	8%	$43,654,889	1,667	2.2%	$13,158,313	75,470	99.8%	$191,440,266
Subtotal Durham	**96,626**	**85,700**	**88.7%**	**$163,179,905**	**8,889**	**9.2%**	**$54,242,424**	**1,901**	**2.0%**	**$14,656,772**	**96,490**	**99.9%**	**$232,079,101**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$36,883,557	2,657	10.8%	$5,166,059	246	1.0%	$2,986,541	24,527	100%	$45,036,157
Town of Carrboro	5,782	5,464	94.5%	$16,504,977	261	4.5%	$2,826,506	46	0.8%	$1,705,569	5,771	99.8%	$21,037,051
Town of Chapel Hill	15,108	13,922	92.1%	$52,706,532	617	4.1%	$9,162,755	528	3.5%	$10,466,470	15,067	99.7%	$72,335,758
Town of Hillsborough	3,883	3,408	87.8%	$6,263,186	358	9.2%	$1,860,930	111	2.9%	$989,004	3,877	99.8%	$9,113,119
Subtotal Orange	**49,306**	**44,418**	**90.1%**	**$112,358,252**	**3,893**	**7.9%**	**$19,016,250**	**931**	**1.9%**	**$16,147,584**	**49,242**	**99.9%**	**$147,522,085**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$20,472,393	2,613	14.8%	$1,731,936	156	0.9%	$1,376,778	17,662	99.7%	$23,581,107
City of Roxboro	6,617	5,754	87.0%	$6,673,123	710	10.7%	$3,141,581	144	2.2%	$1,061,219	6,608	99.9%	$10,875,923
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$27,145,516**	**3,323**	**13.7%**	**$4,873,517**	**300**	**1.2%**	**$2,437,997**	**24,270**	**99.7%**	**$34,457,030**
Total	**245,410**	**217,361**	**88.6%**	**$382,786,256**	**23,461**	**9.6%**	**$104,409,597**	**4,198**	**1.7%**	**$39,928,790**	**245,020**	**99.8%**	**$527,124,644**

Source: NCEM Risk Management Tool

Table 4.77 – Estimated Buildings Impacted by 700-Year Thunderstorm Winds

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$55,149,111	3,425	11.6%	$10,994,118	283	1.0%	$3,121,708	29,619	99.9%	$69,264,937
City of Burlington	24,403	21,618	88.6%	$51,099,779	2,401	9.8%	$23,042,692	320	1.3%	$4,678,992	24,339	99.7%	$78,821,463
City of Graham	7,269	6,575	90.5%	$13,583,852	530	7.3%	$4,135,997	155	2.1%	$2,038,322	7,260	99.9%	$19,758,170
City of Mebane	5,835	5,303	90.9%	$15,341,726	465	8.0%	$8,503,744	64	1.1%	$1,127,008	5,832	99.9%	$24,972,477
Town of Elon	2,760	2,437	88.3%	$7,841,694	147	5.3%	$2,876,455	174	6.3%	$1,818,876	2,758	99.9%	$12,537,024
Town of Green Level	1,177	1,057	89.8%	$1,741,418	109	9.3%	$347,643	10	0.8%	$74,568	1,176	99.9%	$2,163,629
Town of Haw River	2,352	2,139	90.9%	$4,830,103	168	7.1%	$674,524	31	1.3%	$254,448	2,338	99.4%	$5,759,076
Town of Ossipee	330	299	90.6%	$498,921	21	6.4%	$173,836	7	2.1%	$26,103	327	99.1%	$698,860
Town of Swepsonville	573	543	94.8%	$1,441,011	24	4.2%	$775,764	5	0.9%	$53,138	572	99.8%	$2,269,913
Village of Alamance	798	714	89.5%	$1,478,862	66	8.3%	$197,596	17	2.1%	$130,927	797	99.9%	$1,807,385
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$153,006,477**	**7,356**	**9.8%**	**$51,722,369**	**1,066**	**1.4%**	**$13,324,090**	**75,018**	**99.8%**	**$218,052,934**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$48,412,027	2,818	13.4%	$18,150,734	234	1.1%	$2,628,431	21,020	99.9%	$69,191,192
City of Durham	75,588	67,732	89.6%	$234,241,246	6,071	8.0%	$77,366,414	1,667	2.2%	$22,933,440	75,470	99.8%	$334,541,101
Subtotal Durham	**96,626**	**85,700**	**88.7%**	**$282,653,273**	**8,889**	**9.2%**	**$95,517,148**	**1,901**	**2.0%**	**$25,561,871**	**96,490**	**99.9%**	**$403,732,293**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$60,742,010	2,657	10.8%	$7,868,413	246	1.0%	$4,536,056	24,527	100.0%	$73,146,479
Town of Carrboro	5,782	5,464	94.5%	$29,820,852	261	4.5%	$4,303,170	46	0.8%	$2,283,999	5,771	99.8%	$36,408,020
Town of Chapel Hill	15,108	13,922	92.1%	$91,918,912	617	4.1%	$16,155,384	528	3.5%	$17,582,425	15,067	99.7%	$125,656,721
Town of Hillsborough	3,883	3,408	87.8%	$10,765,680	358	9.2%	$3,318,816	111	2.9%	$1,597,144	3,877	99.8%	$15,681,640
Subtotal Orange	**49,306**	**44,418**	**90.1%**	**$193,247,454**	**3,893**	**7.9%**	**$31,645,783**	**931**	**1.9%**	**$25,999,624**	**49,242**	**99.9%**	**$250,892,860**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$44,672,005	2,613	14.8%	$3,185,195	156	0.9%	$3,171,655	17,662	99.7%	$51,028,854
City of Roxboro	6,617	5,754	87.0%	$18,387,907	710	10.7%	$8,042,036	144	2.2%	$3,060,295	6,608	99.9%	$29,490,238
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$63,059,912**	**3,323**	**13.7%**	**$11,227,231**	**300**	**1.2%**	**$6,231,950**	**24,270**	**99.7%**	**$80,519,092**
Total	**245,410**	**217,361**	**88.6%**	**$691,967,116**	**23,461**	**9.6%**	**$190,112,531**	**4,198**	**1.7%**	**$71,117,535**	**245,020**	**99.8%**	**$953,197,179**

Source: NCEM Risk Management Tool

Severe weather can also cause significant agricultural losses. Between 2007-2017, the sum of claims paid for crop damage due to hail and wind damages in the Eno-Haw Region was $3,675,194 or an average of $367,500 in losses every year. Table 4.82 summarizes the crop losses due to severe weather in reported in the RMA system.

Table 4.78 – Crop Losses Resulting from Severe Weather, 2007-2017

Year	Cause Description	Determined Acres	Indemnity Amount
2007	Hail	17.76	$6,365
2008	Hail	339.28	$522,767
2009	Hail	5.64	$7,716
2011	Hail	8.70	$1,474
2012	Hail	284.04	$571,235
2013	Hail	62.40	$9,608
2015	Hail	287.55	$503,031.10
2016	Hail	421.08	$775,615.45
2017	Hail	6.50	$12,388
	Hail Subtotal	**1,433**	**$2,410,200**
2008	Wind/Excess Wind	243.78	$418,020
2009	Wind/Excess Wind	37.65	$7,397
2010	Wind/Excess Wind	53.70	$78,777
2011	Wind/Excess Wind	14.50	$7,827
2012	Wind/Excess Wind	17.33	$11,491
2013	Wind/Excess Wind	572.20	$72,210
2014	Wind/Excess Wind	9.70	$11,228.50
2015	Wind/Excess Wind	143.93	$198,019.36
2016	Wind/Excess Wind	158.55	$404,779
2017	Wind/Excess Wind	68.31	$55,246
	Wind Subtotal	**1,320**	**$1,264,995**
	Total	**2,753**	**$3,675,194**

Source: USDA Risk Management Agency

Environment

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

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

Consequence Analysis

Table 4.79 summarizes the potential negative consequences of severe weather.

Table 4.79 – Consequence Analysis – Severe Weather (Thunderstorm Winds, Lightning, and Hail)

Category	Consequences
Public	Injuries; fatalities
Responders	Injuries; fatalities; potential impacts to response capabilities due to storm impacts

Category	Consequences
Continuity of Operations (including Continued Delivery of Services)	Potential impacts to continuity of operations due to storm impacts; delays in providing services
Property, Facilities and Infrastructure	Possibility of structure fire ignition; potential for disruptions in power and communications infrastructure; destruction and/or damage to any exposed property, especially windows, cars and siding; mobile homes see increased risk
Environment	Potential fire ignition from lightning; hail damage to wildlife and foliage
Economic Condition of the Jurisdiction	Lightning damage contingent on target; can severely impact/destroy critical infrastructure and other economic drivers
Public Confidence in the Jurisdiction's Governance	Public confidence is not generally affected by severe weather events.

Hazard Summary by Jurisdiction

The following table summarizes severe weather hazard risk by jurisdiction. Most aspects of severe weather risk do not vary substantially by jurisdiction; however, wind and hail impacts may be greater in more highly developed areas with higher exposure in terms of both property and population density. Additionally, mobile home units are more vulnerable to wind damage. Mobile home units comprise over 10 percent of the occupied housing in unincorporated Alamance County, unincorporated Orange County, unincorporated Person County, Green Level, Haw River, Ossipee, and Roxboro; therefore, these jurisdictions may face more severe impacts from wind. Where priority ratings vary between thunderstorm wind, lightning, and hail for impact and spatial extent, these scores represent an average rating with greater weight given to thunderstorm wind because it occurs much more frequently.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	4	2	3	4	1	2.9	H
Burlington	4	1	3	4	1	2.6	H
Graham	4	1	3	4	1	2.6	H
Mebane	4	1	3	4	1	2.6	H
Elon	4	1	3	4	1	2.6	H
Green Level	4	2	3	4	1	2.9	H
Haw River	4	2	3	4	1	2.9	H
Ossipee	4	2	3	4	1	2.9	H
Swepsonville	4	1	3	4	1	2.6	H
Alamance	4	1	3	4	1	2.6	H
Durham County	4	2	3	4	1	2.9	H
Durham	4	1	3	4	1	2.6	H
Orange County	4	2	3	4	1	2.9	H
Carrboro	4	1	3	4	1	2.6	H
Chapel Hill	4	1	3	4	1	2.6	H
Hillsborough	4	1	3	4	1	2.6	H
Person County	4	2	3	4	1	2.9	H
Roxboro	4	2	3	4	1	2.9	H

4.5.9 Severe Winter Storm

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Severe Winter Storm	Highly Likely	Critical	Large	More than 24 hrs	More than 1 week	3.3

Hazard Background

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

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

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

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

Warning Time: 1 – More than 24 hours

Duration: 3 – Less than 1 week

Location

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

Extent

The National Oceanic and Atmospheric Administration (NOAA) uses the Regional Snowfall Index (RSI) to assess the societal impact of winter storms in the six easternmost regions in the United States. The index makes use of population and regional differences to assess the impact of snowfall. For example, areas which receive very little snowfall on average may be more adversely affected than other regions, resulting in a higher severity. The Region may experience any level on the RSI scale. During the snowstorm of February 28 to March 3, 1980, which produced the greatest one-day snowfall amounts the region has experienced, the Region was classified as a Category 4 on the RSI scale. It is possible that more severe events and impacts could be felt in the future.

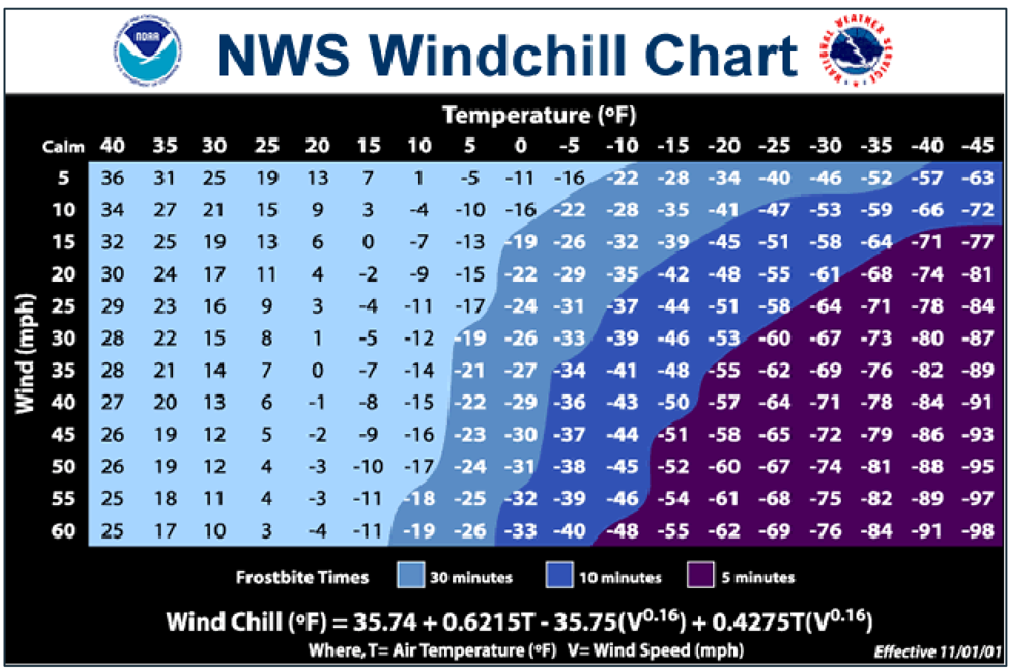
Table 4.80 – Regional Snowfall Index (RSI) Values

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

Source: NOAA

Severe winter storms often involve a mix of hazardous weather conditions. The magnitude of an event can be defined based on the severity of each of the involved factors, including precipitation type, precipitation accumulation amounts, temperature, and wind. The NWS Wind Chill Temperature Index, shown in Figure 4.32, provides a formula for calculating the dangers of winter winds and freezing temperatures.

Figure 4.32 – NWS Wind Chill Temperature Index


NWS Windchill Chart

Temperature (°F)

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

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

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

Where, T= Air Temperature (°F) V= Wind Speed (mph) *Effective 11/01/01*

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

Table 4.81 notes greatest recorded one-day snowfall totals for each county in the Eno Haw Region.

Table 4.81 – Greatest One-Day Snowfall by County

County	Inches	Location	Date
Alamance	18.0	Graham 2 ENE	Jan 24, 1940
Durham	18.5	Rougemont	Dec 18, 1930

County	Inches	Location	Date
Orange	12.0	Chapel Hill 2 W	Feb 15,1902
Person	16.0	Roxboro 7 ESE	Jan 24, 1940

Source: North Carolina Climate Office

The most significant recorded snow depth over the last 20 years took place in January 2018 and December 2018, with recorded depths of up to 12.5 inches across the four-county region. The Region has received six emergency and disaster declarations related to severe winter weather, indicating the impacts can be extensive to the point that assistance is needed for recovery.

Impact: 3 – Critical

Spatial Extent: 4 – Large

The entirety of North Carolina is susceptible to winter storm and freeze events. Some ice and winter storms may be large enough to affect several states, while others might affect limited, localized areas. The degree of exposure typically depends on the normal expected severity of local winter weather. The Eno Haw Region is accustomed to smaller scale severe winter weather conditions and often receives winter weather during the winter months. Given the atmospheric nature of the hazard, the entire Region has uniform exposure to a winter storm.

Historical Occurrences

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

- **Blizzard** – A winter storm which produces the following conditions for 3 consecutive hours or longer: (1) sustained winds or frequent gusts 30 knots (35 mph) or greater, and (2) falling and/or blowing snow reducing visibility frequently to less than 1/4 mile.
- **Cold/Wind Chill** – Period of low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined advisory conditions of 0°F to -14°F with wind speeds 10 mph (9 kt) or greater.
- **Extreme Cold/Wind Chill** – A period of extremely low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined warning criteria, defined as wind chill -15°F or lower with wind speeds 10 mph (9 kt) or greater.
- **Frost/Freeze** – A surface air temperature of 32°F or lower, or the formation of ice crystals on the ground or other surfaces, for a period of time long enough to cause human or economic impact, during the locally defined growing season.
- **Heavy Snow** – Snow accumulation meeting or exceeding 12 and/or 24 hour warning criteria of 3 and 4 inches, respectively.
- **Ice Storm** – Ice accretion meeting or exceeding locally/regionally defined warning criteria of ¼ inch or greater resulting in significant, widespread power outages, tree damage and dangerous travel. Issued only in those rare instances where just heavy freezing rain is expected and there will be no "mixed bag" precipitation meaning no snow, sleet or rain.
- **Sleet** – Sleet accumulations meeting or exceeding locally/regionally defined warning criteria of ½ inch or more.
- **Winter Storm** – A winter weather event that has more than one significant hazard and meets or exceeds locally/regionally defined 12 and/or 24 hour warning criteria for at least one of the precipitation elements. Defined by NWS Raleigh Forecast Office as snow accumulations 3 inches or greater in 12 hours (4 inches or more in 24 hours); Freezing rain accumulations ¼ inch (6 mm)

or greater; Sleet accumulations ½ inch (13 mm) or more. Issued when there is at least a 60% forecast confidence of any one of the three criteria being met.

- **Winter Weather** – A winter precipitation event that causes a death, injury, or a significant impact to commerce or transportation, but does not meet locally/regionally defined warning criteria.

Table 4.82 summarizees the recorded severe winter storm events that have impacted each county in the Eno-Haw Region according to the NCEI Storm Events Database for the 20-year period from 1999 through 2018. Note that many events impacted all or multiple counties. Cumulatively, severe winter storms caused over $6 million in property damage. In this timeframe, the county experienced no fatalities, injuries or crop damage from severe winter storm, though these types of impacts are possible in future events. No blizzard, cold/wind chill, extreme cold/wind chill, frost/freeze, or sleet events were recorded. Impacts in the Eno-Haw Region by incident are recorded in Table 4.83.

Table 4.82 – Total Severe Winter Storm Impacts in Eno-Haw Region, 1999-2018

Event Type	Number of Recorded Incidents	Total Fatalities	Total Injuries	Total Property Damage	Total Crop Damage
Alamance					
Winter Storm	30	0	0	$500,000	$0
Winter Weather	30	0	0	$20,000	$0
Ice Storm	1	0	0	$0	$0
Heavy Snow	1	0	0	$0	$0
Durham					
Winter Storm	25	0	0	$1,000,000	$0
Winter Weather	24	0	0	$30,000	$0
Ice Storm	1	0	0	$400,000	$0
Heavy Snow	1	0	0	$0	$0
Orange					
Winter Storm	30	0	0	$1,000,000	$0
Winter Weather	28	0	0	$30,000	$0
Ice Storm	1	0	0	$2,700,000	$0
Heavy Snow	1	0	0	$0	$0
Person					
Winter Storm	34	0	0	$500,000	$0
Winter Weather	24	0	0	$15,000	$0
Ice Storm	2	0	0	$534,000	$0
Heavy Snow	1	0	0	$0	$0
Region Total					
Winter Storm	37	0	0	$3,000,000	$0
Winter Weather	36	0	0	$95,000	$0
Ice Storm	2	0	0	$3,634,000	$0
Heavy Snow	1	0	0	$0	$0
Total Events	**76**	**0**	**0**	**$6,729,000**	**$0**

Source: NCEI

Table 4.83 – Recorded Severe Winter Storm Impacts in Eno-Haw Region, 1999-2018

Date	Event Type	Fatalities	Injuries	Property Damage	Crop Damage
1/2/1999	Ice Storm	0	0	$0	$0
1/18/2000	Winter Storm	0	0	$0	$0
1/20/2000	Winter Storm	0	0	$0	$0

Date	Event Type	Fatalities	Injuries	Property Damage	Crop Damage
1/22/2000	Winter Storm	0	0	$0	$0
1/24/2000	Winter Storm	0	0	$0	$0
1/28/2000	Winter Storm	0	0	$0	$0
11/19/2000	Heavy Snow	0	0	$0	$0
1/3/2002	Winter Storm	0	0	$0	$0
1/6/2002	Winter Storm	0	0	$0	$0
12/4/2002	Winter Storm	0	0	$0	$0
1/23/2003	Winter Storm	0	0	$0	$0
2/16/2003	Winter Storm	0	0	$0	$0
2/27/2003	Winter Storm	0	0	$0	$0
12/13/2003	Winter Weather	0	0	$0	$0
1/26/2004	Winter Storm	0	0	$0	$0
2/15/2004	Winter Storm	0	0	$0	$0
2/27/2004	Winter Storm	0	0	$0	$0
1/30/2005	Winter Storm	0	0	$0	$0
12/15/2005	Winter Weather	0	0	$0	$0
1/18/2007	Winter Weather	0	0	$0	$0
1/21/2007	Winter Weather	0	0	$0	$0
12/7/2007	Winter Weather	0	0	$95,000	$0
1/17/2008	Winter Weather	0	0	$0	$0
1/19/2008	Winter Storm	0	0	$0	$0
1/19/2008	Winter Weather	0	0	$0	$0
2/13/2008	Winter Weather	0	0	$0	$0
2/13/2008	Winter Storm	0	0	$0	$0
1/20/2009	Winter Storm	0	0	$0	$0
1/22/2009	Winter Weather	0	0	$0	$0
3/1/2009	Winter Storm	0	0	$0	$0
12/18/2009	Winter Storm	0	0	$0	$0
12/30/2009	Winter Weather	0	0	$0	$0
1/29/2010	Winter Storm	0	0	$0	$0
2/5/2010	Winter Weather	0	0	$0	$0
2/5/2010	Winter Storm	0	0	$0	$0
2/12/2010	Winter Weather	0	0	$0	$0
3/2/2010	Winter Weather	0	0	$0	$0
3/2/2010	Winter Storm	0	0	$0	$0
12/4/2010	Winter Weather	0	0	$0	$0
12/16/2010	Winter Weather	0	0	$0	$0
12/18/2010	Winter Weather	0	0	$0	$0
12/18/2010	Winter Weather	0	0	$0	$0
12/25/2010	Winter Storm	0	0	$0	$0
1/7/2011	Winter Weather	0	0	$0	$0
1/10/2011	Winter Weather	0	0	$0	$0
1/17/2013	Winter Storm	0	0	$0	$0
11/26/2013	Winter Weather	0	0	$0	$0
12/26/2013	Winter Weather	0	0	$0	$0
1/21/2014	Winter Weather	0	0	$0	$0
1/28/2014	Winter Weather	0	0	$0	$0

Date	Event Type	Fatalities	Injuries	Property Damage	Crop Damage
2/12/2014	Winter Storm	0	0	$0	$0
3/3/2014	Winter Weather	0	0	$0	$0
3/6/2014	Winter Storm	0	0	$0	$0
3/6/2014	Ice Storm	0	0	$3,634,000	$0
3/17/2014	Winter Weather	0	0	$0	$0
1/13/2015	Winter Weather	0	0	$0	$0
1/27/2015	Winter Weather	0	0	$0	$0
2/16/2015	Winter Storm	0	0	$0	$0
2/24/2015	Winter Weather	0	0	$0	$0
2/25/2015	Winter Storm	0	0	$3,000,000	$0
3/1/2015	Winter Weather	0	0	$0	$0
1/20/2016	Winter Weather	0	0	$0	$0
1/22/2016	Winter Storm	0	0	$0	$0
2/14/2016	Winter Storm	0	0	$0	$0
2/15/2016	Winter Weather	0	0	$0	$0
1/6/2017	Winter Storm	0	0	$0	$0
12/8/2017	Winter Weather	0	0	$0	$0
12/8/2017	Winter Storm	0	0	$0	$0
1/3/2018	Winter Weather	0	0	$0	$0
1/17/2018	Winter Storm	0	0	$0	$0
3/12/2018	Winter Storm	0	0	$0	$0
3/12/2018	Winter Weather	0	0	$0	$0
3/21/2018	Winter Weather	0	0	$0	$0
3/24/2018	Winter Storm	0	0	$0	$0
3/24/2018	Winter Weather	0	0	$0	$0
12/9/2018	Winter Storm	0	0	$0	$0
	Total	**0**	**0**	**$6,729,000**	**$0**

Source: NCEI

Several storm impacts from NCEI are summarized below:

December 7, 2007 – A brief period of light freezing rain fell across central North Carolina. Most of the freezing rain accumulation occurred from southern Wake County, east to Smithfield and north to Wilson, Rock Mount and Roanoke Rapids. Portions of Interstate 40 and Highway 70 in Johnston County were closed due to numerous accidents. Over 150 automobile accidents were reported across central North Carolina due to icy bridges. The storm caused $415,000 in damage across the region; The Eno-Haw region itself suffered $95,000 in recorded damage.

March 6, 2014 – A strong surface low deepening off the Carolina coast brought a wintry mix of snow, sleet, and freezing rain to the northern-northwestern Piedmont counties. Snowfall amounts of 4 to 7 inches fell in Person. Just to the south and east of this area, a corridor of mainly sleet mixed with freezing rain produced significant icing of a quarter to half inch. This icing produced widespread downed trees and power outages over the northwest Piedmont. At the peak of the storm, over 400,000 customers were without power. In Person County, One quarter of an inch of ice from freezing rain resulted in widespread downed trees and power-lines. Additionally, snowfall of 4 to 7 inches fell across the county. Orange and Durham Counties saw one quarter to one half of an inch of ice, leading to widespread downed trees and power lines.

February 25, 2015 – As a low pressure system tracked along the southeast coast, wintry precipitation spread into Central North Carolina. A winter storm warning was issued for the majority of the area. Snowfall/sleet amounts of 5 to 9 inches fell across the region. The heavy wet snow caused extensive power outages from falling trees and power lines. At the peak of the storm, over 45,000 customers were without power.

The Eno-Haw Region received six emergency declarations and presidential disaster declarations since 1968 for incidents related to severe winter storms. As a state, North Carolina received eight disaster declarations related to severe winter storms during this timeframe.

Table 4.84 – Emergency & Disaster Declarations in Eno-Haw Region due to Severe Winter Storms

County	Disaster Number	Date	Disaster Type	Incident Start	Incident End
A,D,O,P	3110	1993	Severe Snowfall & Winter Storm	3/13/1993	3/17/1993
A,D,O,P	1087	1996	Blizzard	1/6/1996	1/12/1996
A,D,O,P	1312	2000	Severe Winter Storm	1/24/2000	2/1/2000
A,D,O,P	1448	2002	Severe Ice Storm	12/4/2002	12/6/2002
A,O,P	1457	2003	Severe Ice Storm	2/27/2003	2/28/2003
A,O,P	4167	2014	Severe Ice Storm	3/6/2014	3/7/2014

Source: FEMA, December 20, 2018
*County code: A = Alamance, D = Durham, O = Orange, P = Person

Probability of Future Occurrence

NCEI records 76 severe winter storm related events during the 20-year period from 1999 through 2018, which is an average of 3.8 events per year or more than 100 percent probability in any given year.

Probability: 4 – Highly Likely

Climate Change

Per the 2018 North Carolina Hazard Mitigation Plan, there is uncertainty associated with climate change impacts on future severe winter storms. Global temperature rise could cause shorter and warmer winters in many areas; however, the likelihood of dangerously low temperatures may increase due to continuing trends of temperature extremes. Warmer winters, however, mean that precipitation that would normally fall as snow may begin to fall as rain or freezing rain instead.

Vulnerability Assessment

People

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

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

Property

According to reported data of storm impacts recorded by the NCEI, between 1999 and 2018 the Eno-Haw Region experienced $6.7 million in property damage related to the impacts of severe winter storm. Based on this data, the Region experiences average annual losses of $336,450 due to severe winter storm events.

Environment

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

Consequence Analysis

Table 4.85 summarizes the potential negative consequences of severe winter storm.

Table 4.85 – Consequence Analysis – Severe Winter Storm

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

Hazard Summary by Jurisdiction

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

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	4	2	4	1	3	3.0	H
Burlington	4	2	4	1	3	3.0	H
Graham	4	2	4	1	3	3.0	H
Mebane	4	2	4	1	3	3.0	H
Elon	4	2	4	1	3	3.0	H
Green Level	4	2	4	1	3	3.0	H
Haw River	4	2	4	1	3	3.0	H
Ossipee	4	2	4	1	3	3.0	H
Swepsonville	4	2	4	1	3	3.0	H
Alamance	4	2	4	1	3	3.0	H
Durham County	4	2	4	1	3	3.0	H
Durham	4	2	4	1	3	3.0	H
Orange County	4	2	4	1	3	3.0	H

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Carrboro	4	2	4	1	3	3.0	H
Chapel Hill	4	2	4	1	3	3.0	H
Hillsborough	4	2	4	1	3	3.0	H
Person County	4	2	4	1	3	3.0	H
Roxboro	4	2	4	1	3	3.0	H

4.5.10 Tornado

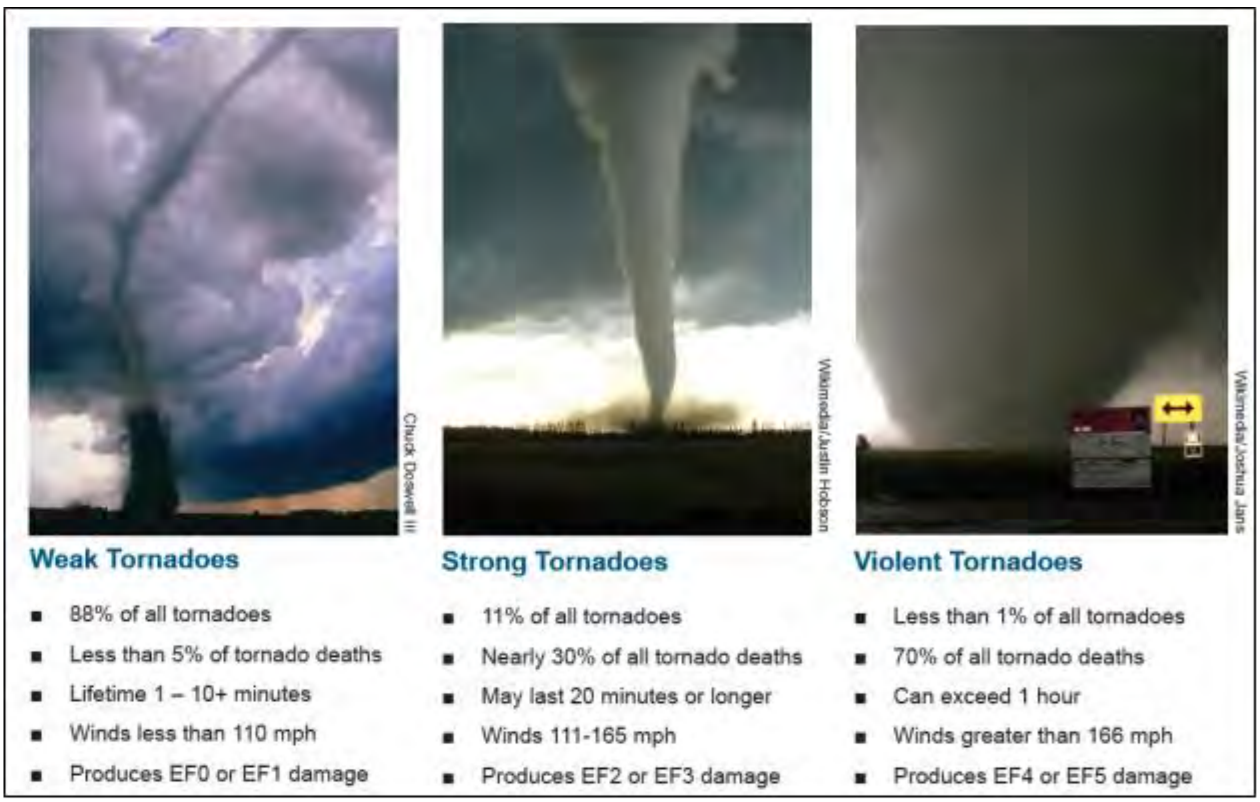
Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Tornado	Likely	Critical	Small	Less than 6 hrs	Less than 6 hours	2.7

Hazard Background

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

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

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



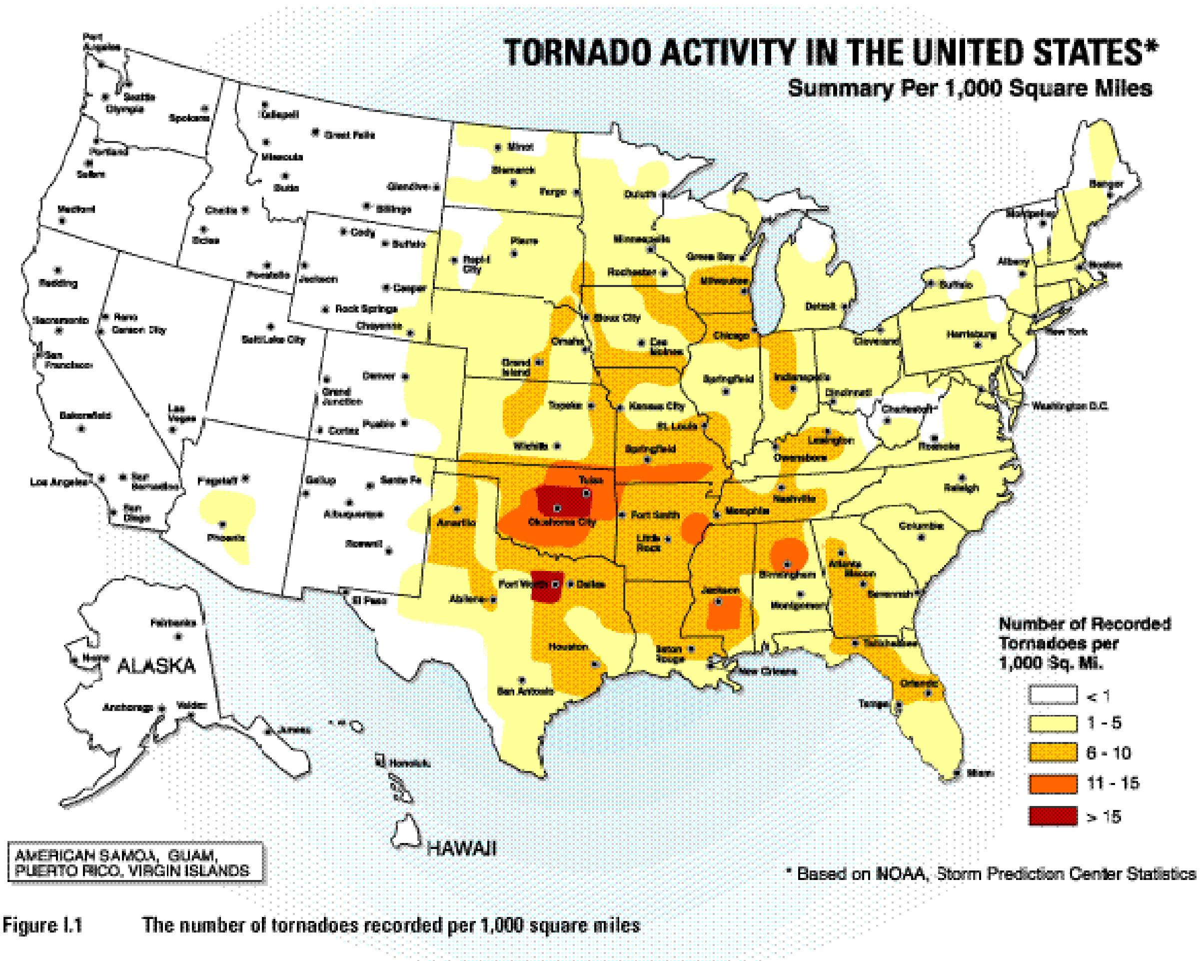
Source: NOAA National Weather Service

Warning Time: 4 – Less than 6 hours

Duration: 1 – Less than 6 hours

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

Figure 4.33 – Tornado Activity in the U.S.

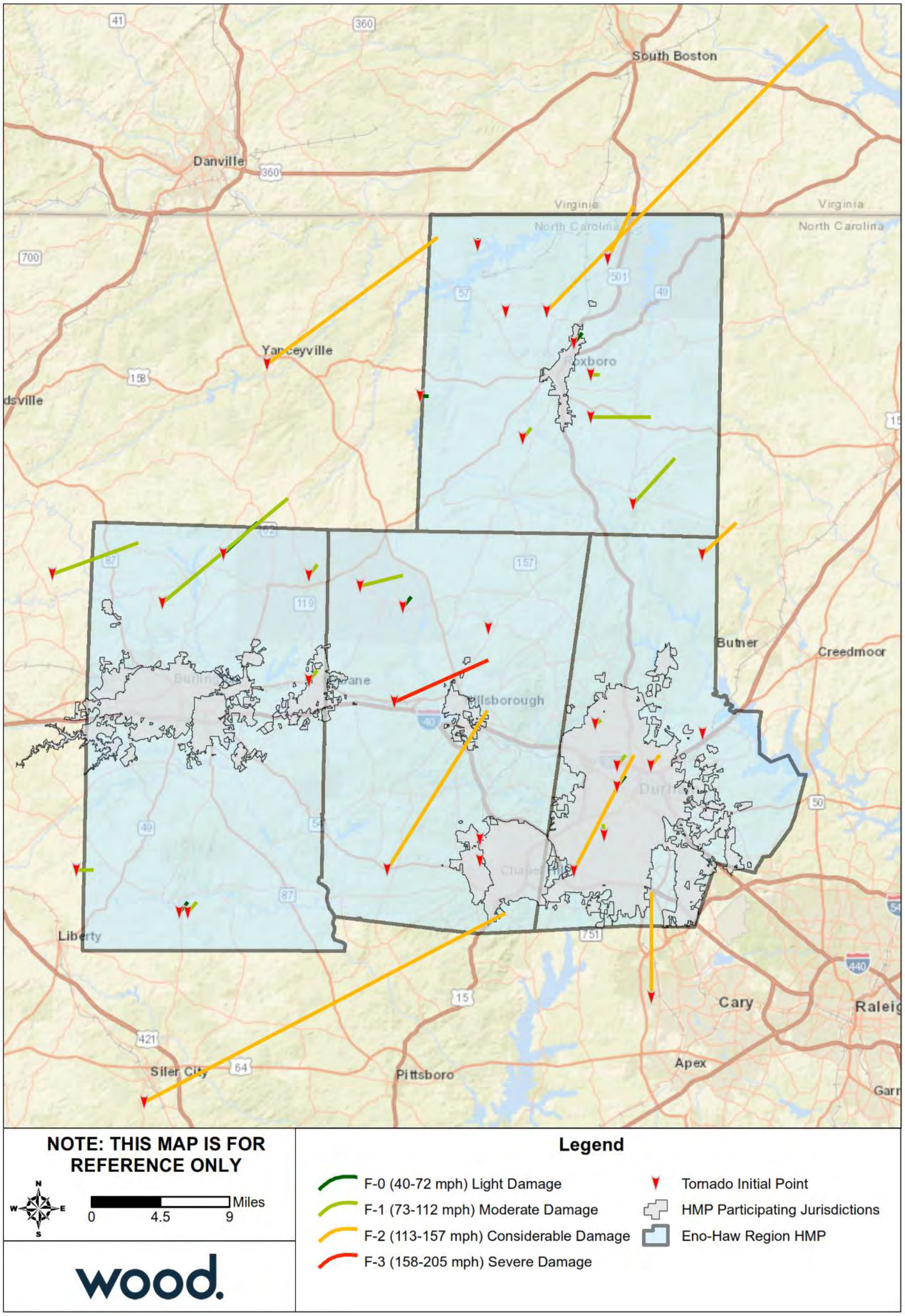


Source: American Society of Civil Engineers

Location

Figure 4.34 reflects the tracks of past tornados that passed through the Eno-Haw region from 1950 through 2017 according to data from the NOAA/National Weather Service Storm Prediction Center.

Figure 4.34 – Tornado Paths Through Eno-Haw Region, 1950-2017



Source: NOAA/NWS Storm Prediction Center

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

Extent

Prior to February 1, 2007, tornado intensity was measured by the Fujita (F) scale. This scale was revised and is now the Enhanced Fujita (EF) scale. Both scales are sets of wind estimates (not measurements) based on damage. The new scale provides more damage indicators (28) and associated degrees of damage, allowing for more detailed analysis, better correlation between damage and wind speed. It is also more precise because it takes into account the materials affected and the construction of structures damaged by a tornado. Table 4.86 shows the wind speeds associated with the enhanced Fujita scale ratings and the damage that could result at different levels of intensity.

Table 4.86 – Enhanced Fujita Scale

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

The most intense tornado to pass through the Eno-Haw Region in the past 20 years was an EF2 in Person County in 2011; this tornado caused $400,000 in property damage and caused the only 2 tornado related injuries. It was also the longest (9.66 miles) and widest (300 yards) tornado the region has experienced Another tornado on the same day in Alamance County caused the most property damage ($580,000).

Impact: 3 – Critical

Spatial Extent: 2 – Small

Historical Occurrences

NCEI storm reports were reviewed from 1999 through 2019 to assess whether recent trends varied from the longer historical record. According to NCEI, the Eno-Haw Region experienced 16 tornado incidents between 1999 and 2019, causing no fatalities, 2 injuries, $4.2 million in property damage and $10,000 in crop damage. Table 4.87 shows historical tornadoes in the Eno-Haw Region during this time period.

Table 4.87 – Recorded Tornadoes in Eno-Haw Region, 1999-2019

Location	Date	Time	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
Carrboro	6/19/2000	1305	F0	0	0	$0	$0
Carrboro	9/8/2004	1145	F0	0	0	$0	$0
Schley	1/14/2005	445	F0	0	0	$0	$0
Ceffo	7/7/2005	1442	F0	0	0	$0	$0
Gorman	5/14/2006	1710	F0	0	0	$0	$0
Union Ridge	3/4/2008	1654	EF0	0	0	$150,000	$0
Mt Tirzah	3/28/2010	2255	EF1	0	0	$250,000	$0
Hesters Store	10/27/2010	1458	EF0	0	0	$0	$10,000
Brooksdale	10/27/2010	1513	EF1	0	0	$75,000	$0
Carr	10/27/2010	1630	EF1	0	0	$250,000	$0
Altamahaw	4/16/2011	1306	EF1	0	0	$580,000	$0
Hyco	4/16/2011	1340	EF2	0	2	$400,000	$0
Cunningham	7/2/2013	1125	EF0	0	0	$100,000	$0
Hope Vly	5/15/2014	1710	EF1	0	0	$250,000	$0
Huckleberry Spg	2/24/2016	1600	EF1	0	0	$100,000	$0
Teer	04/19/2019	1500	EF2	0	0	$2,000,000	
Total				**0**	**2**	**$4,155,000**	**$10,000**

Source: NCEI

Specific incidents with some level of impact include:

March 4, 2008 – A weak EF 0 tornado touched down in northern Alamance County just northeast of the Union Ridge community. The tornado initially touched down about a half mile south of Willie Pace Road. On the north side of Willie Pace Road the tornado blew the roof off of a tobacco barn, lifted a carport, destroyed one shed and caused roof and porch damage to a home. The tornado continued to track northeast into Caswell County for approximately 2 miles. Further north the tornado destroyed a barn on Vinson Road and damaged a tractor and irrigation system. Numerous trees were also blown down in the area. The tornado blew a large oak tree into a brick home on Blaney Road, resulting in substantial roof damage. A garage in the back yard was also destroyed. A single wide mobile home on Baynes Road lost its roof from the high wind. The roof was tossed about 70 feet before becoming wrapped around a tree.

October 27, 2010 – Five weak tornadoes occurred across Person, Orange, Granville and Vance counties during the afternoon and evening. In Person County, a supercell thunderstorm produced a short lived EF-1 tornado which produced significant damage to a double wide modular home along Apple Tree Lane near Allensville Road. Nearby modular homes sustained minor damage to the roof and siding. Numerous trees were either snapped off or uprooted at this location. Winds were estimated to be between 86 to 90 mph. The tornado then tracked eastward and across a wooded area before crossing Ruff Davis Road, where several trees were snapped off and downed in different directions. The tornado lifted as it moved into another wooded area east of Ruff Davis Road.

In Orange County, the tornado produced EF-1 damage with winds between 90 to 95 mph along Carr Store Road near Allie Mae Road in northern Orange County. At this location a church sustained significant damage, with two walls made of cinder blocks blown down and numerous hard and soft wood trees were also snapped off and uprooted. The tornado continued to track east northeast and damaged two homes along Pentecost Road. Both homes sustained roof damage, including a partially collapsed chimney, and numerous trees were snapped and uprooted. Two individuals were home at the time of the tornado and were not injured. Numerous trees where snapped off and uprooted at this location as well. Winds were estimated to range from 86 to 90 mph. The tornado weakened as it continued to track east north-east across McDade Store Road and Efland-Cedar Grove Road before lifting.

April 16, 2011 – A strong storm system produced nine tornadoes in the Raleigh CWA, including two EF3s and four EF2s. The tornadoes left eight dead with approximately 275 injuries. In Altamahaw, an EF1 tornado first touched down at Bethel Methodist Church Road, As it moved through the area, it caused damage to many homes, including collapsing walls, ripping off roofs, and shattering windows. The tornado also caused damages to vehicles and uprooted and snapped many trees, some of which exceeded four feet in diameter. In total, 20 homes were damaged, including 6 homes that were completely destroyed. Another tornado initially touched down 4 miles north northwest of Roxboro as an EF0 but strengthened to an EF2 with intermittent EF1 damage. There were two schools damaged, two homes destroyed, 10 homes with minor damage, and two reported injuries as a result of this incident.

May 15, 2014 – Scattered storms impacted central North Carolina that lead to flash flooding as many areas received 2-4 inches of rain, with isolated amounts up to 5-6 inches. In addition, some isolated wind damage occurred and an isolated EF1 tornado formed near Durham. Damage consisted of dozens of snapped and uprooted trees and approximately 40 homes that experienced roof or other structural damage. Most of the damage to the homes was caused by falling trees and other debris. However, there were at least a half a dozen homes that experienced minor roof damage solely from the wind. In one case, a large oak tree was uprooted and fell onto a home, slicing through the roof and an exterior wall.

April 19, 2019 – A deepening upper-level trough brought severe thunderstorms that produced 7 tornadoes across central NC. The strongest tornado formed in southwestern Orange County and reached EF-2 strength as it neared Hillsborough. The tornado initially touched down in the White Cross area and Leslie Drive area of southwest Orange County. Considerable tree damage occurred in this area, including the snapping and splitting of healthy large-trunk trees. Subsequent damage to vehicles and homes occurred as the trees fell. Given the magnitude and nature of the damage, wind speeds were estimated at 110 mph. The tornado then tracked north-northeast eventually crossing Dodsons Cross Road, Dairlyland Road, Arthur Minnis Road, and Borland Roads, all while producing similar tree damage. The tornado finally began to lift and/or dissipate near Hillsborough just north of I-40 near exit 261, but not before producing considerable damage to several homes just south of exit 261. The roof and several exterior walls of one home were completely destroyed. Damage at this location was estimated at 115 mph.

Probability of Future Occurrence

Probability of future occurrence was calculated based on past occurrences and was assumed to be uniform across the county.

In a twenty-year span between 1999 and 2018, the Eno-Haw Region experienced 15 separate tornado incidents over 12 separate days. This correlates to a 75 percent annual probability that the Region will experience a tornado somewhere in its boundaries. Only one of these past tornado events was a magnitude EF2 or greater; therefore, the annual probability of a significant tornado event is approximately 5 percent.

Probability: 3 – Likely

Climate Change

There presently is not enough data or research to quantify the magnitude of change that climate change may have related to tornado frequency and intensity. NASA's Earth Observatory has conducted studies which aim to understand the interaction between climate change and tornadoes. Based on these studies meteorologists are unsure why some thunderstorms generate tornadoes and others don't, beyond knowing that they require a certain type of wind shear. Tornadoes spawn from approximately one percent of thunderstorms, usually supercell thunderstorms that are in a wind shear environment that promotes rotation. Some studies show a potential for a decrease in wind shear in mid-latitude areas. Because of uncertainty with the influence of climate change on tornadoes, future updates to the mitigation plan should include the latest research on how the tornado hazard frequency and severity could change. The level of significance of this hazard should be revisited over time.

Vulnerability Assessment

People

People and populations exposed to the elements are most vulnerable to tornados. The availability of sheltered locations such as basements, buildings constructed using tornado-resistant materials and methods, and public storm shelters, all reduce the exposure of the population. According to the 2017 American Community Survey (ACS), 19,000 occupied housing units (7.5%) in the Eno-Haw Region are classified as "mobile homes or other types of housing." Based on an estimated average of 2.4 persons per household from the 2017 ACS, there are approximately 45,000 people in the Region living in mobile homes. See Table 4.57 in Section 4.5.6 for details on the amount of mobile home units in each jurisdiction.

Since 1950, the NCEI database records 2 injuries attributed to tornadoes in the Eno-Haw Region.

Property

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

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

Since 1950, damaging tornadoes in the County are directly responsible for $33.6 million worth of damage to property and $10,000 in damage to crops, according to NCEI data.

Table 4.88 through Table 4.92 detail the estimated buildings impacted from tornado events of magnitudes ranging from EF0 to EF4. Note that these tables provide an estimate of building damages should all exposed property be impacted by an event of the stated magnitude. Actual damages resulting from a tornado event of each magnitude would be lower because the event would impact only a fraction of the Region.

Table 4.88 – Estimated Buildings Impacted by EF0 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$166,142,190	3,425	11.6%	$38,959,396	283	1%	$6,870,494	29,619	99.9%	$211,972,080
City of Burlington	24,403	21,618	88.6%	$136,928,807	2,401	9.8%	$115,309,319	320	1.3%	$10,719,010	24,339	99.7%	$262,957,136
City of Graham	7,269	6,575	90.5%	$41,631,328	530	7.3%	$19,412,298	155	2.1%	$4,267,932	7,260	99.9%	$65,311,558
City of Mebane	5,835	5,303	90.9%	$40,737,269	465	8%	$35,465,046	64	1.1%	$2,624,545	5,832	99.9%	$78,826,860
Town of Elon	2,760	2,437	88.3%	$19,742,907	147	5.3%	$6,545,156	174	6.3%	$3,988,785	2,758	99.9%	$30,276,848
Town of Green Level	1,177	1,057	89.8%	$5,250,796	109	9.3%	$1,403,519	10	0.8%	$67,770	1,176	99.9%	$6,722,086
Town of Haw River	2,352	2,139	90.9%	$11,602,722	168	7.1%	$4,480,324	31	1.3%	$464,746	2,338	99.4%	$16,547,792
Town of Ossipee	330	299	90.6%	$1,540,046	21	6.4%	$409,088	7	2.1%	$112,991	327	99.1%	$2,062,126
Town of Swepsonville	573	543	94.8%	$3,978,658	24	4.2%	$2,275,968	5	0.9%	$232,647	572	99.8%	$6,487,273
Village of Alamance	798	714	89.5%	$4,986,272	66	8.3%	$1,275,871	17	2.1%	$394,410	797	99.9%	$6,656,553
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$432,540,995**	**7,356**	**9.8%**	**$225,535,985**	**1,066**	**1.4%**	**$29,743,330**	**75,018**	**99.8%**	**$687,820,312**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$157,359,493	2,818	13.4%	$128,314,558	234	1.1%	$10,473,253	21,020	99.9%	$296,147,303
City of Durham	75,588	67,732	89.6%	$650,105,392	6,071	8%	$394,548,411	1,667	2.2%	$65,890,002	75,470	99.8%	$1,110,543,805
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$807,464,885**	**8,889**	**9.20%**	**$522,862,969**	**1,901**	**1.97%**	**$76,363,255**	**96,490**	**99.86%**	**$1,406,691,108**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$241,863,256	2,657	10.8%	$48,758,037	246	1%	$16,589,379	24,527	100%	$307,210,671
Town of Carrboro	5,782	5,464	94.5%	$75,803,920	261	4.5%	$11,260,171	46	0.8%	$6,282,145	5,771	99.8%	$93,346,236
Town of Chapel Hill	15,108	13,922	92.1%	$243,832,227	617	4.1%	$55,780,702	528	3.5%	$36,529,467	15,067	99.7%	$336,142,396
Town of Hillsborough	3,883	3,408	87.8%	$30,772,972	358	9.2%	$18,696,740	111	2.9%	$8,332,215	3,877	99.8%	$57,801,928
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$592,272,375**	**3,893**	**7.90%**	**$134,495,650**	**931**	**1.89%**	**$67,733,206**	**49,242**	**99.87%**	**$794,501,231**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$132,188,535	2,613	14.8%	$21,275,483	156	0.9%	$8,981,136	17,662	99.7%	$162,445,153
City of Roxboro	6,617	5,754	87%	$46,846,920	710	10.7%	$41,838,462	144	2.2%	$10,113,865	6,608	99.9%	$98,799,247
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$179,035,455**	**3,323**	**13.7%**	**$63,113,945**	**300**	**1.2%**	**$19,095,001**	**24,270**	**99.7%**	**$261,244,400**
Total	**245,410**	**217,361**	**88.6%**	**$2,011,313,710**	**23,461**	**9.6%**	**$946,008,549**	**4,198**	**1.7%**	**$192,934,792**	**245,020**	**99.8%**	**$3,150,257,051**

Source: NCEM Risk Management Tool

Table 4.89 – Estimated Buildings Impacted by EF1 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$1,199,435,283	3,425	11.6%	$257,670,367	283	1%	$38,487,642	29,619	99.9%	$1,495,593,292
City of Burlington	24,403	21,618	88.6%	$992,713,821	2,401	9.8%	$715,529,497	320	1.3%	$63,915,578	24,339	99.7%	$1,772,158,896
City of Graham	7,269	6,575	90.5%	$301,322,610	530	7.3%	$123,040,252	155	2.1%	$26,800,426	7,260	99.9%	$451,163,289
City of Mebane	5,835	5,303	90.9%	$293,610,650	465	8%	$229,881,612	64	1.1%	$15,761,180	5,832	99.9%	$539,253,442
Town of Elon	2,760	2,437	88.3%	$142,999,357	147	5.3%	$53,946,784	174	6.3%	$29,473,326	2,758	99.9%	$226,419,466
Town of Green Level	1,177	1,057	89.8%	$37,321,119	109	9.3%	$8,910,581	10	0.8%	$545,592	1,176	99.9%	$46,777,292
Town of Haw River	2,352	2,139	90.9%	$83,387,807	168	7.1%	$30,271,855	31	1.3%	$3,394,721	2,338	99.4%	$117,054,383
Town of Ossipee	330	299	90.6%	$11,184,995	21	6.4%	$2,499,366	7	2.1%	$726,465	327	99.1%	$14,410,826
Town of Swepsonville	573	543	94.8%	$29,036,656	24	4.2%	$17,350,502	5	0.9%	$1,095,062	572	99.8%	$47,482,219
Village of Alamance	798	714	89.5%	$36,565,204	66	8.3%	$8,608,292	17	2.1%	$2,074,076	797	99.9%	$47,247,572
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$3,127,577,502**	**7,356**	**9.8%**	**$1,447,709,108**	**1,066**	**1.4%**	**$182,274,068**	**75,018**	**99.8%**	**$4,757,560,677**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$1,161,038,559	2,818	13.4%	$868,665,334	234	1.1%	$60,558,884	21,020	99.9%	$2,090,262,777
City of Durham	75,588	67,732	89.6%	$4,681,106,982	6,071	8%	$2,425,252,901	1,667	2.2%	$418,667,079	75,470	99.8%	$7,525,026,961
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$5,842,145,541**	**8,889**	**9.20%**	**$3,293,918,235**	**1,901**	**1.97%**	**$479,225,963**	**96,490**	**99.86%**	**$9,615,289,738**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$1,748,461,726	2,657	10.8%	$319,405,019	246	1%	$91,580,103	24,527	100%	$2,159,446,848
Town of Carrboro	5,782	5,464	94.5%	$541,716,527	261	4.5%	$72,023,960	46	0.8%	$29,305,655	5,771	99.8%	$643,046,141
Town of Chapel Hill	15,108	13,922	92.1%	$1,748,266,135	617	4.1%	$341,890,557	528	3.5%	$231,729,609	15,067	99.7%	$2,321,886,301
Town of Hillsborough	3,883	3,408	87.8%	$222,355,911	358	9.2%	$112,156,341	111	2.9%	$41,634,386	3,877	99.8%	$376,146,638
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$4,260,800,299**	**3,893**	**7.90%**	**$845,475,877**	**931**	**1.89%**	**$394,249,753**	**49,242**	**99.87%**	**$5,500,525,928**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$951,094,656	2,613	14.8%	$135,901,815	156	0.9%	$52,943,723	17,662	99.7%	$1,139,940,194
City of Roxboro	6,617	5,754	87%	$337,429,945	710	10.7%	$273,640,829	144	2.2%	$53,186,889	6,608	99.9%	$664,257,662
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$1,288,524,601**	**3,323**	**13.7%**	**$409,542,644**	**300**	**1.2%**	**$106,130,612**	**24,270**	**99.7%**	**$1,804,197,856**
Total	**245,410**	**217,361**	**88.6%**	**$14,519,047,943**	**23,461**	**9.6%**	**$5,996,645,864**	**4,198**	**1.7%**	**$1,161,880,396**	**245,020**	**99.8%**	**$21,677,574,199**

Source: NCEM Risk Management Tool

Table 4.90 – Estimated Buildings Impacted by EF2 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$2,152,312,869	3,425	11.6%	$530,898,994	283	1%	$121,857,316	29,619	99.9%	$2,805,069,179
City of Burlington	24,403	21,618	88.6%	$1,934,437,747	2,401	9.8%	$1,720,489,541	320	1.3%	$208,120,631	24,339	99.7%	$3,863,047,919
City of Graham	7,269	6,575	90.5%	$585,042,814	530	7.3%	$290,783,348	155	2.1%	$89,155,573	7,260	99.9%	$964,981,735
City of Mebane	5,835	5,303	90.9%	$572,668,639	465	8%	$546,352,865	64	1.1%	$51,477,017	5,832	99.9%	$1,170,498,521
Town of Elon	2,760	2,437	88.3%	$280,873,786	147	5.3%	$133,106,846	174	6.3%	$103,920,025	2,758	99.9%	$517,900,656
Town of Green Level	1,177	1,057	89.8%	$64,524,039	109	9.3%	$21,136,002	10	0.8%	$1,974,262	1,176	99.9%	$87,634,302
Town of Haw River	2,352	2,139	90.9%	$150,510,662	168	7.1%	$70,917,508	31	1.3%	$11,925,119	2,338	99.4%	$233,353,289
Town of Ossipee	330	299	90.6%	$20,365,015	21	6.4%	$6,203,240	7	2.1%	$2,439,170	327	99.1%	$29,007,424
Town of Swepsonville	573	543	94.8%	$54,287,234	24	4.2%	$37,109,512	5	0.9%	$3,157,442	572	99.8%	$94,554,188
Village of Alamance	798	714	89.5%	$68,473,459	66	8.3%	$19,430,817	17	2.1%	$6,365,484	797	99.9%	$94,269,759
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$5,883,496,264**	**7,356**	**9.8%**	**$3,376,428,673**	**1,066**	**1.4%**	**$600,392,039**	**75,018**	**99.8%**	**$9,860,316,972**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$2,529,869,988	2,818	13.4%	$2,324,419,926	234	1.1%	$328,417,209	21,020	99.9%	$5,182,707,123
City of Durham	75,588	67,732	89.6%	$10,624,724,413	6,071	8%	$7,584,677,591	1,667	2.2%	$2,341,289,284	75,470	99.8%	$20,550,691,288
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$13,154,594,401**	**8,889**	**9.20%**	**$9,909,097,517**	**1,901**	**1.97%**	**$2,669,706,493**	**96,490**	**99.86%**	**$25,733,398,411**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$3,214,244,532	2,657	10.8%	$680,602,468	246	1%	$288,179,167	24,527	100%	$4,183,026,168
Town of Carrboro	5,782	5,464	94.5%	$1,091,118,771	261	4.5%	$172,140,967	46	0.8%	$84,030,692	5,771	99.8%	$1,347,290,431
Town of Chapel Hill	15,108	13,922	92.1%	$3,529,705,528	617	4.1%	$827,226,638	528	3.5%	$795,048,600	15,067	99.7%	$5,151,980,766
Town of Hillsborough	3,883	3,408	87.8%	$428,175,191	358	9.2%	$279,835,936	111	2.9%	$124,321,322	3,877	99.8%	$832,332,449
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$8,263,244,022**	**3,893**	**7.90%**	**$1,959,806,009**	**931**	**1.89%**	**$1,291,579,781**	**49,242**	**99.87%**	**$11,514,629,814**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$1,689,469,662	2,613	14.8%	$332,024,227	156	0.9%	$171,491,334	17,662	99.7%	$2,192,985,223
City of Roxboro	6,617	5,754	87%	$632,571,764	710	10.7%	$646,571,425	144	2.2%	$163,188,103	6,608	99.9%	$1,442,331,292
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$2,322,041,426**	**3,323**	**13.7%**	**$978,595,652**	**300**	**1.2%**	**$334,679,437**	**24,270**	**99.7%**	**$3,635,316,515**
Total	**245,410**	**217,361**	**88.6%**	**$29,623,376,113**	**23,461**	**9.6%**	**$16,223,927,851**	**4,198**	**1.7%**	**$4,896,357,750**	**245,020**	**99.8%**	**$50,743,661,712**

Source: NCEM Risk Management Tool

Table 4.91 – Estimated Buildings Impacted by EF3 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$2,487,029,632	3,425	11.6%	$630,358,188	283	1%	$189,931,114	29,619	99.9%	$3,307,318,933
City of Burlington	24,403	21,618	88.6%	$2,417,060,798	2,401	9.8%	$2,176,925,295	320	1.3%	$325,855,955	24,339	99.7%	$4,919,842,049
City of Graham	7,269	6,575	90.5%	$730,839,150	530	7.3%	$361,530,908	155	2.1%	$140,061,154	7,260	99.9%	$1,232,431,213
City of Mebane	5,835	5,303	90.9%	$724,668,108	465	8%	$658,808,326	64	1.1%	$80,636,670	5,832	99.9%	$1,464,113,104
Town of Elon	2,760	2,437	88.3%	$354,331,614	147	5.3%	$177,245,511	174	6.3%	$164,685,188	2,758	99.9%	$696,262,313
Town of Green Level	1,177	1,057	89.8%	$74,210,137	109	9.3%	$25,714,925	10	0.8%	$3,140,283	1,176	99.9%	$103,065,345
Town of Haw River	2,352	2,139	90.9%	$176,927,587	168	7.1%	$81,931,597	31	1.3%	$18,887,914	2,338	99.4%	$277,747,098
Town of Ossipee	330	299	90.6%	$23,591,695	21	6.4%	$7,818,555	7	2.1%	$3,837,345	327	99.1%	$35,247,594
Town of Swepsonville	573	543	94.8%	$64,072,184	24	4.2%	$42,164,538	5	0.9%	$4,842,102	572	99.8%	$111,078,824
Village of Alamance	798	714	89.5%	$80,107,337	66	8.3%	$21,659,137	17	2.1%	$9,869,977	797	99.9%	$111,636,451
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$7,132,838,242**	**7,356**	**9.8%**	**$4,184,156,980**	**1,066**	**1.4%**	**$941,747,702**	**75,018**	**99.8%**	**$12,258,742,924**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$2,589,086,376	2,818	13.4%	$2,324,419,926	234	1.1%	$328,417,209	21,020	99.9%	$5,241,923,510
City of Durham	75,588	67,732	89.6%	$12,434,227,951	6,071	8%	$7,589,695,227	1,667	2.2%	$2,342,456,981	75,470	99.8%	$22,366,380,159
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$15,023,314,327**	**8,889**	**9.20%**	**$9,914,115,153**	**1,901**	**1.97%**	**$2,670,874,190**	**96,490**	**99.86%**	**$27,608,303,669**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$3,803,114,902	2,657	10.8%	$826,821,271	246	1%	$448,364,911	24,527	100%	$5,078,301,084
Town of Carrboro	5,782	5,464	94.5%	$1,445,444,137	261	4.5%	$229,615,650	46	0.8%	$128,734,094	5,771	99.8%	$1,803,793,881
Town of Chapel Hill	15,108	13,922	92.1%	$4,582,606,601	617	4.1%	$1,143,791,302	528	3.5%	$1,218,954,181	15,067	99.7%	$6,945,352,084
Town of Hillsborough	3,883	3,408	87.8%	$532,364,636	358	9.2%	$363,042,252	111	2.9%	$191,853,741	3,877	99.8%	$1,087,260,629
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$10,363,530,276**	**3,893**	**7.90%**	**$2,563,270,475**	**931**	**1.89%**	**$1,987,906,927**	**49,242**	**99.87%**	**$14,914,707,678**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$1,947,887,687	2,613	14.8%	$411,520,220	156	0.9%	$268,286,254	17,662	99.7%	$2,627,694,161
City of Roxboro	6,617	5,754	87%	$771,414,967	710	10.7%	$779,740,838	144	2.2%	$253,020,495	6,608	99.9%	$1,804,176,301
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$2,719,302,654**	**3,323**	**13.7%**	**$1,191,261,058**	**300**	**1.2%**	**$521,306,749**	**24,270**	**99.7%**	**$4,431,870,462**
Total	**245,410**	**217,361**	**88.6%**	**$35,238,985,499**	**23,461**	**9.6%**	**$17,852,803,666**	**4,198**	**1.7%**	**$6,121,835,568**	**245,020**	**99.8%**	**$59,213,624,733**

Source: NCEM Risk Management Tool

Table 4.92 – Estimated Buildings Impacted by EF4 Tornado

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	25,911	87.4%	$2,489,407,280	3,425	11.6%	$646,628,811	283	1%	$203,849,721	29,619	99.9%	$3,339,885,811
City of Burlington	24,403	21,618	88.6%	$2,454,675,492	2,401	9.8%	$2,259,677,120	320	1.3%	$346,997,520	24,339	99.7%	$5,061,350,131
City of Graham	7,269	6,575	90.5%	$742,338,329	530	7.3%	$373,949,908	155	2.1%	$148,278,625	7,260	99.9%	$1,264,566,863
City of Mebane	5,835	5,303	90.9%	$738,200,254	465	8%	$678,712,544	64	1.1%	$85,796,647	5,832	99.9%	$1,502,709,446
Town of Elon	2,760	2,437	88.3%	$360,522,097	147	5.3%	$181,537,479	174	6.3%	$171,709,082	2,758	99.9%	$713,768,658
Town of Green Level	1,177	1,057	89.8%	$74,397,746	109	9.3%	$26,613,523	10	0.8%	$3,252,974	1,176	99.9%	$104,264,243
Town of Haw River	2,352	2,139	90.9%	$177,823,301	168	7.1%	$83,937,634	31	1.3%	$19,712,118	2,338	99.4%	$281,473,054
Town of Ossipee	330	299	90.6%	$23,604,936	21	6.4%	$8,176,015	7	2.1%	$4,052,387	327	99.1%	$35,833,338
Town of Swepsonville	573	543	94.8%	$64,304,068	24	4.2%	$42,538,986	5	0.9%	$5,344,274	572	99.8%	$112,187,328
Village of Alamance	798	714	89.5%	$80,201,494	66	8.3%	$21,877,126	17	2.1%	$10,689,059	797	99.9%	$112,767,678
Subtotal Alamance	**75,147**	**66,596**	**88.6%**	**$7,205,474,997**	**7,356**	**9.8%**	**$4,323,649,146**	**1,066**	**1.4%**	**$999,682,407**	**75,018**	**99.8%**	**$12,528,806,550**
Durham County													
Unincorporated Durham County	21,038	17,968	85.4%	$2,589,086,376	2,818	13.4%	$2,324,419,926	234	1.1%	$328,417,209	21,020	99.9%	$5,241,923,510
City of Durham	75,588	67,732	89.6%	$12,434,227,951	6,071	8%	$7,590,798,683	1,667	2.2%	$2,342,569,833	75,470	99.8%	$22,367,596,468
Subtotal Durham	**96,626**	**85,700**	**88.69%**	**$15,023,314,327**	**8,889**	**9.20%**	**$9,915,218,609**	**1,901**	**1.97%**	**$2,670,987,042**	**96,490**	**99.86%**	**$27,609,519,978**
Orange County													
Unincorporated Orange County	24,533	21,624	88.1%	$3,823,989,828	2,657	10.8%	$849,324,545	246	1%	$482,111,367	24,527	100%	$5,155,425,740
Town of Carrboro	5,782	5,464	94.5%	$1,485,802,409	261	4.5%	$239,506,927	46	0.8%	$142,333,389	5,771	99.8%	$1,867,642,726
Town of Chapel Hill	15,108	13,922	92.1%	$4,690,742,042	617	4.1%	$1,194,488,017	528	3.5%	$1,286,782,219	15,067	99.7%	$7,172,012,277
Town of Hillsborough	3,883	3,408	87.8%	$540,389,208	358	9.2%	$379,563,608	111	2.9%	$209,480,982	3,877	99.8%	$1,129,433,797
Subtotal Orange	**49,306**	**44,418**	**90.09%**	**$10,540,923,487**	**3,893**	**7.90%**	**$2,662,883,097**	**931**	**1.89%**	**$2,120,707,957**	**49,242**	**99.87%**	**$15,324,514,540**
Person County													
Unincorporated Person County	17,714	14,893	84.1%	$1,950,079,217	2,613	14.8%	$428,732,875	156	0.9%	$286,100,406	17,662	99.7%	$2,664,912,497
City of Roxboro	6,617	5,754	87%	$780,609,400	710	10.7%	$804,007,921	144	2.2%	$274,031,484	6,608	99.9%	$1,858,648,805
Subtotal Person	**24,331**	**20,647**	**84.9%**	**$2,730,688,617**	**3,323**	**13.7%**	**$1,232,740,796**	**300**	**1.2%**	**$560,131,890**	**24,270**	**99.7%**	**$4,523,561,302**
Total	**245,410**	**217,361**	**88.6%**	**$35,500,401,428**	**23,461**	**9.6%**	**$18,134,491,648**	**4,198**	**1.7%**	**$6,351,509,296**	**245,020**	**99.8%**	**$59,986,402,370**

Source: NCEM Risk Management Tool

Environment

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

Consequence Analysis

Table 4.93 summarizes the potential negative consequences of tornado.

Table 4.93 – Consequence Analysis - Tornado

Category	Consequences
Public	Injuries; fatalities
Responders	Injuries; fatalities; potential impacts to response capabilities due to storm impacts
Continuity of Operations (including Continued Delivery of Services)	Potential impacts to continuity of operations due to storm impacts; delays in providing services
Property, Facilities and Infrastructure	The weakest tornadoes, EF0, can cause minor roof damage, while strong tornadoes can destroy frame buildings and even badly damage steel reinforced concrete structures. Buildings are vulnerable to direct impact from tornadoes and also from wind borne debris. Mobile homes are particularly susceptible to damage during tornadoes.
Environment	Potential devastating impacts in storm's path
Economic Condition of the Jurisdiction	Contingent on tornado's path; can severely impact/destroy critical infrastructure and other economic drivers
Public Confidence in the Jurisdiction's Governance	Public confidence in the jurisdiction's governance may be influenced by severe tornado events if response and recovery are not timely and effective.

Hazard Summary by Jurisdiction

The following table summarizes tornado hazard risk by jurisdiction. Tornado hazard risk does not vary substantially by jurisdiction.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	3	3	2	4	1	2.7	H
Burlington	3	3	2	4	1	2.7	H
Graham	3	3	2	4	1	2.7	H
Mebane	3	3	2	4	1	2.7	H
Elon	3	3	2	4	1	2.7	H
Green Level	3	3	2	4	1	2.7	H
Haw River	3	3	2	4	1	2.7	H
Ossipee	3	3	2	4	1	2.7	H
Swepsonville	3	3	2	4	1	2.7	H
Alamance	3	3	2	4	1	2.7	H
Durham County	3	3	2	4	1	2.7	H
Durham	3	3	2	4	1	2.7	H
Orange County	3	3	2	4	1	2.7	H
Carrboro	3	3	2	4	1	2.7	H
Chapel Hill	3	3	2	4	1	2.7	H
Hillsborough	3	3	2	4	1	2.7	H
Person County	3	3	2	4	1	2.7	H
Roxboro	3	3	2	4	1	2.7	H

4.5.11 Wildfire

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Wildfire	Possible	Limited	Moderate	Less than 6 hrs	Less than 1 week	2.5

Hazard Background

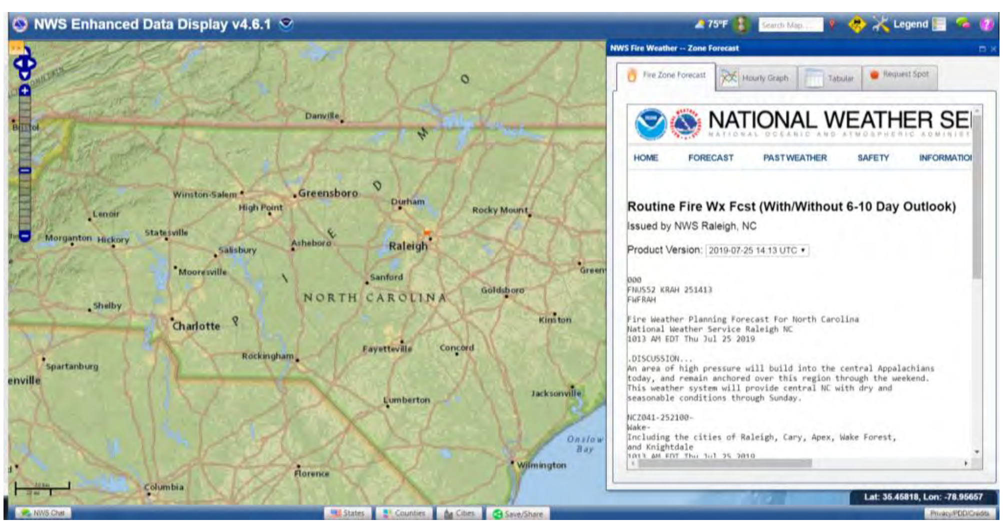
A wildfire is an uncontained fire that spreads through the environment. Wildfires have the ability to consume large areas, including infrastructure, property, and resources. When massive fires, or conflagrations, develop near populated areas, evacuations possibly ensue. Not only do the flames impact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

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

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

Weather plays a major role in the birth, growth and death of a wildfire. In support of forecasting for fire weather, the National Weather Service Fire Weather Program emerged in response to a need for weather support to large and dangerous wildfires. This service is provided to federal and state land management agencies for the prevention, suppression, and management of forest and rangeland fires. As shown in Figure 4.35, the National Weather Service Raleigh Forecast Office provides year-round fire weather forecasts for the region.

Figure 4.35 – Fire Weather Forecast, Eno-Haw Region



Source: National Weather Service

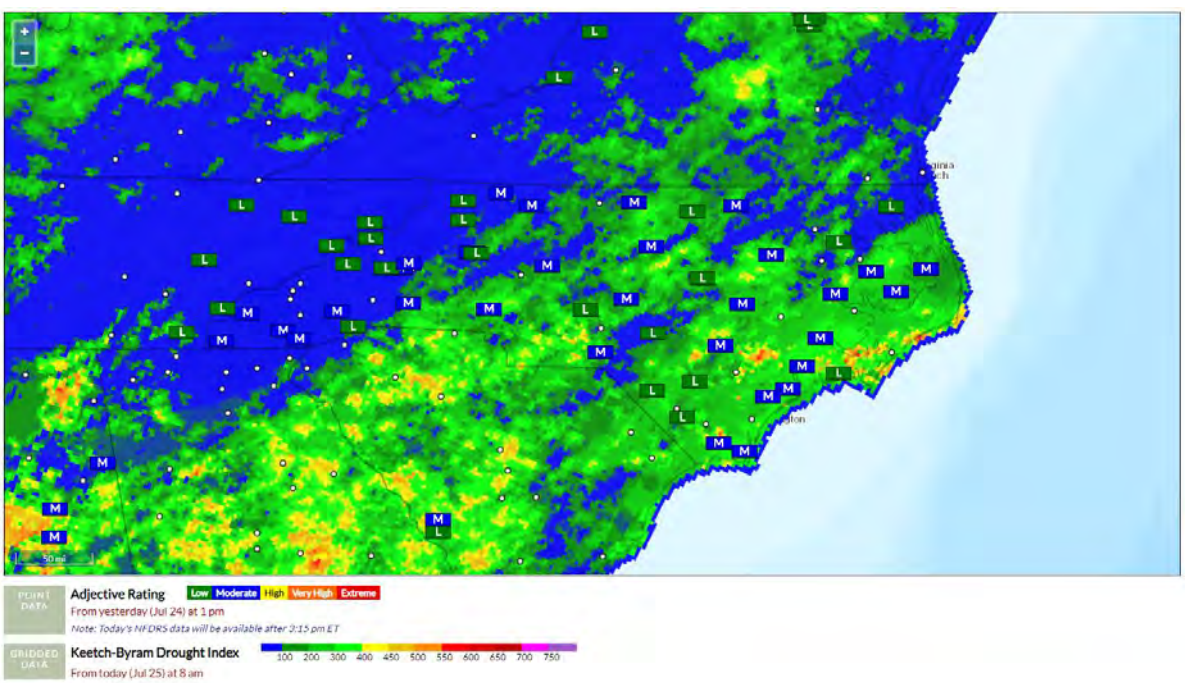
Weather conditions favorable to wildfire include drought, which increases flammability of surface fuels, and winds, which aid a wildfire's progress. The combination of wind, temperature, and humidity affects how fast wildland fires can spread. Rapid response can contain wildfires and limit their threat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

The Eno-Haw Region experiences a variety of wildfire conditions found in the Keetch-Byram Drought Index, which is described in Table 4.94. The Keetch-Byram Drought Index (KBDI) for July 24, 2019 is shown in Figure 4.36 along with a Daily Fire Danger Estimate Adjective Rating for certain points across the state. The KBDI for the Eno-Haw Region at this time was between 0 and 500, and the Fire Danger Estimate for the nearby area was "Low" to "Medium."

Table 4.94 – Keetch-Byram Drought Index Fire Danger Rating System

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

Figure 4.36 – Keetch-Byram Drought Index, July 2019



Source: USFS Wildland Fire Assessment System

Warning Time: 4 – Less than 6 hours

Duration: 3 – Less than 1 week

Location

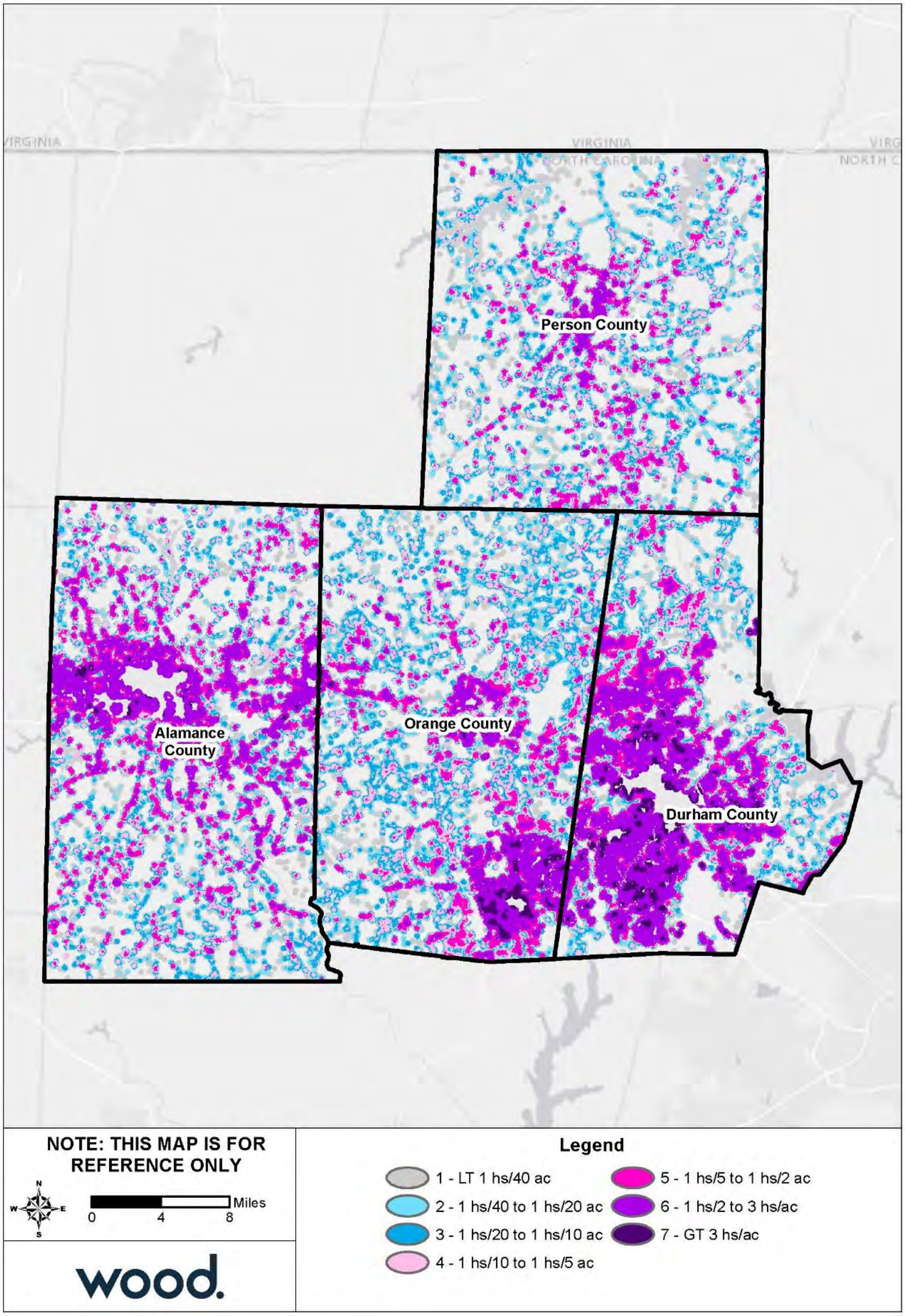
The location of wildfire risk can be defined by the acreage of Wildland Urban Interface (WUI). The WUI is described as the area where structures and other human improvements meet and intermingle with undeveloped wildland or vegetative fuels, and thus demarcates the spatial extent of wildfire risk. The WUI is essentially all the land in the county that is not heavily urbanized. The Southern Wildfire Risk Assessment (SWRA) estimates that 89.9 percent of the Eno-Haw Region's population lives within the WUI. The expansion of residential development from urban centers out into rural landscapes increases the potential for wildland fire threat to public safety and the potential for damage to forest resources and dependent industries. Population growth within the WUI substantially increases the risk of wildfire. Table 4.95 details the extent of the WUI in the Eno-Haw Region, and Figure 4.37 maps the WUI.

Table 4.95 – Wildland Urban Interface, Population and Acres

	Housing Density	WUI Population	Percent of WUI Population	WUI Acres	Percent of WUI Acres
	LT 1hs/40ac	1,955	0.4 %	124,393	20.0 %
	1hs/40ac to 1hs/20ac	4,320	0.8 %	79,359	12.8 %
	1hs/20ac to 1hs/10ac	13,920	2.6 %	108,088	17.4 %
	1hs/10ac to 1hs/5ac	28,861	5.4 %	101,696	16.4 %
	1hs/5ac to 1hs/2ac	60,086	11.2 %	91,307	14.7 %
	1hs/2ac to 3hs/1ac	305,404	57.1 %	106,566	17.1 %
	GT 3hs/1ac	120,303	22.5 %	10,484	1.7 %
	Total	**534,849**	**100.0 %**	621,893	100.0 %

Source: Southern Wildfire Risk Assessment

Figure 4.37 – Wildland Urban Interface, Eno-Haw Region



Source: Southern Wildfire Risk Assessment

Extent

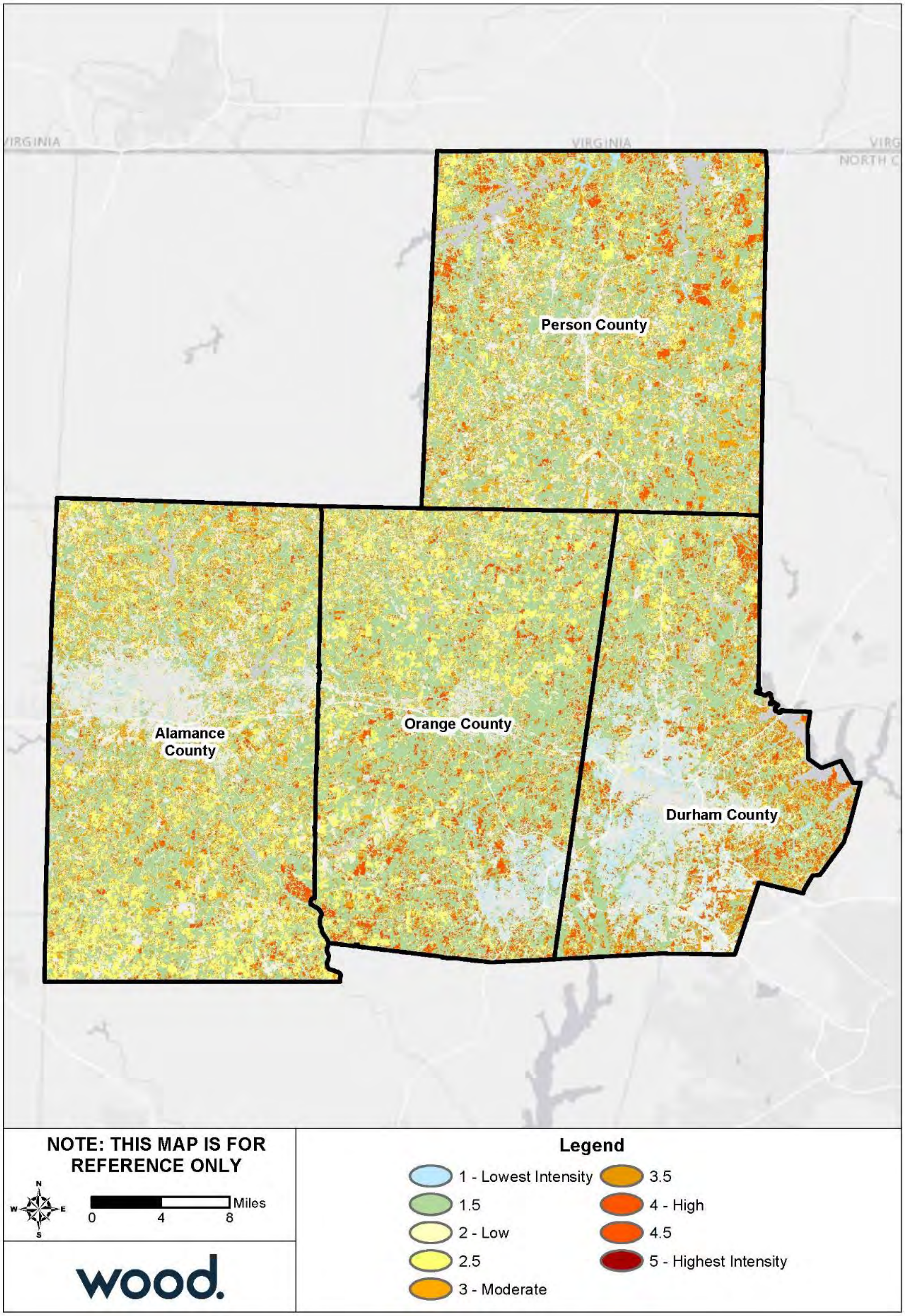
Wildfire extent can be defined by the fire's intensity and measured by the Characteristic Fire Intensity Scale, which identifies areas where significant fuel hazards which could produce dangerous fires exist. Fire Intensity ratings identify where significant fuel hazards and dangerous fire behavior potential exist based on fuels, topography, and a weighted average of four percentile weather categories. The Fire Intensity Scale consists of five classes, as defined by Southern Wildfire Risk Assessment. Figure 4.38 shows the potential fire intensity within the WUI across the Eno-Haw region.

Table 4.96 – Fire Intensity Scale

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

Source: Southern Wildfire Risk Assessment

Figure 4.38 – Characteristic Fire Intensity, Eno-Haw Region



Source: Southern Wildfire Risk Assessment

A small portion, approximately 4.2 percent, of the Eno-Haw Region may experience up to a Class 4 Fire Intensity, which poses significant harm or damage to life and property. 16 percent of the Eno-Haw Region may experience Class 3 Fire Intensity, which has potential for harm to life and property but is easier to suppress with dozer and plows. The remainder of the region is either non-burnable (17.1%) or would face a Class 1 or Class 2 Fire Intensity, which are easily suppressed.

Impact: 2 – Limited

Spatial Extent: 3 – Moderate

Historical Occurrences

The North Carolina Forest Service (NCFS) began keeping records of fire occurrence on private and state-owned lands in 1928. Since this time, there has been an average of approximately 4,000 fires burning more than 115,000 acres annually. Recently, within the last 10 years, the State has averaged closer to 3,200 fires per year and 15,000 acres burned annually.

Table 4.97 through Table 4.100 summarize past occurrences of wildfire in the Eno-Haw region by county since 1999 as provided by the NCFS in July 2019. This data only accounts for occurrences within unincorporated areas, which fall under the NCFS jurisdiction, as well as larger events in incorporated areas where local fire departments requested NCFS support for fire suppression. Actual number of fires and acreage burned are higher than what can be reported here.

Table 4.97 – Records for Wildfire in Alamance County, 1999-2018

Year	Number of Fires	Acreage Burned	Homes/Structures Protected	Value of Protected Homes/Structures
1999	19	29.8	N/A	N/A
2000	11	60.7	N/A	N/A
2001	47	72.6	N/A	N/A
2002	29	47.6	N/A	N/A
2003	5	7.2	N/A	N/A
2004	12	49.9	N/A	N/A
2005	14	53.7	N/A	N/A
2006	46	70.9	N/A	N/A
2007	20	163.6	N/A	N/A
2008	7	30.3	N/A	N/A
2009	5	11.4	13	$102,000
2010	3	1.7	2	$200,000
2011	10	47.8	41	$4,865,000
2012	3	4.5	1	$75,000
2013	2	1.1	4	$350,000
2014	6	33.7	8	$900,000
2015	10	13.56	4	$550,000
2016	24	15.08	23	$1,634,000
2017	35	21.41	34	$2,370,500
2018	23	14.75	38	$2,313,300
Total	**331**	**751.3**	**168**	**$13,359,800**

Source: NC Forest Service

Table 4.98 – Records for Wildfire in Durham County, 1999-2018

Year	Number of Fires	Acreage Burned	Homes/Structures Protected	Value of Protected Homes/Structures
1999	48	121.7	N/A	N/A
2000	21	117.2	N/A	N/A
2001	38	65.6	N/A	N/A
2002	27	97	N/A	N/A
2003	16	19.7	N/A	N/A
2004	21	21.6	N/A	N/A
2005	36	35.7	N/A	N/A
2006	40	92.1	N/A	N/A
2007	58	82.6	N/A	N/A
2008	18	106.6	N/A	N/A
2009	18	25	23	$1,995,000
2010	20	58.5	40	$4,892,000
2011	12	62.8	34	$6,364,000
2012	8	196	12	$690,000
2013	11	37.3	42	$1,695,000
2014	3	33	24	$3,300,000
2015	15	24.27	59	$20,640,000
2016	33	3.7	74	$23,083,500
2017	63	35.99	126	$29,843,000
2018	28	8.96	31	$6,123,500
Total	**534**	**1,245.32**	**465**	**$98,626,000**

Source: NC Forest Service

Table 4.99 – Records for Wildfire in Orange County, 1999-2018

Year	Number of Fires	Acreage Burned	Homes/Structures Protected	Value of Protected Homes/Structures
1999	68	63.8	N/A	N/A
2000	55	43.5	N/A	N/A
2001	113	117.9	N/A	N/A
2002	85	55.6	N/A	N/A
2003	37	28.2	N/A	N/A
2004	41	54	N/A	N/A
2005	40	39.2	N/A	N/A
2006	64	102.5	N/A	N/A
2007	23	323.2	N/A	N/A
2008	23	18.4	N/A	N/A
2009	17	46.5	7	$1,153,000
2010	31	42.3	37	$5,425,700
2011	35	47.5	55	$13,137,000
2012	13	31.5	123	$22,493,500
2013	16	43.6	63	$10,965,000
2014	23	33.5	37	$8,061,090
2015	36	46.98	59	$12,340,000
2016	62	44.34	110	$27,980,000
2017	75	80.86	139	$27,105,000
2018	35	21.76	58	$9,475,000
Total	**892**	**1,285.14**	**688**	**$138,135,290**

Source: NC Forest Service

Table 4.100 – Records for Wildfire in Person County, 1999-2018

Year	Number of Fires	Acreage Burned	Homes/Structures Protected	Value of Protected Homes/Structures
1999	33	73.6	N/A	N/A
2000	33	33.7	N/A	N/A
2001	87	121.4	N/A	N/A
2002	62	155.7	N/A	N/A
2003	6	2.7	N/A	N/A
2004	31	221.4	N/A	N/A
2005	33	45.5	N/A	N/A
2006	50	135.7	N/A	N/A
2007	53	103.8	N/A	N/A
2008	28	52.2	N/A	N/A
2009	17	13.7	2	$55,000
2010	15	62.9	19	$285,000
2011	26	27.6	6	$185,000
2012	9	10	6	$290,000
2013	16	26.7	11	$680,500
2014	15	21.6	22	$1,227,000
2015	26	36.12	13	$931,000
2016	47	134.55	11	$438,000
2017	61	46.56	17	$994,000
2018	39	146.94	7	$21,000
Total	**687**	**1,472.37**	**114**	**$5,106,500**

Source: NC Forest Service

The region experienced prolonged periods of severe drought in 2001, 2002, 2007, and 2008, as well as moderate drought in 2011, 2012, and 2018. These periods of drought may explain some of the annual variation in fires and acreage burned.

On average, the Eno-Haw Region experiences 122.2 fires and 237.7 acres burned annually from fires that require the North Carolina Forest Service to respond. Actual number of fires and acreage burned is likely higher because smaller fires within jurisdictional boundaries are managed by local fire departments.

Probability of Future Occurrence

The Southern Wildfire Risk Assessment provides a Burn Probability analysis which predicts the probability of an area burning based on landscape conditions, weather, historical ignition patterns, and historical fire prevention and suppression efforts. Burn Probability data is generated by simulating fires under different weather, fire intensity, and other conditions. Values in the Burn Probability (BP) data layer indicate, for each pixel, the number of times that cell was burned by a modeled fire, divided by the total number of annual weather scenarios simulated. The simulations are calibrated to historical fire size distributions. The Burn Probability for the Eno-Haw Region is presented in Table 4.101 and illustrated in Figure 4.39.

Table 4.101 – Burn Probability, Eno-Haw Region

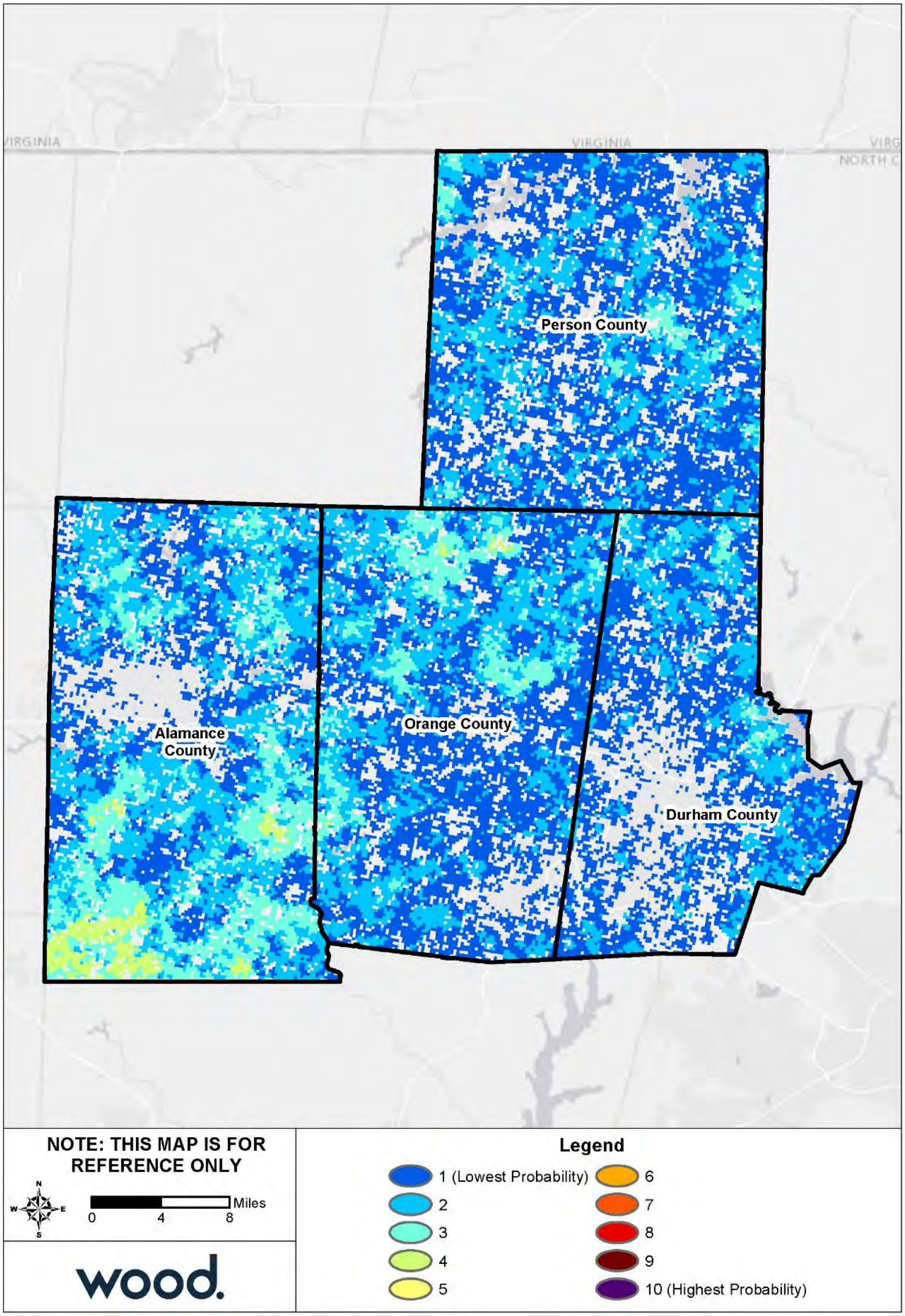
Class	Acres	Percent
1	373,069	51.0 %
2	265,850	36.4 %
3	81,153	11.1 %
4	10,898	1.5 %
5	0	0.0 %
6	0	0.0 %
7	0	0.0 %
8	0	0.0 %
9	0	0.0 %
10	0	0.0 %
Total	**730,970**	**100.0 %**

Source: Southern Wildfire Risk Assessment

All of the Eno-Haw Region has a relatively low burn probability, with the highest probabilities reaching a rating of 4 or less. The areas of moderate burn probability are located primarily in unincorporated Alamance County, particularly in the southwestern corner of the county. There is also limited area of moderate burn probability in northern unincorporated Orange County. The probability of wildfire across the region is considered possible, defined as between a 1% and 10% annual chance of occurrence. While all jurisdictions fall within this threshold, the communities containing moderate burn probability, noted above, have a comparatively higher probability of occurrence.

Probability: 2 – Possible

Figure 4.39 – Burn Probability, Eno-Haw Region



Source: Southern Wildfire Risk Assessment

Climate Change

Wildfires are usually prevalent with a combination of high temperatures and dry conditions, combustible fuels and an ignition source. Climate change has been linked to longer, warmer and drier conditions in the southeast, exacerbating key potential conditions for a wildfire to spread. Per the Triangle Regional Resilience Assessment, increasing temperatures and longer periods of drought in the region will contribute to increased wildfires frequency, intensity, and size.

Vulnerability Assessment

Methodologies and Assumptions

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

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

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

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

People

Wildfire can cause fatalities and human health hazards. Ensuring procedures are in place for rapid warning and evacuation are essential to reducing vulnerability. Table 4.102 details the population estimated to be at risk to wildfire according to the NCEM IRISK database.

Table 4.102 – Estimated Population Impacted by Wildfire

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Alamance County									
Unincorporated Alamance County	43,522	38,164	87.7%	6,358	5,575	87.7%	2,742	2,404	87.7%
City of Burlington	56,075	9,574	17.1%	8,192	1,396	17.0%	3,533	603	17.1%
City of Graham	16,584	5,520	33.3%	2,423	807	33.3%	1,045	348	33.3%
City of Mebane	14,590	11,262	77.2%	2,020	1,559	77.2%	893	689	77.2%
Town of Elon	10,006	4,301	43.0%	1,462	628	43.0%	630	271	43.0%
Town of Green Level	2,368	1,060	44.8%	346	155	44.8%	149	67	45.0%
Town of Haw River	3,773	2,759	73.1%	551	403	73.1%	238	174	73.1%
Town of Ossipee	544	227	41.7%	79	33	41.8%	34	14	41.2%
Town of Swepsonville	1,151	964	83.8%	168	141	83.9%	73	61	83.6%
Village of Alamance	1,462	1,108	75.8%	214	162	75.7%	92	70	76.1%

Jurisdiction	Total Population	Total Population at Risk		All Elderly Population	Elderly Population at Risk		All Children Population	Children at Risk	
		Number	Percent		Number	Percent		Number	Percent
Subtotal Alamance	**150,075**	**74,939**	**49.9%**	**21,813**	**10,859**	**49.8%**	**9,429**	**4,701**	**49.9%**
Durham County									
Unincorporated Durham County	38,181	1,094	2.9%	3,725	107	2.9%	2,826	81	2.9%
City of Durham	225,814	667	0.3%	22,031	65	0.3%	16,715	49	0.3%
Subtotal Durham	**263,995**	**1,761**	**0.7%**	**25,756**	**172**	**0.7%**	**19,541**	**130**	**0.7%**
Orange County									
Unincorporated Orange County	45,470	3,401	7.5%	4,381	328	7.5%	2,342	175	7.5%
Town of Carrboro	20,883	4	0.0%	2,012	0	0.0%	1,076	0	0.0%
Town of Chapel Hill	59,351	0	0.0%	5,722	0	0.0%	3,117	0	0.0%
Town of Hillsborough	8,467	374	4.4%	816	36	4.4%	436	19	4.4%
Subtotal Orange	**134,171**	**3,779**	**2.8%**	**12,931**	**364**	**2.8%**	**6,971**	**194**	**2.8%**
Person County									
Unincorporated Person County	26,396	4,073	15.4%	4,007	618	15.4%	1,584	244	15.4%
City of Roxboro	13,079	1,005	7.7%	1,986	153	7.7%	785	60	7.6%
Subtotal Person	**39,475**	**5,078**	**12.9%**	**5993**	**771**	**12.9%**	**2369**	**304**	**12.8%**
Total	**587,716**	**85,557**	**14.6%**	**66,493**	**12,166**	**18.3%**	**38,310**	**5,329**	**13.9%**

Source: NCEM Risk Management Tool

Property

Wildfire can cause direct property losses, including damage to buildings, vehicles, landscaped areas, agricultural lands, and livestock. Construction practices and building codes can increase fire resistance and fire safety of structures. Techniques for reducing vulnerability to wildfire include using street design to ensure accessibility to fire trucks, incorporating fire resistant materials in building construction, and using landscaping practices to reduce flammability and the ability for fire to spread. Properties within the WUI and outside an eight- minute drive time from a fire station are highly vulnerable.

Table 4.104 provides building counts and estimated damages for Critical Infrastructure and Key Resources (CIKR) buildings across all jurisdictions, by sector. The sectors facing the greatest risk to wildfire in the Region are commercial facilities, critical manufacturing, and government facilities.

Table 4.103 details the buildings at risk to wildfire in the Eno-Haw Region.

Table 4.103 – Estimated Buildings Impacted by Wildfire

Jurisdiction	All Buildings	Residential Buildings at Risk			Commercial Buildings at Risk			Public Buildings at Risk			Total Buildings at Risk		
	Num	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages	Num	% of Total	Estimated Damages
Alamance County													
Unincorporated Alamance County	29,650	22,720	76.6%	$2,189,482,865	3,206	10.8%	$592,495,065	255	0.9%	$184,154,306	26,181	88.3%	$2,966,132,236
City of Burlington	24,403	3,656	15%	$401,745,660	391	1.6%	$526,148,769	63	0.3%	$92,455,203	4,110	16.8%	$1,020,349,632
City of Graham	7,269	2,186	30.1%	$273,255,114	137	1.9%	$138,863,882	33	0.5%	$63,536,803	2,356	32.4%	$475,655,799
City of Mebane	5,835	4,091	70.1%	$580,442,829	275	4.7%	$455,518,397	42	0.7%	$68,570,137	4,408	75.5%	$1,104,531,363
Town of Elon	2,760	1,047	37.9%	$170,893,947	65	2.4%	$68,564,795	117	4.2%	$135,141,122	1,229	44.5%	$374,599,865
Town of Green Level	1,177	473	40.2%	$33,891,997	47	4%	$12,176,135	6	0.5%	$2,150,024	526	44.7%	$48,218,156
Town of Haw River	2,352	1,564	66.5%	$134,526,958	92	3.9%	$55,157,383	29	1.2%	$18,985,559	1,685	71.6%	$208,669,900
Town of Ossipee	330	125	37.9%	$10,933,983	15	4.5%	$7,404,940	5	1.5%	$3,301,904	145	43.9%	$21,640,827
Town of Swepsonville	573	455	79.4%	$56,169,359	21	3.7%	$37,867,378	3	0.5%	$4,890,848	479	83.6%	$98,927,585
Village of Alamance	798	541	67.8%	$65,102,560	47	5.9%	$19,385,064	13	1.6%	$9,156,697	601	75.3%	$93,644,321
Subtotal Alamance	**75,147**	**36,858**	**49%**	**$3,916,445,272**	**4,296**	**5.7%**	**$1,913,581,808**	**566**	**0.8%**	**$582,342,603**	**41,720**	**55.5%**	**$6,412,369,684**
Durham County													
Unincorporated Durham County	21,038	515	2.4%	$67,944,537	177	0.8%	$141,967,552	6	0%	$4,012,437	698	3.3%	$213,924,525
City of Durham	75,588	193	0.3%	$39,333,190	18	0%	$100,332,565	8	0%	$52,251,529	219	0.3%	$191,917,284
Subtotal Durham	**96,626**	**708**	**0.73%**	**107,277,727**	**195**	**0.20%**	**242,300,117**	**14**	**0.01%**	**56,263,966**	**917**	**0.95%**	**405,841,809**
Orange County													
Unincorporated Orange County	24,533	1,617	6.6%	$265,704,238	567	2.3%	$111,940,237	33	0.1%	$67,853,955	2,217	9%	$445,498,430
Town of Carrboro	5,782	1	0%	$226,330	0	0%	$0	0	0%	$0	1	0%	$226,330
Town of Chapel Hill	15,108	0	0%	$0	0	0%	$0	0	0%	$0	0	0%	$0
Town of Hillsborough	3,883	148	3.8%	$24,261,113	32	0.8%	$47,243,754	13	0.3%	$73,591,389	193	5%	$145,096,256
Subtotal Orange	**49,306**	**1,766**	**5.2%**	**$290,191,681**	**599**	**1.8%**	**$159,183,991**	**46**	**0.1%**	**$141,445,344**	**2,411**	**7.1%**	**$590,821,016**
Person County													
Unincorporated Person County	17,714	2,299	13%	$301,898,644	523	3%	$37,110,347	15	0.1%	$20,159,406	2,837	16%	$359,168,397
City of Roxboro	6,617	443	6.7%	$62,595,545	84	1.3%	$59,718,889	7	0.1%	$14,987,106	534	8.1%	$137,301,540
Subtotal Person	**24,331**	**2,742**	**11.3%**	**$364,494,189**	**607**	**2.5%**	**$96,829,236**	**22**	**0.1%**	**$35,146,512**	**3,371**	**13.9%**	**$496,469,937**
Total	**245,410**	**42,074**	**17.1%**	**$4,678,408,869**	**5,697**	**2.3%**	**$2,411,895,152**	**648**	**0.3%**	**$815,198,425**	**48,419**	**19.7%**	**$7,905,502,446**

Source: NCEM Risk Management Tool

Table 4.104 – Critical Infrastructure and Key Resources Buildings at Risk to Wildfire by Sector

Sector	Number of Buildings at Risk	Estimated Damages
Banking and Finance	22	$12,240,521
Commercial Facilities	1,405	$1,141,325,876
Communications	2	$707,732
Critical Manufacturing	564	$840,428,481
Defense Industrial Base	3	$31,172,887
Emergency Services	14	$7,704,597
Energy	13	$210,084,334
Food and Agriculture	3,559	$203,121,864
Government Facilities	291	$505,499,028
Healthcare and Public Health	90	$144,570,968
Nuclear Reactors, Materials and Waste	1	$50,000
Transportation Systems	386	$292,939,196
Water	50	$341,060,599
All Categories	**6,400**	**$3,730,906,083**

Source: NCEM Risk Management Tool

Environment

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

Consequence Analysis

Table 4.105 summarizes the potential detrimental consequences of wildfire.

Table 4.105 – Consequence Analysis - Wildfire

Category	Consequences
Public	In addition to the potential for fatalities, wildfire and the resulting diminished air quality pose health risks. Exposure to wildfire smoke can cause serious health problems within a community, including asthma attacks and pneumonia, and can worsen chronic heart and lung diseases. Vulnerable populations include children, the elderly, people with respiratory problems or with heart disease. Even healthy citizens may experience minor symptoms, such as sore throats and itchy eyes.
Responders	Public and firefighter safety is the first priority in all wildland fire management activities. Wildfires are a real threat to the health and safety of the emergency services. Most fire-fighters in rural areas are 'retained'. This means that they are part-time and can be called away from their normal work to attend to fires.
Continuity of Operations (including Continued Delivery of Services)	Wildfire events can result in a loss of power which may impact operations. Downed trees, power lines and damaged road conditions may prevent access to critical facilities and/or emergency equipment.
Property, Facilities and Infrastructure	Wildfires frequently damage community infrastructure, including roadways, communication networks and facilities, power lines, and water distribution systems. Restoring basic services is critical and a top priority. Efforts to restore roadways include the costs of maintenance and damage assessment teams, field data collection, and replacement or repair costs. Direct impacts to municipal water supply may occur through contamination of ash and debris during the fire, destruction of aboveground

Category	Consequences
	distribution lines, and soil erosion or debris deposits into waterways after the fire. Utilities and communications repairs are also necessary for equipment damaged by a fire. This includes power lines, transformers, cell phone towers, and phone lines.
Environment	Wildfires cause damage to the natural environment, killing vegetation and animals. The risk of floods and debris flows increases after wildfires due to the exposure of bare ground and the loss of vegetation. In addition, the secondary effects of wildfires, including erosion, landslides, introduction of invasive species, and changes in water quality, are often more disastrous than the fire itself.
Economic Condition of the Jurisdiction	Wildfires can have significant short-term and long-term effects on the local economy. Wildfires, and extreme fire danger, may reduce recreation and tourism in and near the fires. If aesthetics are impaired, local property values can decline. Extensive fire damage to trees can significantly alter the timber supply, both through a short-term surplus from timber salvage and a longer-term decline while the trees regrow. Water supplies can be degraded by post-fire erosion and stream sedimentation.
Public Confidence in the Jurisdiction's Governance	Wildfire events may cause issues with public confidence because they have very visible impacts on the community. Public confidence in the jurisdiction's governance may be influenced by actions taken pre-disaster to mitigate and prepare for impacts, including the amount of public education provided; efforts to provide warning to residents; event response efforts; and recovery efforts,

Hazard Summary by Jurisdiction

The following table summarizes wildfire hazard risk by jurisdiction. Wildfire warning time and duration do not vary by jurisdiction. Spatial extent ratings were based on the proportion of area within the WUI; all jurisdictions have at least 50% of their area in the WUI and were assigned a rating of 3. Impact ratings were based on fire intensity data from SWRA. No jurisdictions have significant clusters of moderate to high fire intensity; therefore, all jurisdictions were assigned a rating of 2. Probability ratings were determined based on burn probability data from SWRA. Jurisdictions with clusters of moderate burn probability were assigned a rating of 3; all other jurisdictions were assigned a probability of 2.

Jurisdiction	Probability	Impact	Spatial Extent	Warning Time	Duration	Score	Priority
Alamance County	3	2	3	4	3	2.8	H
Burlington	2	2	3	4	3	2.5	H
Graham	2	2	3	4	3	2.5	H
Mebane	2	2	3	4	3	2.5	H
Elon	2	2	3	4	3	2.5	H
Green Level	2	2	3	4	3	2.5	H
Haw River	2	2	3	4	3	2.5	H
Ossipee	2	2	3	4	3	2.5	H
Swepsonville	2	2	3	4	3	2.5	H
Alamance	2	2	3	4	3	2.5	H
Durham County	2	2	3	4	3	2.5	H
Durham	2	2	3	4	3	2.5	H
Orange County	3	2	3	4	3	2.8	H
Carrboro	2	2	3	4	3	2.5	H
Chapel Hill	2	2	3	4	3	2.5	H
Hillsborough	2	2	3	4	3	2.5	H
Person County	2	2	3	4	3	2.5	H
Roxboro	2	2	3	4	3	2.5	H

4.5.12 Civil Unrest

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Civil Unrest	Possible	Limited	Small	Less than 6 hrs	Less than 1 week	2.3

Hazard Background

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

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

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

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

Types of Crowds

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

Casual Crowd — A casual crowd is merely a group of people who happen to be in the same place at the same time. Examples of this type include shoppers and sightseers. The likelihood of violent conduct is all but nonexistent.

Cohesive Crowd — A cohesive crowd consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common activity, such as worshiping, dancing, or watching a sporting event. Although they may have intense internal discipline (e.g., rooting for a team), they require substantial provocation to arouse to action.

Expressive Crowd — An expressive crowd is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of common sentiment or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest something.

Aggressive Crowd — An aggressive crowd is made up of individuals who have assembled for a specific purpose. This crowd often has leaders who attempt to arouse the members or motivate them to action.

Members are noisy and threatening and will taunt authorities. They tend to be impulsive and highly emotional and require only minimal stimulation to arouse them to violence. Examples of this type of crowd include demonstrations and strikers.

Types of Mobs

A mob can be defined as a large disorderly crowd or throng. Mobs are usually emotional, loud, tumultuous, violent, and lawless. Like crowds, mobs have different levels of commitment and can be classified into four categories:

Aggressive Mob—An aggressive mob is one that attacks, riots, and terrorizes. The object of violence may be a person, property, or both. An aggressive mob is distinguished from an aggressive crowd only by lawless activity. Examples of aggressive mobs are the inmate mobs in prisons and jails, mobs that act out their frustrations after political defeat, or violent mobs at political protests or rallies.

Escape Mob—An escape mob is attempting to flee from something such as a fire, bomb, flood, or other catastrophe. Members of escape mobs have lost their capacity to reason and are generally impossible to control. They are characterized by unreasonable terror.

Acquisitive Mob—An acquisitive mob is one motivated by a desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits a lack of control by authorities in safeguarding property. Examples of acquisitive mobs would include the looting in South Central Los Angeles in 1992, or food riots in other countries.

Expressive Mob—An expressive mob is one that expresses fervor or revelry following some sporting event, religious activity, or celebration. Members experience a release of pent up emotions in highly charged situations. Examples of this type of mob include the June 1994 riots in Canada following the Stanley Cup professional hockey championship, European soccer riots, and those occurring after other sporting events in many countries, including the United States.

Although members of mobs have differing levels of commitment, as a group they are far more committed than members of a crowd. As such, a “mob mentality” sets in, which creates a cohesiveness and sense of purpose that is lacking in crowds. Thus, any strategy that causes individual members to contemplate their personal actions will tend to be more effective than treating an entire mob as a single entity.

Warning Time: 4 – Less than six hours

Duration: 3 – Less than one week

Location

Civil disorder can arise from a number of causes for a variety of reasons. Circumstances may be spontaneous or may result from escalating tensions. Civil disorder can erupt anywhere, but the most likely locations are those areas with large population groupings or gatherings. Sites that are attractive for political or other rallies should be considered as probable locations for the epicenter of civil disorder events; arenas and stadiums are another type of venue where civil disorder can occur. Civil disorder can also occur in proximity to locations where a “trigger event” occurred.

Extent

The ultimate extent of any civil disorder incident will depend on the magnitude of that event and its location. The more widespread an incident is, the greater the likelihood of excessive injury, loss of life and property damage; additional factors, such as the ability of law enforcement to contain the event, are also critical in minimizing damages.

Impact: 2 – Limited

Spatial Extent: 2 – Small

Historical Occurrences

Events in North Carolina's early history, as well as those from the late 1960s through this decade, indicate the State is not immune to riots, protests, and social upheaval. Some brief examples of civil unrest across the state are provided below.

The Greensboro Uprising in 1969 occurred on and around the campuses of James B. Dudley High School and North Carolina Agricultural and Technical State University (A&T) in Greensboro in May 1969. The uprising was sparked by perceived civil rights issues at the segregated high school, and then spread to the A&T campus. The uprising ended after the National Guard made a sweep of A&T dormitories, taking hundreds of students into protective custody.

The Wilmington Ten were arrested for a firebombing in February 1971 in Wilmington. Responders reported being shot at by snipers from the roof of a nearby church; the neighborhood erupted in rioting that lasted through the next day, leaving two people dead. The National Guard was activated and entered the church the next day to remove the suspects; the violence resulted in two deaths, six injuries, and more than a half million dollars in property damage. Nine young black men and a white female were arrested in connection with the crime and convicted, though their sentences were commuted; ultimately, they were granted full pardons in 2012.

The Greensboro Massacre took place in November 1979, when members of the Communist Workers' Party and others demonstrated against the Ku Klux Klan in Greensboro. Gunfire was exchanged between the demonstrators and members of the KKK and the American Nazi Party. The incident resulted in five fatalities and twelve injuries.

The Charlotte Riot of 2016 was a protest that lasted for three days, as a reaction to the shooting of a black man by a black police officer. One person was killed by a civilian, and multiple officers and civilians were injured in the unrest. The City of Charlotte eventually instituted a citywide curfew to quell the violence, and a State of Emergency was issued by the Governor, providing additional law enforcement and national guard support. The shooting was eventually ruled as justified.

Since 2010, civil unrest has again trended toward race relations as a cause. From controversial shootings of African American men by white police officers to the resulting Black Lives Matter movement, these trends may continue into the future as the country finds ways to improve race relations. North Carolina has experienced specific incidents of racial unrest and violence as part of this trend, and may continue to see these types of incidents in the future.

Specific incidents occurring in a single jurisdiction can cause civil unrest nationally; the Michael Brown shooting incident in Ferguson, MO is an example of this. On November 25, 2014, CNN reported that thousands of people in more than 170 U.S. cities rallied to protest the grand jury decision not to indict the officer involved. Protests also took place internationally, with demonstrations held in several major cities in Canada, and as far away as London.

Another recent trend is the destruction and/or defacement of statues dedicated to the Confederacy during the Civil War; the planning area itself has experienced incidents of this nature, including the destruction of the Confederate Soldiers Monument in Durham County in August 2017, and the destruction of the Silent Sam statue at the University of North Carolina at Chapel Hill in 2018. As the country continues to debate whether monuments to the Confederacy are still appropriate in 2019, these types of incidents may continue to occur.

Probability of Future Occurrence

In their article on "Understanding Riots" published in the *Cato Journal* (Vol. 14, No 1), David D. Haddock and Daniel D. Polsby note that a large crowd itself is not an incipient riot merely because it assembles a great many people. Haddock and Polsby explain that "starting signals" must occur for civil disorder to erupt; these starting signals include certain kinds of high profile events. In fact, incidents can become signals simply because they have been signals in the past. In Detroit, for example, Devils Night (the night before Halloween) has in recent years become a springboard for multiple, independent, and almost simultaneous acts of arson. With any conventional triggering event, such as news of an assassination or unpopular jury verdict, crowds form spontaneously in various places as word of the incident spreads, without any one person having to recruit them. But since not every crowd threatens to evolve into a riot, the authors reason that a significant number of people must expect and desire that the crowd will become riotous. In addition, "someone has to serve as a catalyst—a sort of entrepreneur to get things going." A typical action is the breaking of a window (a signal that can be heard by many who do not necessarily see it). Someone will throw the first stone, so to speak, when he calculates the risk of being apprehended has diminished to an acceptable level. This diminished risk is generally based on two variables—the size of the crowd relative to the police force and the probability that others will follow if someone leads. The authors conclude that once someone has taken a risk to get things started, the rioting will begin and spread until civil authorities muster enough force to make rioters believe they face a realistic prospect of arrest.

Nationwide, riots are apt to be a recurrent, if unpredictable, feature of social life. Without question, the planning area will continue to experience future episodes of marches, protests, demonstrations, and gatherings in various cities and communities that could lead to some type of disruptive civil disorder. However, based on the State's general history of civil disturbance and the various human factors noted above, the probability that such incidents will develop into full-scale, widespread riots is considered low.

Should the planning area experience future incidents of disruptive civil disorder or rioting, the severity of a given event could range from low to high, depending on many factors. A spirited demonstration that gets out of hand may result in several arrests, minor damage to property (police vehicles with broken windows, etc.), some injuries, and manpower/overtime costs for police, fire, and other response services. To a greater extent, the threat of urban or intercity riots has the potential for millions of dollars in property damage, possible loss of life, and serious injuries, and extensive arrests. Sustaining police at the scene for extended periods, and possibly mobilizing state highway patrol and National Guard units, can add to the extensive manpower costs. Still, such riots tend to be confined to a single site or general area of a community rather than multiple locations or several areas of the State at the same time. Once a riot has occurred, police in other cities are generally on standby for possible riotous conditions and are better able to alleviate potential disturbances before they develop into full-scale riots.

Probability: 2 – Possible

Climate Change

As a human-caused hazard, any changes in climate would not have a direct impact on civil disorder. Far more relevant, though, could be the implications of future climate change as a cause for civil disorder. Climate change impact forecasts include increasingly extreme weather patterns that exacerbate issues of drought, flooding, severe weather and other weather hazards globally that could affect whole ecosystems. Incidents of civil disobedience could be a secondary result related to societal unrest as a result of other climate-impacted hazards.

Vulnerability Assessment

As discussed above, the impacts from civil disorder vary greatly depending on the nature, severity, and success of the attack.

When rioting does break out, it generally proves extremely difficult for first-responder law enforcement authorities to quell the mob promptly. The rules of constitutional law set stringent limits on how police officers can behave toward the people they try to arrest. Restraint also plays a crucial part in avoiding any action that “fans the flames.” Initial police presence is often undermined because forces may be staffed below the peak loads needed to bring things back under control. At a result, the riot may continue until enough state police or National Guard units arrive to bolster the arrest process and subsequently restore order. In many cases, damage to life and property may already be extensive.

Methodologies and Assumptions

Vulnerability to incidents of civil unrest were assessed based on past occurrences nationally and internationally as well as publicly available information on these vulnerabilities.

People

Injuries and fatalities can occur during civil unrest.

Property

Should a large gathering of people turn violent, damage to property and infrastructure can result, as well as looting of property.

Environment

Environmental impacts could occur if the civil unrest occurs in an outdoor or environmentally sensitive area. These impacts would be tied to the parameters of the incident.

Consequence Analysis

Table 4.106 summarizes the potential consequences of civil unrest.

Table 4.106 – Consequence Analysis – Civil Unrest

Category	Consequences
Public	Localized impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Responders	Localized impact expected to be severe for unprotected personnel and moderate to light for protected personnel.
Continuity of Operations (including Continued Delivery of Services)	Damage to facilities/personnel in the area of the incident may require temporary relocation of operations; localized disruption of lines of communication and destruction of facilities may postpone delivery of some services.
Property, Facilities and Infrastructure	Localized impact to facilities and infrastructure in the area of the incident. Some severe damage possible.
Environment	May cause extensive damage in isolated cases and some denial or delays in the use of some areas. Remediation needed.
Economic Condition of the Jurisdiction	Local economy and finances adversely affected, possibly for an extended period of time, depending on damage.

Category	Consequences
Public Confidence in the Jurisdiction’s Governance	Ability to respond and recover may be questioned and challenged if planning, response, and recovery not timely and effective.

4.5.13 Critical Infrastructure Failure

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Critical Infrastructure Failure	Possible	Critical	Small	Less than 6 hrs	More than 1 week	2.7

Hazard Background

Aging infrastructure is a concern across the United States, and transportation and utility systems in the Eno-Haw region are no exception. Per a FEMA Strategic Foresight Initiative report on Critical Infrastructure, infrastructure is becoming more prone to failure as average structure age increases, with age being the leading indicator of potential for failure in some cases. Average structure age has been steadily increasing as structures are being replaced at a slower rate. Circulation around the Eno-Haw region depends on several key bridges and roads for access and services. While there is redundancy in the transportation system in the more urban parts of the planning area, there is less redundancy in the more rural areas. As such, these key pieces of infrastructure are integral to the functioning of the communities in the planning area and would cause varying levels disruption should they become inaccessible. Damage to any of this infrastructure could result from the majority of the natural and human-caused hazards described in this plan. In addition to a secondary or cascading impact from another primary hazard, infrastructure can fail as a result of faulty equipment, lack of maintenance, degradation over time, or accidental damage such as a barge colliding with a bridge support.

Utility failure is another form critical infrastructure failure. Utility Failure refers to loss of electric power, water, sewage, natural gas, or other utilities. These failures might occur to either government or privately operated utility systems. They often occur because of, or in conjunction with, other disaster events such as high winds, hurricanes, tornadoes, winter storm events, flooding, or others. Critical utility failures might exacerbate the impacts and recovery times of such events. Failure might also be caused by accident separate of another hazard event and create hazardous conditions of their own.

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

Warning Time: 4 – Less than six hours

Duration: 4 – More than one week

Location

Critical infrastructure failure is generally localized to the site of key transportation and utility infrastructure.

Bridges are generally designed to last 50 years, therefore one way to target the location of critical transportation infrastructure failure is to identify the location of bridges 45 years or older. The North Carolina Department of Transportation maintains a list of bridges in North Carolina. Bridges built in 1975 or prior are listed below in Table 4.107, there are 206 in the region.

Utilities in the region are provided by various public and private entities as detailed in Table 4.108, and utility failures may occur anywhere in the region where utilities are provided.

Table 4.107 – Bridges Built in 1975 or Prior

County	Bridge Number	Route	Crossing	Year Built	Age (years)
Orange	32	US70	Eno River	1922	98
Alamance	92	NC49	Little Alamance Creek	1923	97
Person	28	US158	Deep Creek	1923	97
Alamance	72	NC87	Alamance Creek	1928	92
Alamance	14	NC87	Cane Creek	1929	91
Alamance	40	NC87	Branch Of Varnals Creek	1929	91
Durham	89	SR1902	Lick Creek	1930	90
Orange	16	NC751	Southern R.R.	1930	90
Person	11	US158	South Hyco Creek	1932	88
Durham	28	SR1774 (CLOSED)	Flat River	1935	85
Durham	98	NC55	Norfolk & Southern	1936	84
Alamance	81	US70	Back Creek	1938	82
Orange	86	SR1005	University Lake	1939	81
Durham	245	SR1321	Ellerbee Creek	1940	80
Orange	46	US70	Eno River	1941	79
Alamance	26	NC62	Gunn Creek	1949	71
Alamance	112	NC87	Reedy Fork Creek	1949	71
Alamance	119	NC87	Haw River	1949	71
Alamance	126	NC87	Mill Race	1949	71
Alamance	164	SR1113	Stinking Quarter Creek	1949	71
Orange	4	SR1004	West Fork Eno River	1949	71
Alamance	113	SR1003	Cane Creek	1950	70
Alamance	114	SR1003	South Fork Cane Creek	1950	70
Alamance	128	SR2369	Cane Creek	1950	70
Alamance	141	SR1005	Wells Creek	1950	70
Alamance	153	SR2371	Cane Creek	1950	70
Alamance	190	SR1005	Poppaw Creek	1950	70
Alamance	336	SR1569	Creek	1950	70
Orange	84	SR1005	Collins Creek	1950	70
Person	44	SR1111	South Flat River	1950	70
Alamance	22	SR1001	Mine Creek	1951	69
Durham	6	SR1617	Mountain Creek	1951	69
Durham	24	SR1004	Eno River	1951	69
Durham	25	SR1004	Little Creek	1951	69
Durham	44	PETTIGREW ST	NC55	1951	69
Durham	99	NC751	US15BUS, US501BUS	1951	69
Orange	24	SR1001	North Fork Little River	1951	69
Orange	37	NC86	New Hope Creek	1951	69
Orange	99	SR1723	New Hope Creek	1951	69
Person	15	SR1715	Rock Fork Branch	1951	69
Person	21	SR1715	North Flat River	1951	69
Alamance	170	SR1212	Prong Alamance Creek	1952	68
Durham	61	SR1464	Mountain Creek	1952	68
Orange	31	SR1010	Bolin Creek	1952	68
Orange	39	SR1010	Booker Creek	1952	68
Orange	41	SR1010 NBL	US15, US501 SBL	1952	68
Orange	45	US15, US501 SBL	NC54	1952	68

County	Bridge Number	Route	Crossing	Year Built	Age (years)
Durham	220	SR1004	Creek Off Eno River	1953	67
Orange	7	US70E	SR1239 W	1953	67
Orange	51	SR1534	Buffalo Creek	1953	67
Alamance	3	SR1529	Dry Creek	1954	66
Alamance	238	SR2128	Haw Creek	1954	66
Durham	106	US70 E BYP	NC98	1954	66
Durham	115	US70 W BYP	NC98	1954	66
Orange	49	NC86	Southern Railway	1954	66
Orange	77	SR1113	New Hope Creek	1954	66
Orange	114	SR1548	South Fork Little River	1954	66
Alamance	258	SR1522	Staley Creek	1955	65
Durham	92	US70 BUS., NC98	Norfolk & Western R.R.	1955	65
Durham	117	SR1308	Mud Creek	1955	65
Durham	128	US70 BUS WBL	US70 Bypass EBL	1955	65
Durham	195	SR1675	I85	1955	65
Orange	90	SR1940	Pritchard MILL CREEK	1955	65
Orange	137	SR1550	Forrest Creek	1955	65
Person	27	SR1138	Creek	1955	65
Durham	20	SR1616	Dial Creek	1956	64
Durham	80	US15/US501NBL	SR1308	1956	64
Durham	109	US15/501 NBL	NC751	1956	64
Durham	114	US15/501B SB	Norfolk Southern Railway	1956	64
Durham	216	I85 & US15 NBL	SR1637 & Southern R.R.	1956	64
Orange	18	SR1421	Branch	1956	64
Orange	61	SR1002	Creek	1956	64
Orange	73	SR1115	Cane Creek	1956	64
Orange	104	SR1712	Stoney Creek	1956	64
Orange	189	SR1114	Cane Creek	1956	64
Alamance	15	SR1530	Haw River	1957	63
Alamance	51	SR1712	Haw River	1957	63
Durham	222	I85,US15 N	SR1637	1957	63
Orange	5	US15/US501	NC54	1957	63
Orange	20	SR1365	Branch Of Stagg Creek	1957	63
Orange	59	NC86	I85	1957	63
Orange	81	I85N, NC86	SR1006	1957	63
Orange	82	I85S, NC86	SR1006	1957	63
Orange	91	I85 NBL	Southern R.R.	1957	63
Orange	93	I85 SBL	Southern R.R.	1957	63
Orange	95	SR1709	I85	1957	63
Orange	96	SR1712	I85	1957	63
Orange	209	SR1366	Frank Creek	1957	63
Person	35	SR1120 (CLOSED)	South Flat River	1957	63
Person	98	SR1565	Tar River	1957	63
Alamance	35	NC62	Haw River	1958	62
Alamance	103	SR2182	Big Branch	1958	62
Alamance	148	I40,I85	Haw River	1958	62
Orange	11	SR1336	Eno River	1958	62
Orange	63	SR1567	Eno River	1958	62

County	Bridge Number	Route	Crossing	Year Built	Age (years)
Orange	69	SR1134	Eno River	1958	62
Orange	83	I85N, NC86	SR1009	1958	62
Orange	87	I85S, NC86	SR1009	1958	62
Orange	98	I85 NBL	SR1713	1958	62
Orange	100	I85 SBL	SR1713	1958	62
Orange	103	I85 N	US70 E	1958	62
Orange	106	I85S, US70W	US70 EBL	1958	62
Orange	110	I85SBL,US70 EBL	US70 BUS WBL	1958	62
Orange	111	I85 SBL	US70 BUS WBL	1958	62
Alamance	52	SR1729	Stoney Creek	1959	61
Person	184	SR1532	Marlowe's Creek	1959	61
Alamance	24	SR1581	Stony Creek	1960	60
Alamance	36	SR1613	Tom's Creek	1960	60
Alamance	38	SR1611	Stoney Creek	1960	60
Alamance	41	SR1002	Stoney Creek	1960	60
Alamance	42	SR1002	Tom's Creek	1960	60
Alamance	173	SR1149	Back Creek	1960	60
Alamance	254	SR2104	Big Branch	1960	60
Durham	93	SR1945	Third Fork Creek	1960	60
Alamance	24	SR1581	Stony Creek	1960	60
Alamance	36	SR1613	Tom's Creek	1960	60
Alamance	38	SR1611	Stoney Creek	1960	60
Alamance	41	SR1002	Stoney Creek	1960	60
Alamance	42	SR1002	Tom's Creek	1960	60
Alamance	173	SR1149	Back Creek	1960	60
Alamance	254	SR2104	Big Branch	1960	60
Durham	93	SR1945	Third Fork Creek	1960	60
Alamance	301	SR2364	Wells Creek	1961	59
Durham	56	NC157	South Fork Little River	1961	59
Orange	27	SR1507	South Fork Little River	1961	59
Orange	192	SR1556	Strouds Creek	1961	59
Person	23	NC157	S. Flat River	1961	59
Person	50	SR1343	South Hyco Creek	1961	59
Person	51	SR1343 CLAYTON RD	Richland Creek	1961	59
Durham	85	SR1814	Little Lick Creek	1962	58
Alamance	59	SR1927	Quaker Creek Reservior	1963	57
Alamance	95	SR2116	Big Alamance Creek	1963	57
Alamance	121	SR1136	Stinking Quarter Cr.	1963	57
Orange	6	US70 BUS	Eno River	1963	57
Orange	240	SR1009	Southern Railroad	1963	57
Person	16	NC57	Hyco Lake	1963	57
Person	20	NC57	Cobbs Creek	1963	57
Person	32	NC57	Hyco Lake	1963	57
Durham	49	SR1401	Eno River	1964	56
Orange	65	SR1002	Prong Eno River	1964	56
Person	197	SR1326	N & W Railroad	1964	56
Person	198	SR1336	Norfolk & West Railway	1964	56
Person	199	SR1194	Spillway	1964	56

County	Bridge Number	Route	Crossing	Year Built	Age (years)
Alamance	109	SR2309	Alamance Creek	1965	55
Durham	200	I85 NBL, US15 NBL	SR1632	1965	55
Durham	201	I85 SBL&US15	SR1632	1965	55
Durham	218	I85, US15 SBL	SR1637 & Southern R.R.	1965	55
Durham	223	I85& US15 SB	SR1637	1965	55
Alamance	307	SR1936	Back Creek	1966	54
Durham	100	SR2028	I40	1966	54
Alamance	71	NC62	Stoney Creek	1967	53
Durham	35	US501	Eno River	1967	53
Durham	36	SR1671	Goose Creek	1967	53
Durham	55	US501N.B.	Little River(Lake)	1967	53
Durham	58	US501 S.B.	Little River(Lake)	1967	53
Durham	247	SR2028	Southern R/R	1967	53
Orange	102	SR1710	Stoney Creek	1967	53
Person	200	SR1325	Powell Creek	1967	53
Alamance	44	SR1768	Jordan's Creek	1968	52
Durham	71	US15/501 S	NC147	1968	52
Durham	147	SR1127	NC147	1968	52
Durham	154	SR1361	NC147	1968	52
Durham	156	SR1445	NC147	1968	52
Durham	160	NC147SBL	Blackwell Street	1968	52
Durham	163	NC147 NBL	Blackwell Street	1968	52
Durham	164	NC147 SBL	US15/501 NBL(BUS)	1968	52
Durham	166	NC147 NBL	US15, US501 NBL(BUS)	1968	52
Durham	169	SR1118	NC147	1968	52
Durham	173	NC147 SBL	Grant St.	1968	52
Durham	175	NC147 NBL	Grant St.	1968	52
Durham	202	SR2028 TW ALEXAND.	NC147	1968	52
Alamance	73	SR1928	Back Creek	1969	51
Durham	186	BRIGGS AVENUE	NC147	1969	51
Durham	194	SR1940	NC147	1969	51
Durham	226	I85NBL,US15N	Neuse River/Falls Lake	1969	51
Durham	227	I85 SBL,US15S	Neuse River/Falls Lake	1969	51
Durham	228	SR1959	I40	1969	51
Person	55	SR1337	Chub Lake	1969	51
Alamance	165	SR1131	Stinking Quarter Creek	1970	50
Alamance	178	SR1154	Little Alamance Creek	1970	50
Alamance	355	US70W	Storm Drain	1970	50
Durham	177	NC147 SBL	Bacon Street	1970	50
Durham	180	NC147 NBL	Bacon Street	1970	50
Durham	188	NC147 SBL	Southern Rr	1970	50
Durham	189	NC147NBL	Southern Railroad	1970	50
Durham	191	NC147 SBL	SR1171	1970	50
Durham	192	NC147 NBL	SR1171	1970	50
Person	33	SR1125	South Flat River	1970	50
Alamance	165	SR1131	Stinking Quarter Creek	1970	50
Alamance	178	SR1154	Little Alamance Creek	1970	50
Durham	83	US15/US501	SR1308	1971	49

County	Bridge Number	Route	Crossing	Year Built	Age (years)
Durham	113	US15BYP,US501	NC751	1971	49
Alamance	68	SR1928	Southern R.R.	1972	48
Alamance	105	SR2174	Mary's Creek	1972	48
Alamance	136	SR2351	South Fork Cane Creek	1972	48
Alamance	34	NC54	Back Creek	1973	47
Alamance	70	NC54	Haw Creek	1973	47
Alamance	293	SR2123	Back Creek	1973	47
Durham	206	SR1121	NC147	1973	47
Durham	212	I40 EBL RAMP	NC147 NBL	1973	47
Durham	224	SR1999	I40	1973	47
Durham	260	SR1118	American Tobacco Trail	1973	47
Person	56	SR1322	Hyco Reservoir	1973	47
Person	202	SR1313	Hyco Canal	1973	47
Person	203	SR1316	Intake Canal (CP&L)	1973	47
Alamance	98	SR1003	Mary's Creek	1974	46
Durham	137	SR1322	NC147	1974	46
Durham	138	NC147 SBL	Campus Drive	1974	46
Durham	140	NC147 NBL	Campus Drive	1974	46
Durham	142	NC147 SBL	Buchanan Blvd	1974	46
Durham	144	NC147 N	Buchanan Blvd	1974	46
Orange	17	NC54	Cane Creek	1974	46
Orange	228	SR1009	New Hope Creek	1974	46
Durham	82	SR1815	Lick Creek	1975	45
Durham	84	SR1815	Chunky Pipe Creek	1975	45
Orange	199	SR1946	Neville Creek	1975	45

Table 4.108 – Local Utility Providers

Utility Type	Local Providers
Electricity	• Duke Energy • Piedmont Electric Membership Corporation
Natural Gas	• Piedmont Natural Gas Company • Dominion Energy (Public Service Company of North Carolina)
Water & Sewer	• City of Burlington • City of Elon • City of Graham • Town of Haw River • Durham County Water Management • City of Durham • Town of Hillsborough • Orange Water and Sewer Authority • Orange-Alamance Water System • Efland Sewer System • Graham-Mebane Water System • City of Mebane • City of Roxboro

Extent

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

Critical utility failures also vary depending on the location and circumstances surrounding the failure itself. Such failures might be localized or impact large swaths of the planning area and can range in duration – lasting anywhere from a few hours to multiple days or weeks. Impacts could be small losses of communication systems or larger losses of lifelines such as water and electricity, especially to critical facilities.

Impact: 3 – Critical

Spatial Extent: 3 – Moderate

Historical Occurrences

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

A search of local newspapers and historical records did not return any instances of bridge failure in the four-county region.

Utility infrastructure failure, on the other hand, is more ubiquitous, particularly electricity outages. While small scale outages occur regularly, from high winds or downed branches, larger scale outages also occur, often in concert with large scale weather events like Hurricane Florence. The HMPC also noted two recent large scale water outages, although smaller events also occur:

- April 2016 – East Rosemary Street in Chapel Hill was shut down due to a water main break. The break caused 50 homes in the area to be without water for multiple hours as it was being repaired.
- November 2018 – A critical OWASA pipe broke in front of OWASA's building, filling Jones Ferry Road. The break left more than 80,000 customers in the Chapel Hill-Carrboro area under a boil water advisory and with limited water for over 24 hours, asking users to limit water use to save water for necessary uses, like the UNC Hospital and UNC Chilled Water facilities. UNC Classes were cancelled, and Chapel Hill-Carrboro City schools were closed for two days. The broken pipe drained more than four water towers – neighboring Chatham, Hillsborough, and Durham piped in over 3.5 million gallons of water to supplement the system while the pipe was being fixed. The brake occurred in a 77-year old pipe.
- March 2020 – OWASA had to repair to broken mains in Chapel Hill, one on South Road between Country Club Road and Raleigh Street and another on East Franklin Street between Estes Drive and Elliott Road.

The frequency of the above events highlights the fragility of aging infrastructure throughout not only the OWASA system, but across the planning area and the State of North Carolina.

Probability of Future Occurrence

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

According to the Federal Highway Administration (FHA), North Carolina ranks 27th among the 50 states in having the most roads in poor condition (6.6 percent) and 18th in terms of number of bridges rated as structurally deficient (9.9 percent). According to the U.S. Census Bureau's 2017 Annual Survey of State Government Finances, 8.8 percent of North Carolina's public spending is devoted to highways, ranking 11th among all states, and well above the national average of 5.6 percent.

Outages of critical utilities, however, are likely to occur more frequently. Power outages or water main breaks of some size happen regularly, with major incidents happening less frequently. The probability of some sort of critical infrastructure failure, then, is likely when considering large scale utility events and transportation network disruptions.

Probability: 3 – Likely

Vulnerability Assessment

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

Methodologies and Assumptions

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

People

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

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

In extreme cases, a transportation failure could leave residents stranded without power, food, or other emergency supplies.

Utility failures can severely impact the health and safety of the public, particularly for children or elderly residents. An outage at any time poses risks to vulnerable populations who cannot be without water and electricity for medical treatments or refrigerated medications. Loss of water and electricity also poses a large risk to hospitals and health systems. During periods of extreme heat or cold, loss of electricity can pose a safety hazard. In the planning area, 36% of homes are heated by utility gas and 55% by electricity. The following table summarizes the number of Medicare recipients by county who are electricity-dependent. This is defined by the Department of Health and Human Services as Medicare recipients who rely on electricity dependent medical equipment.

County by Zip Code	Electricity Dependent Medicare Recipients
Alamance County	**1,775**
Durham County	**1,329**
Orange County	**663**
Person County	**486**

Source: Department of Health and Human Services emPOWER

Property

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

Downed power lines might directly fall on houses or indirectly cause fires. Water or sewer pipe breaks or backups might cause flooding to property.

Environment

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

Consequence Analysis

Table 4.109 summarizes the potential consequences of a critical infrastructure failure.

Table 4.109 – Consequence Analysis - Critical Infrastructure Failure

Category	Consequences
Public	Potential injuries and fatalities.
Responders	Potential injuries and fatalities, as well as potentially significant delays to response times.
Continuity of Operations (including Continued Delivery of Services)	Loss of key utilities, roads, or bridges can affect delivery of services. Water, sewer, or electric outages can affect jurisdictions and entities abilities to operate at full capacity.
Property, Facilities and Infrastructure	In addition to the loss of transportation infrastructure itself, sustained road closure can impact supply chain deliveries to other critical facilities. Potential damage to property due to downed power lines
Environment	Potential for contamination of natural environment depending on the utility or infrastructure failure. May result in excess resource consumption.
Economic Condition of the Jurisdiction	May cause temporary shutdown of businesses. Delays in movement of people, goods, and services. Jurisdiction may incur costs of rebuilding or upgrading failed infrastructure.
Public Confidence in the Jurisdiction's Governance	Can cause loss of confidence in government's ability to maintain other critical infrastructure.

4.5.14 Cyber Threat

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Cyber Threat	Possible	Limited	Small	Less than 6 hrs	More than 1 week	2.4

Hazard Background

The State of North Carolina Hazard Mitigation Plan defines cyber attacks as "deliberate attacks on information technology systems in an attempt to gain illegal access to a computer, or purposely cause damage." Cyber-attacks use malicious code to alter computer operations or data. The vulnerability of computer systems to attacks is a growing concern as people and institutions become more dependent upon networked technologies. The Federal Bureau of Investigation (FBI) reports that "cyber intrusions are becoming more commonplace, more dangerous, and more sophisticated," with implications for private- and public-sector networks.

There are many types of cyber-attacks. Among the most common is a direct denial of service, or DDoS attack. This is when a server or website will be queried or pinged rapidly with information requests, overloading the system and causing it to crash.

Malware, or malicious software, can cause numerous problems once on a computer or network, from taking control of users' machines to discreetly sending out confidential information. Ransomware is a specific type of malware that blocks access to digital files and demands a payment to release them. Hospitals, school districts, state and local governments, law enforcement agencies, businesses, and even individuals can be targeted by ransomware.

Cyber spying or espionage is the act of illicitly obtaining intellectual property, government secrets, or other confidential digital information, and often is associated with attacks carried out by professional agents working on behalf of a foreign government or corporation. According to cybersecurity firm Symantec, in 2016 "…the world of cyber espionage experienced a notable shift towards more overt activity, designed to destabilize and disrupt targeted organizations and countries."

Major data breaches - when hackers gain access to large amounts of personal, sensitive, or confidential information - have become increasingly common. The Symantec report says more than seven billion identities have been exposed in data breaches over the last eight years. In addition to networked systems, data breaches can occur due to the mishandling of external drives, as has been the case with losses of some state employee data.

Cyber crime can refer to any of the above incidents when motivated primarily by financial gain or other criminal intent.

The most severe type of attack is cyber terrorism, which aims to disrupt or damage systems in order to cause fear, injury, and loss to advance a political agenda.

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

Warning Time: 4 – Less than six hours

Duration: 4 – More than one week

Location

Cyber disruption events can occur and/or impact virtually any location in the state where computing devices are used. Incidents may involve a single location or multiple geographic areas. A disruption can have far-reaching effects beyond the location of the targeted system; disruptions that occur far outside the region can still impact people, businesses, and institutions within the region.

Extent

The extent or magnitude/severity of a cyber disruption event is variable depending on the nature of the event. A disruption affecting a small, isolated system could impact only a few functions/processes. Disruptions of large, integrated systems could impact many functions/processes, as well as many individuals that rely on those systems.

There is no universally accepted scale to quantify the severity of cyber-attacks. The strength of a DDoS attack is sometimes explained in terms of a data transmission rate. One of the largest DDoS disruptions ever, which brought down some of the internet's most popular sites on October 21, 2016, peaked at 1.2 terabytes per second.

Data breaches are often described in terms of the number of records or identities exposed.

Impact: 2 – Limited

Spatial Extent: 2 – Small

Historical Occurrences

Symantec reports there were a total of 1,209 data breaches worldwide in 2016, 15 of which involved the theft of more than 10 million identities. While the number of breaches has remained relatively steady, the average number of identities stolen has increased to almost one million per incident. The report also found that one in every 131 emails contains malware, and the company's software blocked an average of 229,000 web attacks every day.

The Privacy Rights Clearinghouse, a nonprofit organization based in San Diego, maintains a timeline of 2,631 data breaches resulting from computer hacking incidents in the United States from 2005-2018. The database lists 6 data breaches in North Carolina, totaling over 2.6 million impacted records. One attack was recorded in Chapel Hill, and some of the rest almost certainly included information on individuals who live in the region. Similarly, some residents in the region were almost certainly affected by national and international data breaches. Media reports indicate an uptick in cyber attacks across the state.

Orange County was attacked with a ransomware virus in March 2019, causing slowdowns and service problems at key public offices such as the Register of Deeds, the sheriff's office and county libraries. The attack impacted a variety of county services, including disrupting the county's capability to process real estate closings, issue marriage licenses, process housing vouchers and verify tax bills. The county's Planning Department was unable to process fees or permits, and the county libraries' computers were out of service.

Probability of Future Occurrence

Cyber attacks occur daily, but most have negligible impacts at the local or regional level. The possibility of a larger disruption affecting systems within the region is a constant threat, but it is difficult to quantify the exact probability due to such highly variable factors as the type of attack and intent of the attacker. Minor attacks against business and government systems have become a commonplace occurrence but are usually stopped with minimal impact. Similarly, data breaches impacting the information of residents of the Eno-Haw Region are almost certain to happen in coming years. Major attacks or breaches specifically targeting systems in the region are less likely but cannot be ruled out.

Probability: 2 – Possible

Vulnerability Assessment

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

Methodologies and Assumptions

Vulnerability to cyber attacks was assessed based on past occurrences nationally and internationally as well as publicly available information on these vulnerabilities, as well as attacks occurring in the region.

People

Cyber-attacks can have a significant cumulative economic impact. Symantec reports that in the last three years, businesses have lost $3 billion due to spear-phishing email scams alone. A major cyber-attack has the potential to undermine public confidence and build doubt in their government's ability to protect them from harm. Injuries or fatalities from cyber attacks would generally only be possible from a major cyber terrorist attack against critical infrastructure.

Property

Short of a major cyber terrorist attacks against critical infrastructure, property damage from cyber attacks is typically limited to computer systems.

Environment

Short of a major cyber terrorist attacks against critical infrastructure, property damage from cyber attacks is typically limited to computer systems. A major cyber terrorism attack could potentially impact the environment by triggering a release of a hazardous materials, or by causing an accident involving hazardous materials by disrupting traffic-control devices.

Consequence Analysis

Table 4.110 summarizes the potential consequences of a cyber threat.

Table 4.110 – Consequence Analysis – Cyber Threat

Category	Consequences
Public	Cyber attacks can impact personal data and accounts. Injuries or fatalities could potentially result from a major cyber terrorist attacks against critical infrastructure.
Responders	Cyber attacks can impact personal data and accounts. Injuries or fatalities could potentially result from a major cyber terrorist attacks against critical infrastructure.
Continuity of Operations (including Continued Delivery of Services)	Agencies that rely on electronic backup of critical files are vulnerable. The delivery of services can be impacted since governments rely, to a great extent, upon electronic delivery of services.
Property, Facilities and Infrastructure	Rare. Most attacks affect only data and computer systems. Sabotage of utilities and infrastructure from a major cyber terrorist attacks could potentially result in system failures that damage property on a scale equal with natural disasters. Facilities and infrastructure may become unusable as a result of a cyber-attack.
Environment	Rare. A major attack could theoretically result in a hazardous materials release.
Economic Condition of the Jurisdiction	Could greatly affect the economy. In an electronic-based commerce society, any disruption to daily activities can have disastrous impacts to the economy. It is difficult to measure the true extent of the impact.
Public Confidence in the Jurisdiction's Governance	The government's inability to protect critical systems or confidential personal data could impact public confidence. An attack could raise questions regarding the security of using electronic systems for government services.

4.5.15 Hazardous Materials Incident

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Hazardous Materials Incident	Likely	Minor	Negligible	Less than 6 hrs	Less than 24 hrs	2.0

Hazard Background

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

Fixed Hazardous Materials Incident

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

Transportation Hazardous Materials Incident

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

Pipeline Incident

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

Warning Time: 4 – Less than six hours

Duration: 2 – Less than 24 hours

Location

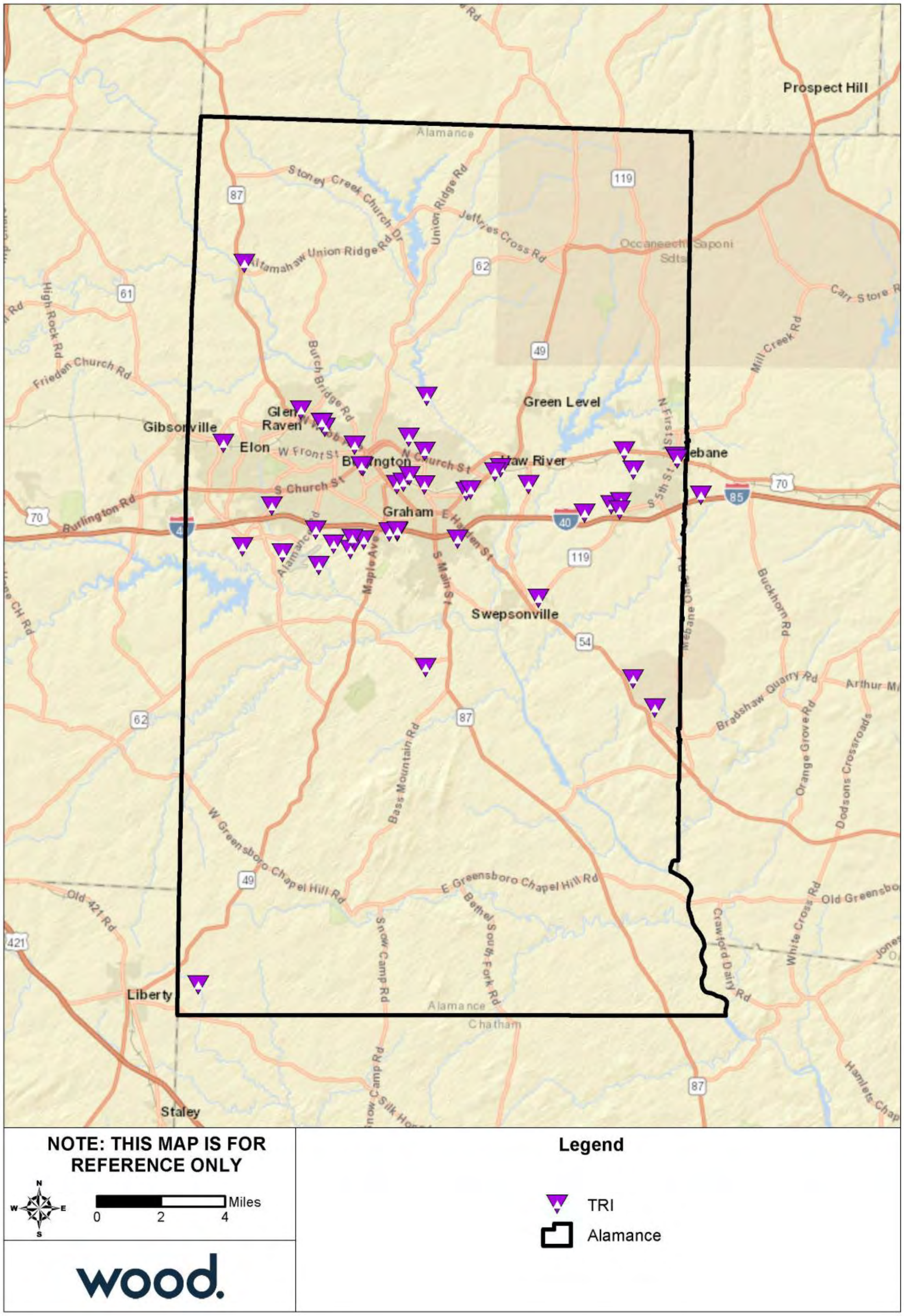
The Toxics Release Inventory (TRI) Program run by the U.S. Environmental Protection Agency (EPA) maintains a database of industrial facilities across the country and the type and quantity of toxic chemicals they release. The program also tracks pollution prevention activities and which facilities are reducing toxic releases. The Toxic Release Inventory reports 36 sites with hazardous materials in the planning area, broken out as follows:

- Alamance – 13 facilities
- Durham – 11 facilities
- Orange – 5 facilities
- Person – 7 facilities

These sites are shown in Figure 4.40 through Figure 4.43. Figure 4.44 shows Tier II sites located in Orange County. Tier II sites are those with certain chemicals above a given threshold, unique to each chemical. There are 67 sites in total across the County.

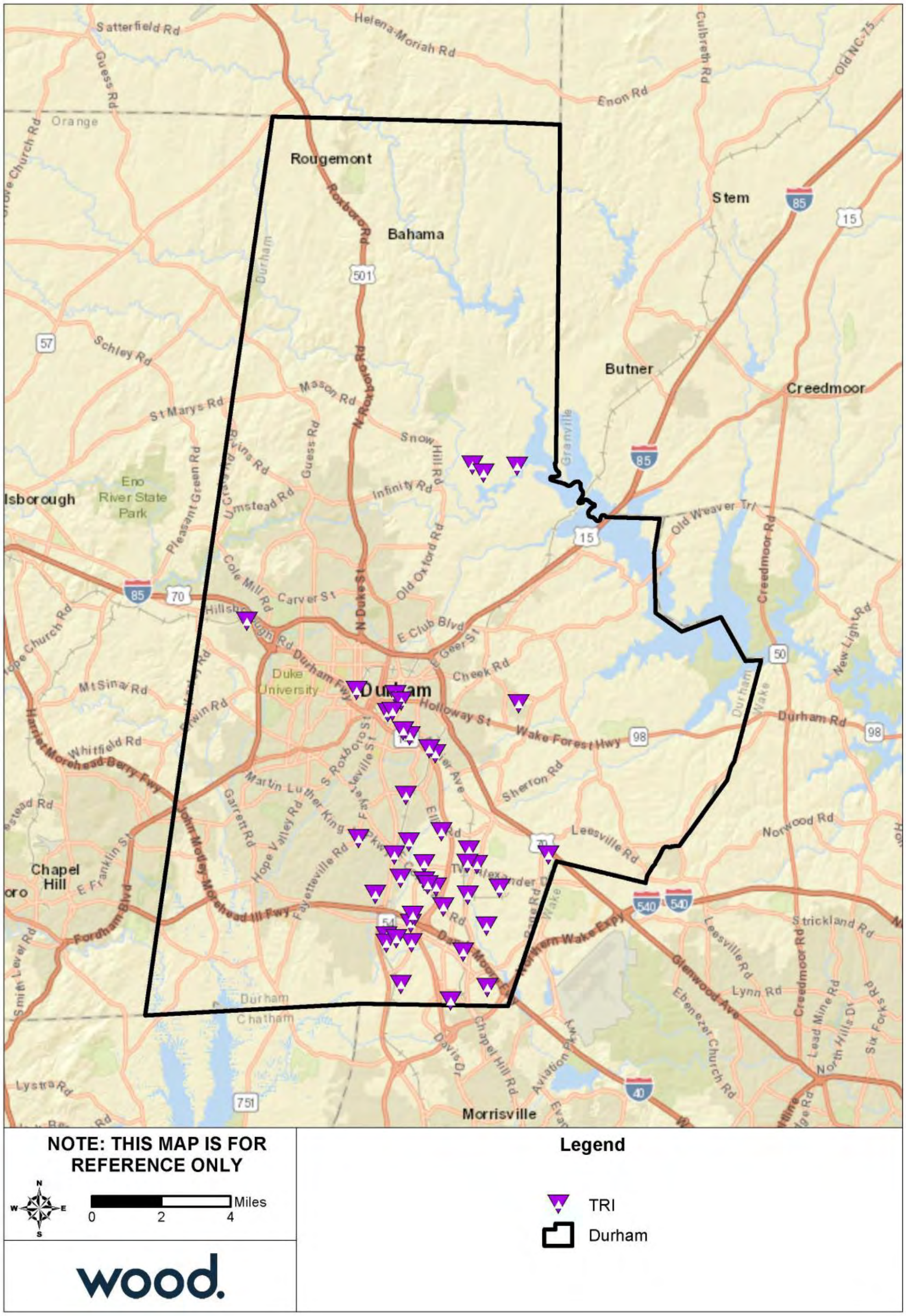
The U.S. Department of Transportation (USDOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) maintains an inventory of the location of all gas transmission and hazardous liquid pipelines as well as liquid natural gas plants and hazardous liquid breakout tanks. The location of pipelines and pipeline infrastructure in the Eno-Haw Region are shown in Figure 4.45 through Figure 4.48.

Figure 4.40 – Toxic Release Inventory Sites in Alamance County



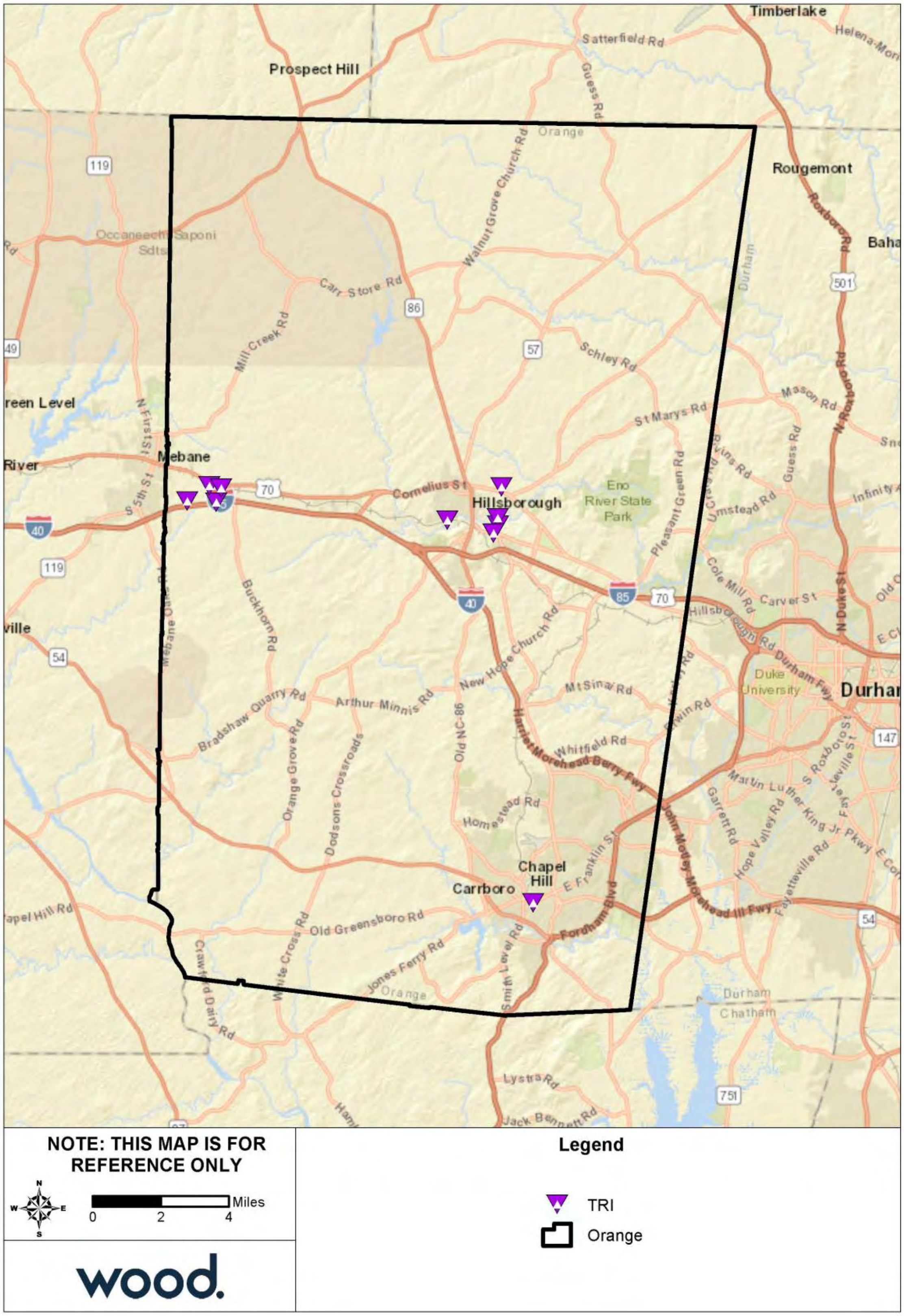
Source: EPA Toxic Release Inventory

Figure 4.41 – Toxic Release Inventory Sites in Durham County



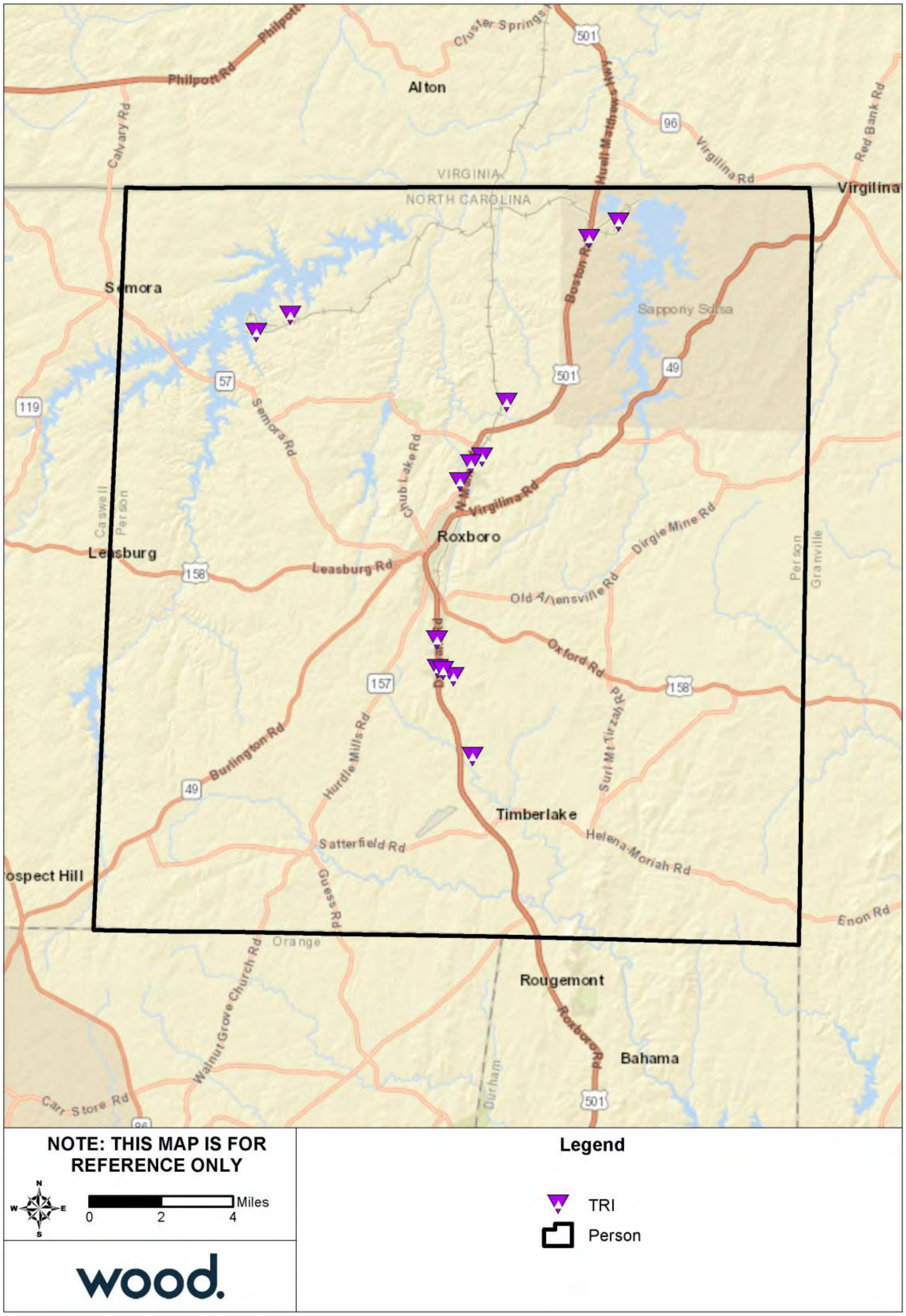
Source: EPA Toxic Release Inventory

Figure 4.42 – Toxic Release Inventory Sites in Orange County



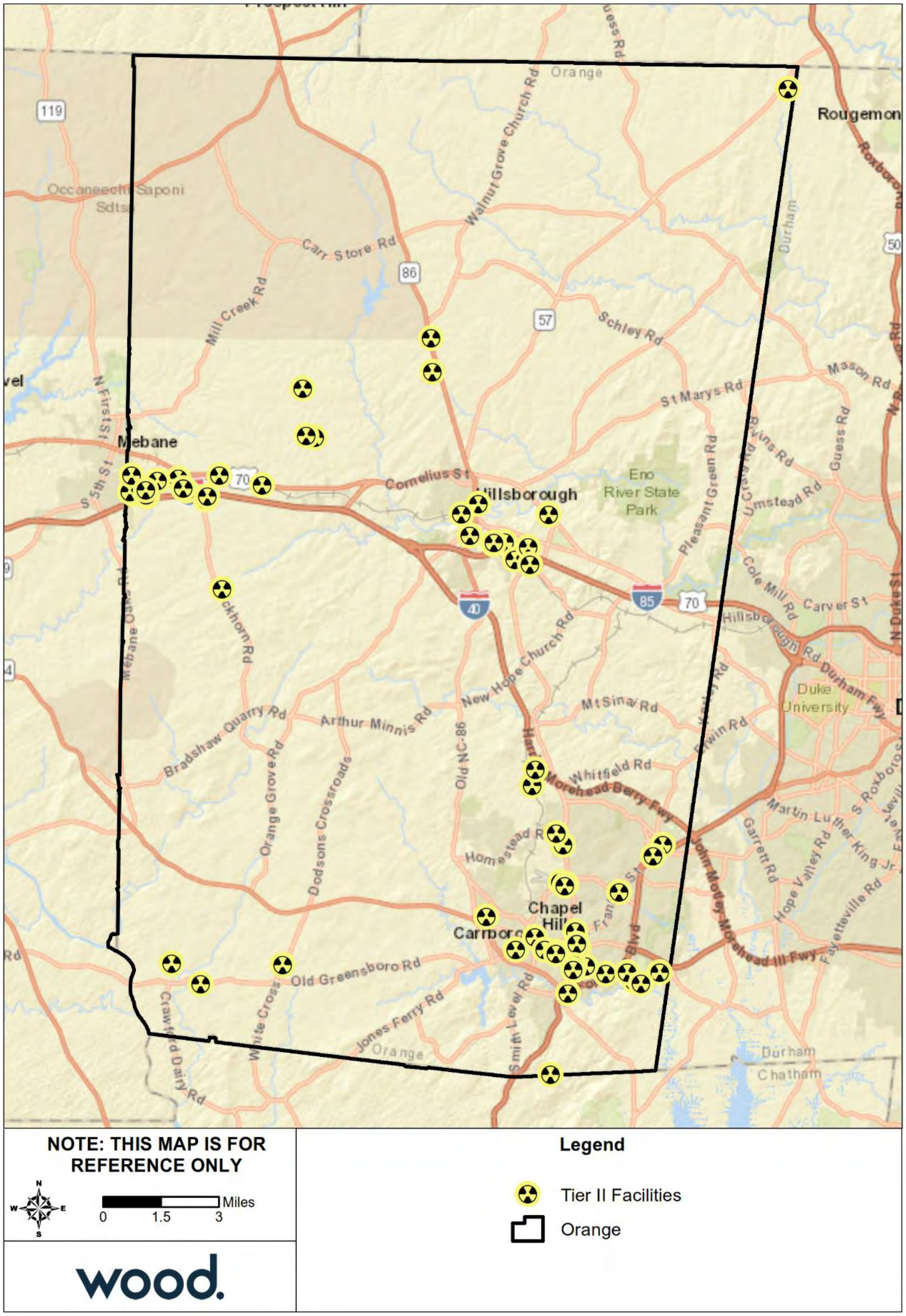
Source: EPA Toxic Release Inventory

Figure 4.43 – Toxic Release Inventory Sites in Person County



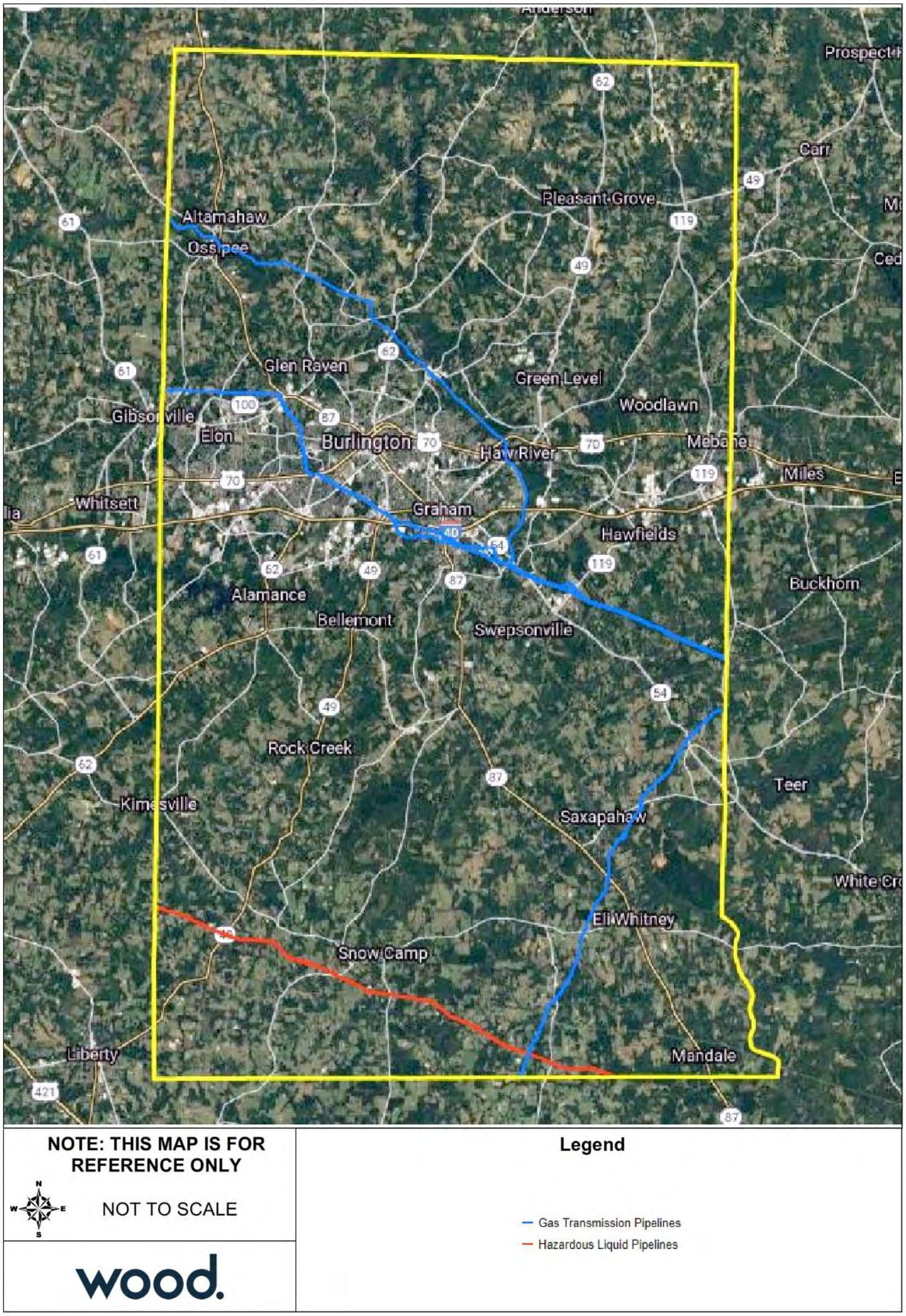
Source: EPA Toxic Release Inventory

Figure 4.44 – Tier II Sites, Orange County



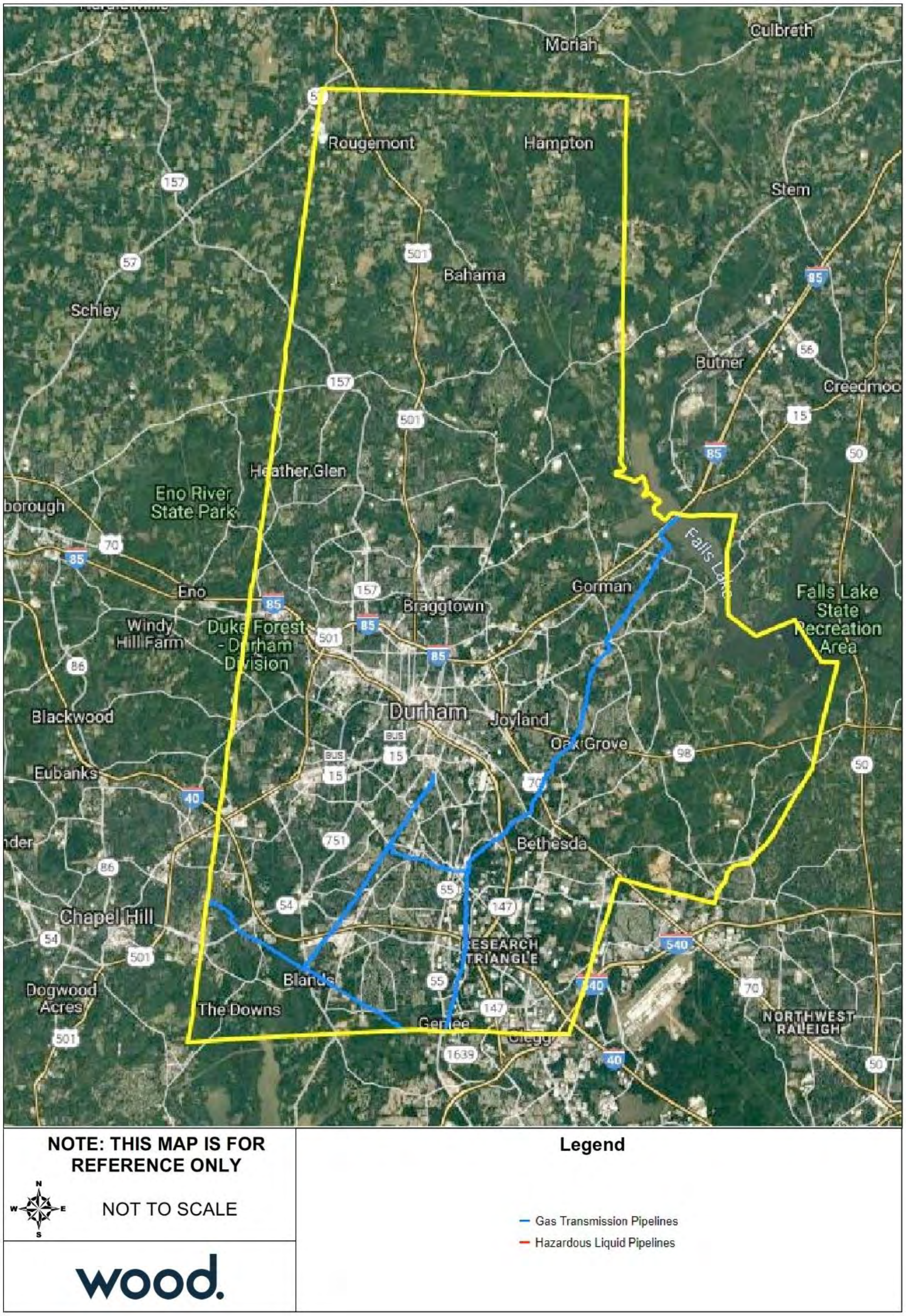
Source: EPA Toxic Release Inventory

Figure 4.45 – Pipelines and Pipeline Infrastructure in Alamance County



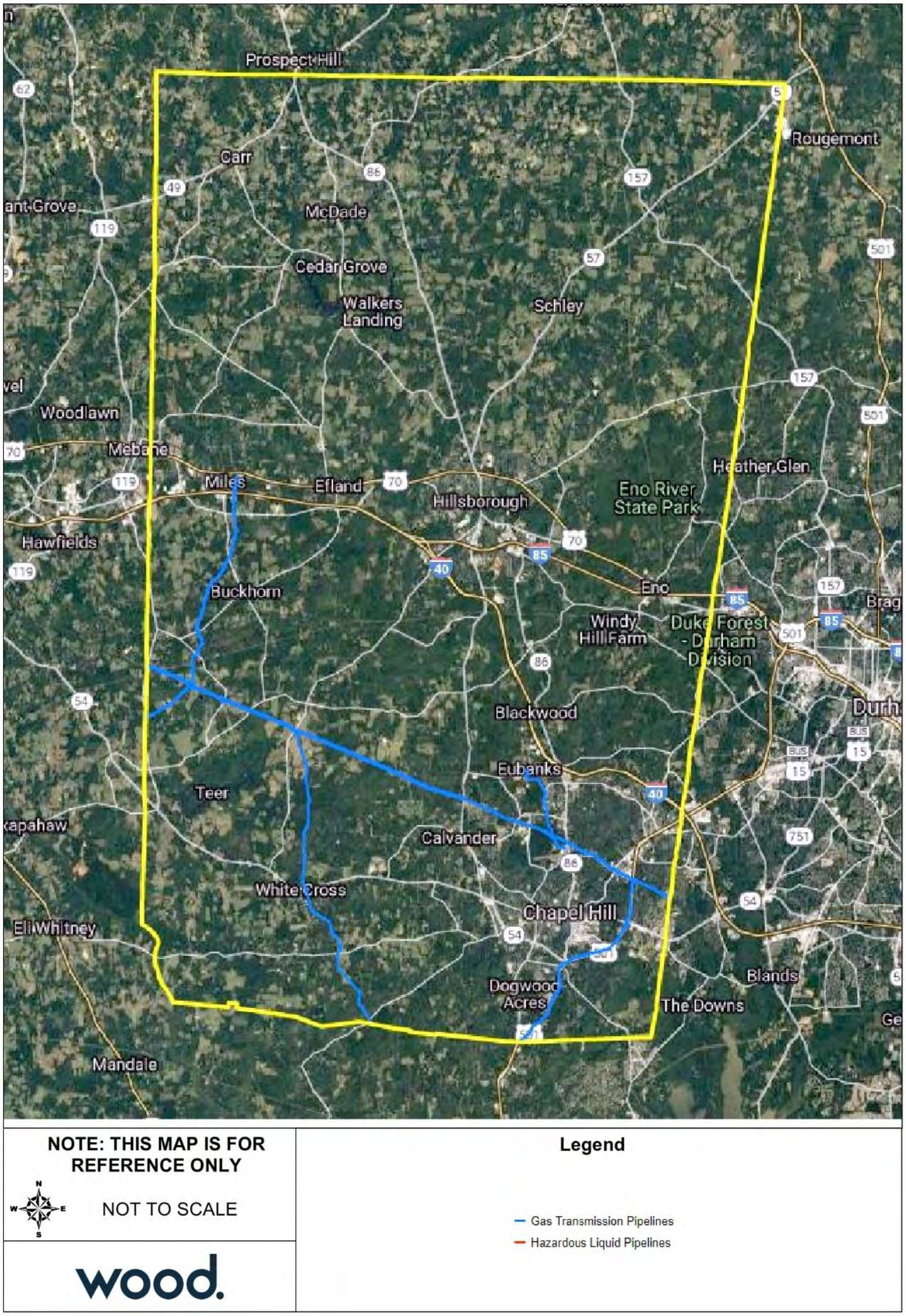
Source: US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, National Pipeline Mapping System

Figure 4.46 – Pipelines and Pipeline Infrastructure in Durham County



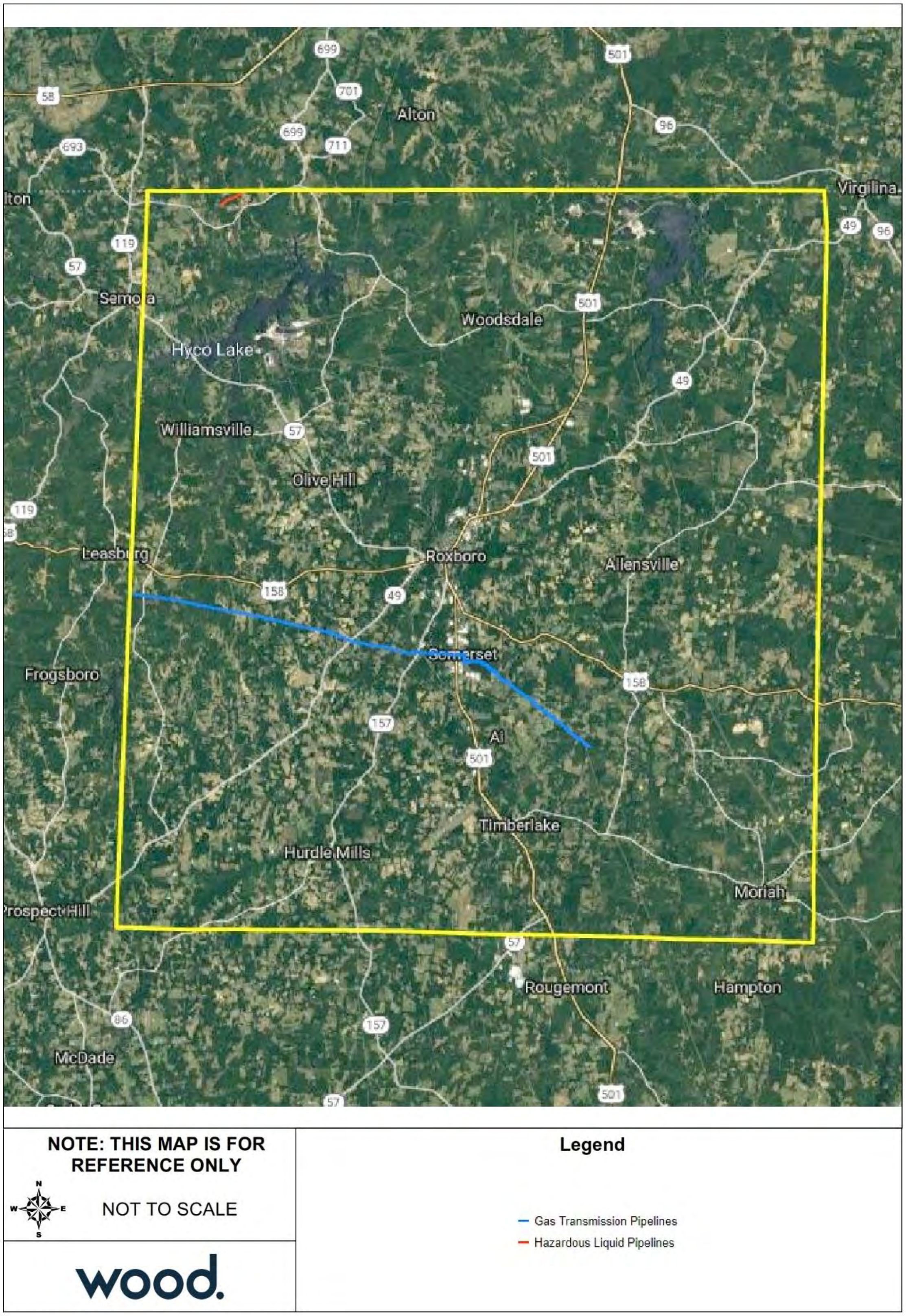
Source: US Department of Transportation, Pipeline and Hazardous Materials Safety Administration, National Pipeline Mapping System

Figure 4.47 – Pipelines and Pipeline Infrastructure in Orange County



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

Figure 4.48 – Pipelines and Pipeline Infrastructure in Person County



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

Extent

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

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

Impact: 1 – Minor

Spatial Extent: 1 – Negligible

Historical Occurrences

The Eno-Haw Region experiences several hazardous materials incidents every year. The National Response Center (NRC), operated by the U.S. Coast Guard as part of the National Response System, maintains a database of reported oil, chemical, radiological, biological and etiological discharges into the environment, anywhere in the United States and its territories. NRC records list 510 hazardous materials incidents in the four counties of the Eno-Haw Region from 1990 through 2018. 48% of those incidents were in Durham County, with 24% in Alamance County and 14% each in Orange and Person Counties.

Table 4.111 – Reported Hazardous Materials Incidents by County 1990-2018

Year	Region	Alamance	Durham	Orange	Person
1990	9	4	4	1	0
1991	12	3	5	4	0
1992	20	8	8	2	2
1993	11	1	5	1	4
1994	19	8	3	3	5
1995	8	2	2	2	2
1996	25	4	10	3	8
1997	16	4	6	3	3
1998	18	3	13	0	2
1999	17	7	5	1	4
2000	34	12	13	5	4
2001	20	3	13	3	1
2002	34	3	22	5	4
2003	28	2	11	12	3
2004	13	5	5	0	3
2005	10	3	4	2	1
2006	18	2	12	2	2
2007	15	3	7	1	4

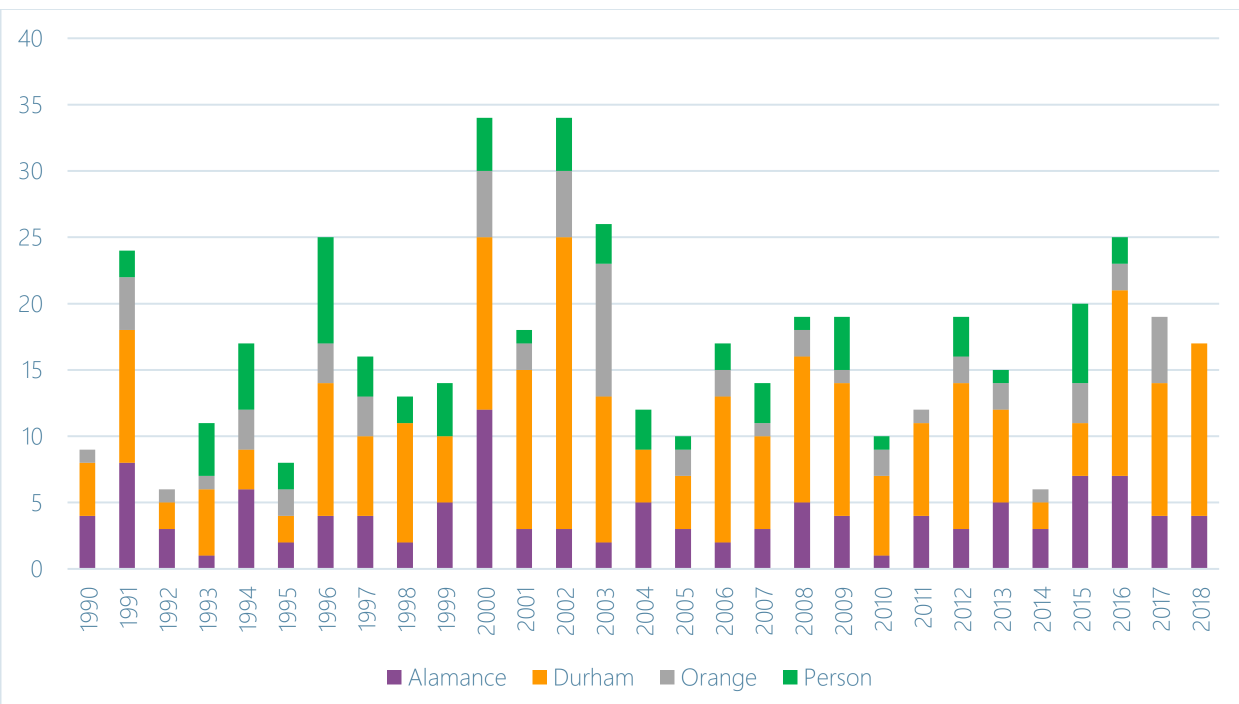
Year	Region	Alamance	Durham	Orange	Person
2008	19	5	11	2	1
2009	21	5	10	2	4
2010	11	2	6	2	1
2011	13	4	7	2	0
2012	22	4	13	2	3
2013	15	5	7	2	1
2014	14	4	9	1	0
2015	20	7	4	3	6
2016	15	4	7	2	2
2017	15	3	10	2	0
2018	18	4	14	6	0
Total	**510**	**124**	**246**	**70**	**70**
Avg/Year	**18**	**4**	**8**	**2**	**2**

Source: USCG National Response Center http://nrc.uscg.mil/

Note that these numbers only capture incidents reported to the NRC, and likely excludes a number of minor spills.

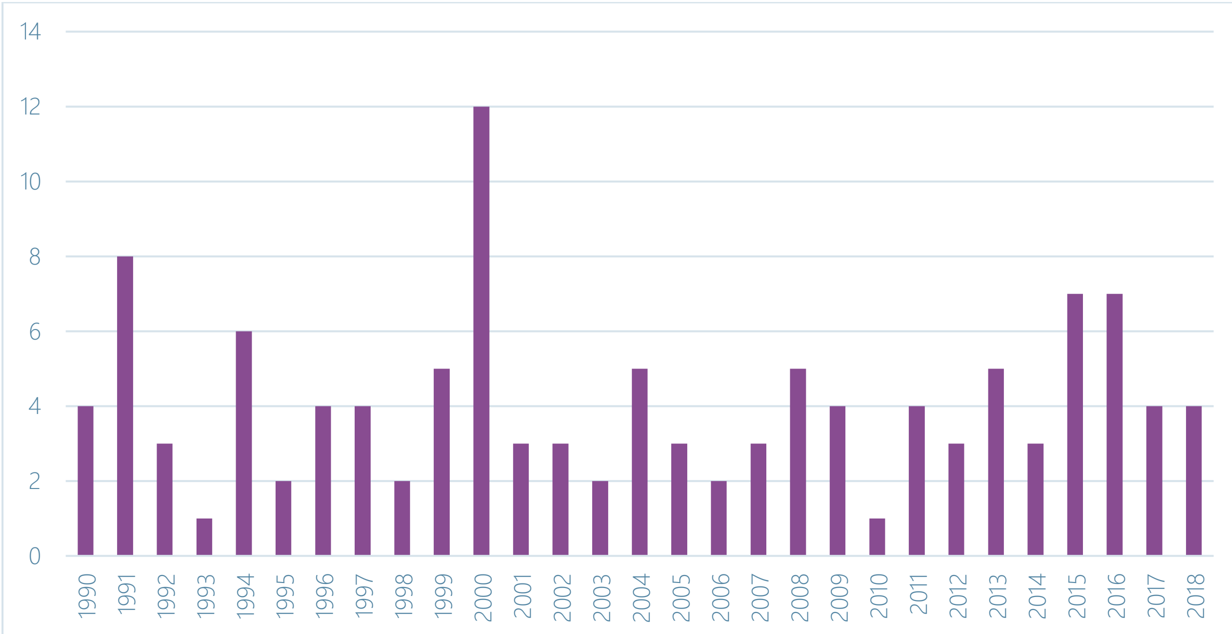
As the following figures show, the number of reported hazardous materials incidents varies greatly from year to year. During the 1990s the Region averaged approximately 16 hazardous materials a year. During the 2000s, that number increased to an average of 21 incidents a year, driven largely by an increase in Durham County. However, the 2010s so far have seen the number of reported hazardous materials decline back to an average of 16 per year.

Figure 4.49 – Reported Hazardous Materials Incidents by Year 1990-2018



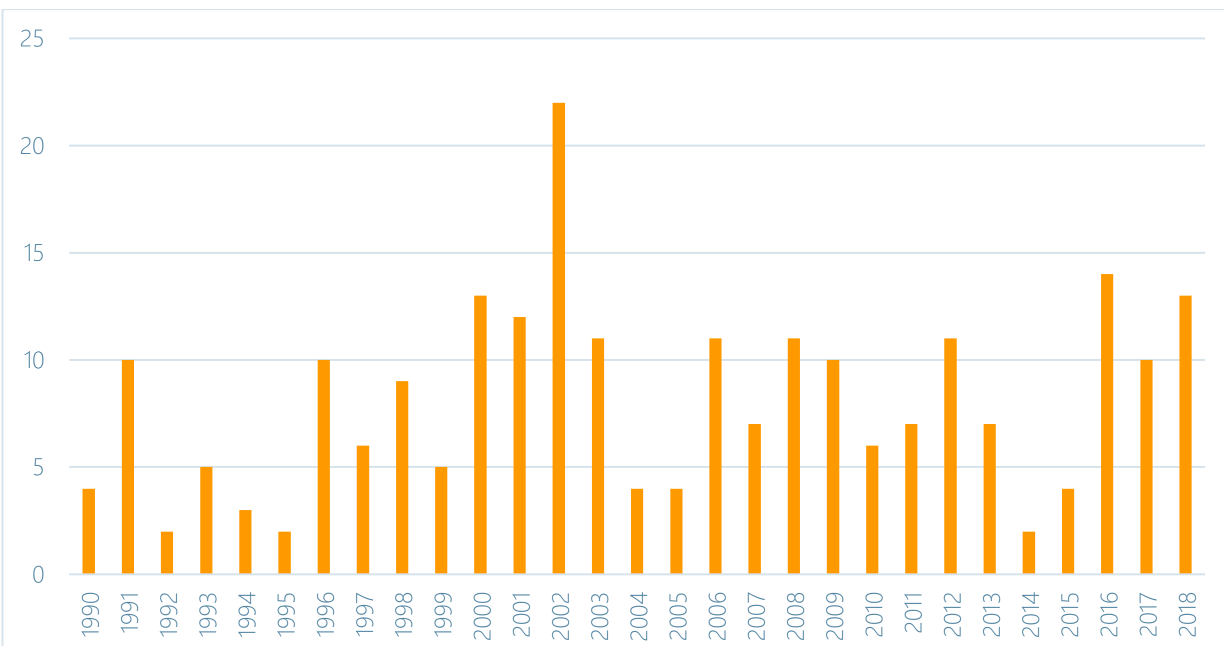
Source: USCG National Response Center http://nrc.uscg.mil/

Figure 4.50 – Reported Hazardous Materials Incidents in Alamance County 1990-2018



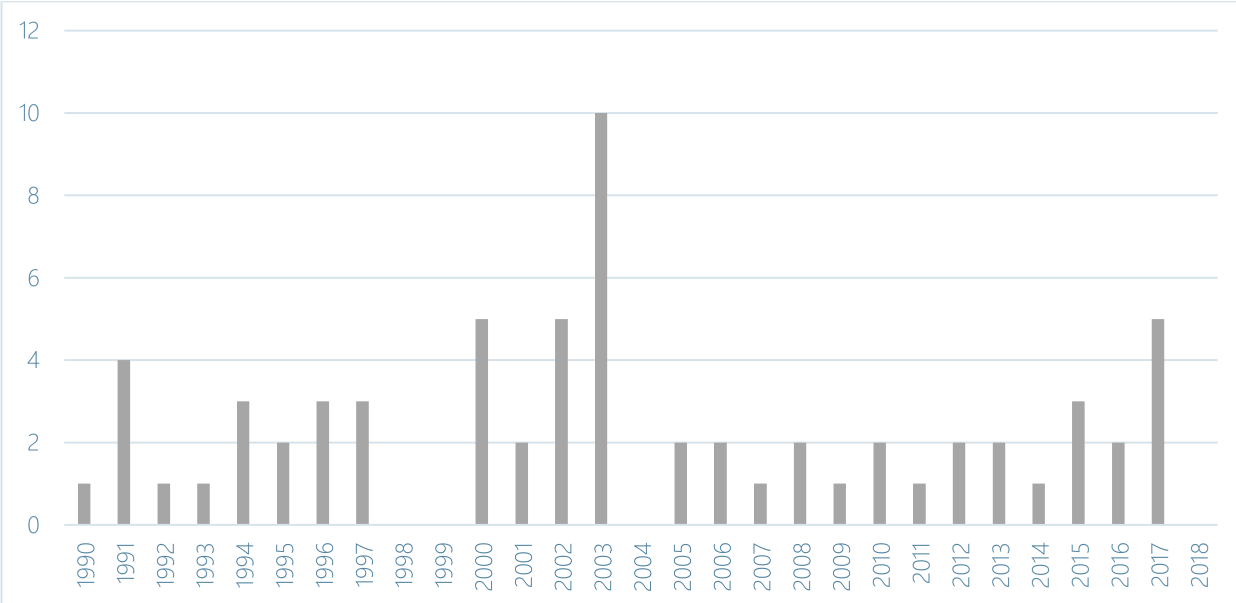
Source: USCG National Response Center http://nrc.uscg.mil/

Figure 4.51 – Reported Hazardous Materials Incidents in Durham County 1990-2018



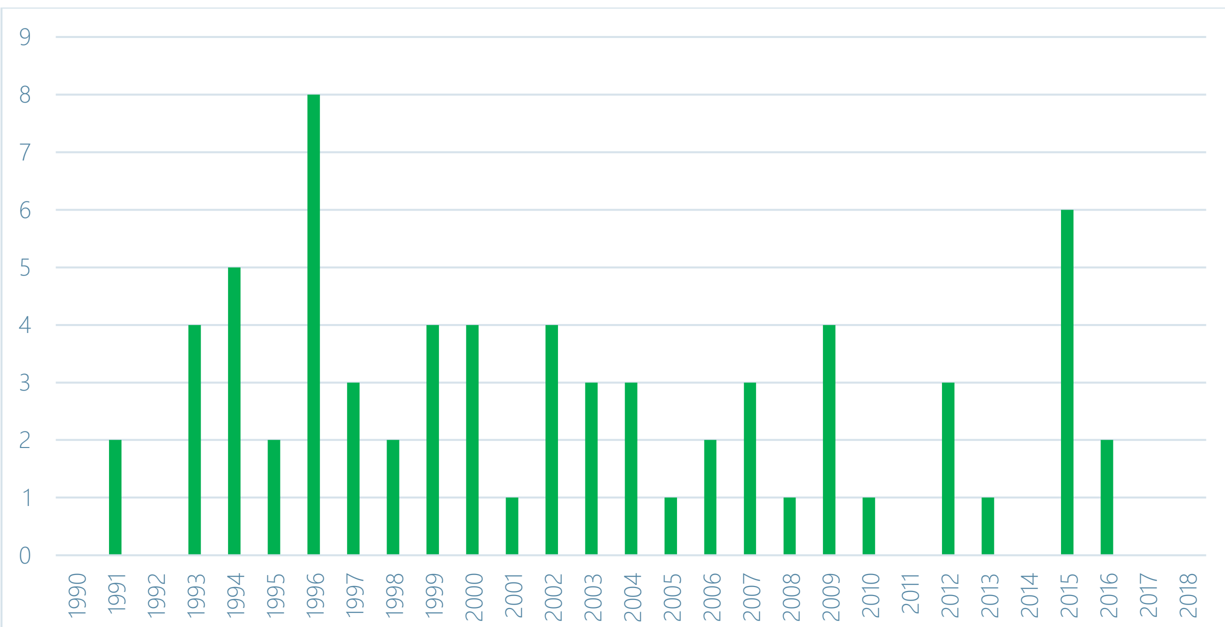
Source: USCG National Response Center http://nrc.uscg.mil/

Figure 4.52 – Reported Hazardous Materials Incidents in Orange County 1990-2018



Source: USCG National Response Center http://nrc.uscg.mil/

Figure 4.53 – Reported Hazardous Materials Incidents in Person County 1990-2018



Source: USCG National Response Center http://nrc.uscg.mil/

The vast majority of these hazardous materials incidents were relatively minor with only minimal, localized impacts. Of the 510 incidents reported to the NRC from 1990 through 2018, only 41 (8%) resulted in any injuries, fatalities, or property damage; an additional 5 incidents (1%) led to evacuations but did not cause any injuries, fatalities, or property damage. The NRC records record 9 fatalities, 33 injuries (20 of which required hospitalization), 225 people evacuated, and $690,000 in property damage resulting from those incidents. However, it should be noted that not all of these injuries, fatalities, or damages came from exposure to hazardous materials; many were likely the result of whatever physical accident or event caused the release.

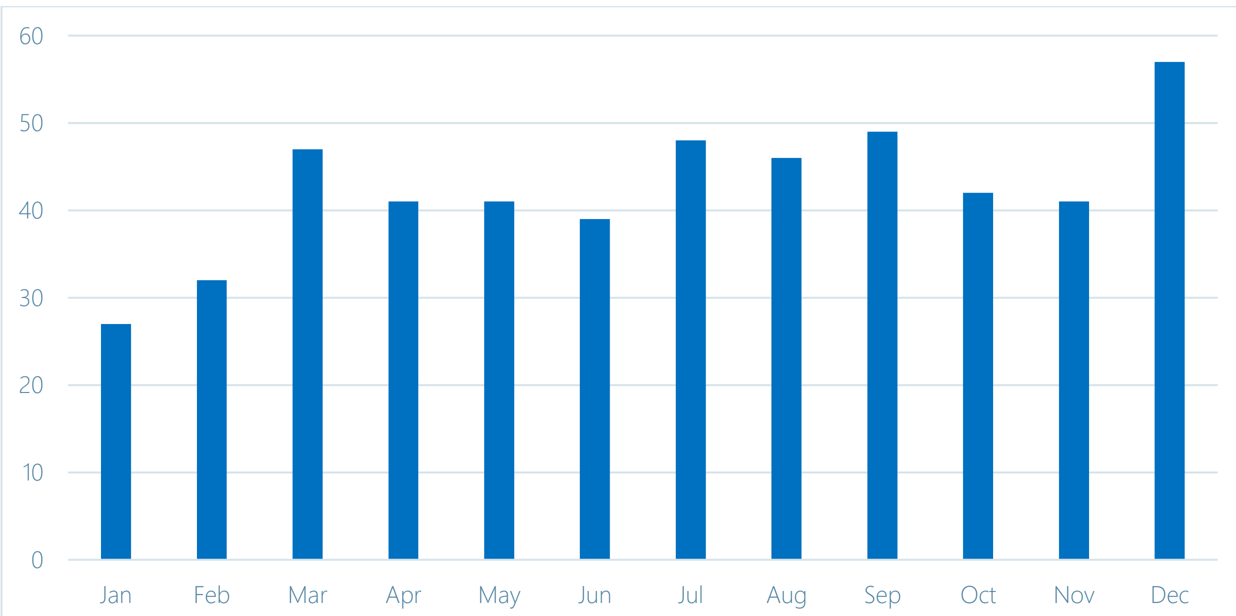
Table 4.112 – Damaging Hazardous Materials Incidents 1990-2018

	# of Incidents	# of Individuals	Damages
Fatalities	6	9	
Injuries	28	33	
Hospitalizations	20	20	
Evacuations	14	225	
Damage	6		$690,000

Source: USCG National Response Center http://nrc.uscg.mil/

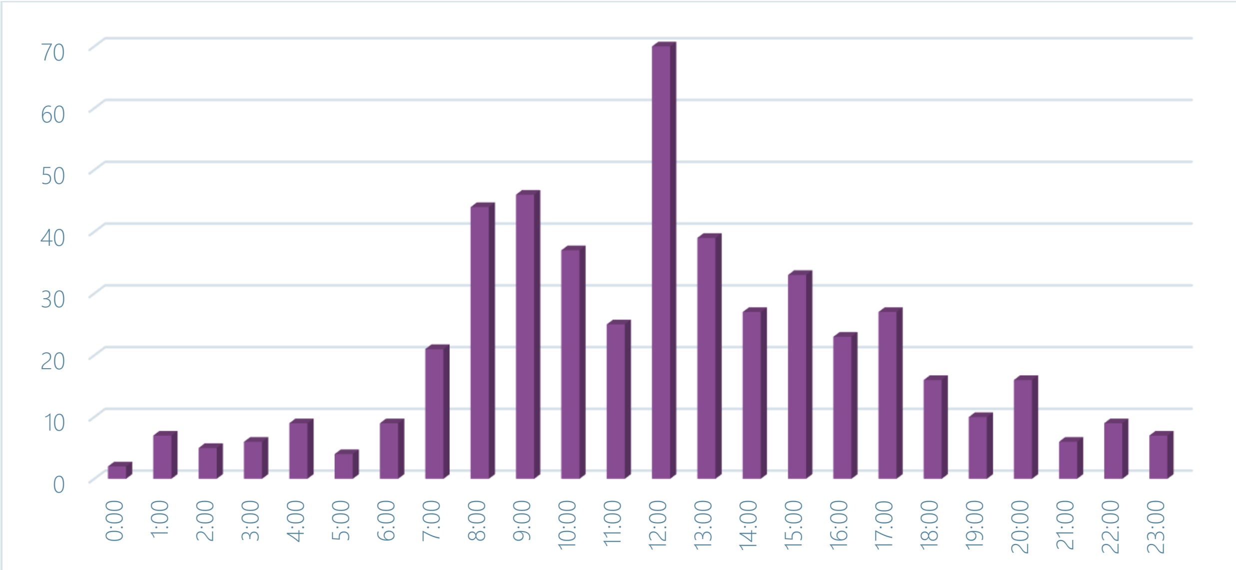
Hazardous materials incidents can happen in any month. NRC records show that they are most common in December, are least common in January and February, and are relatively consistent March through November. Most incidents occur during daylight hours, particularly during morning and noon rush hour.

Figure 4.54 – Reported Hazardous Materials Incidents by Month 1990-2018



Source: USCG National Response Center http://nrc.uscg.mil/

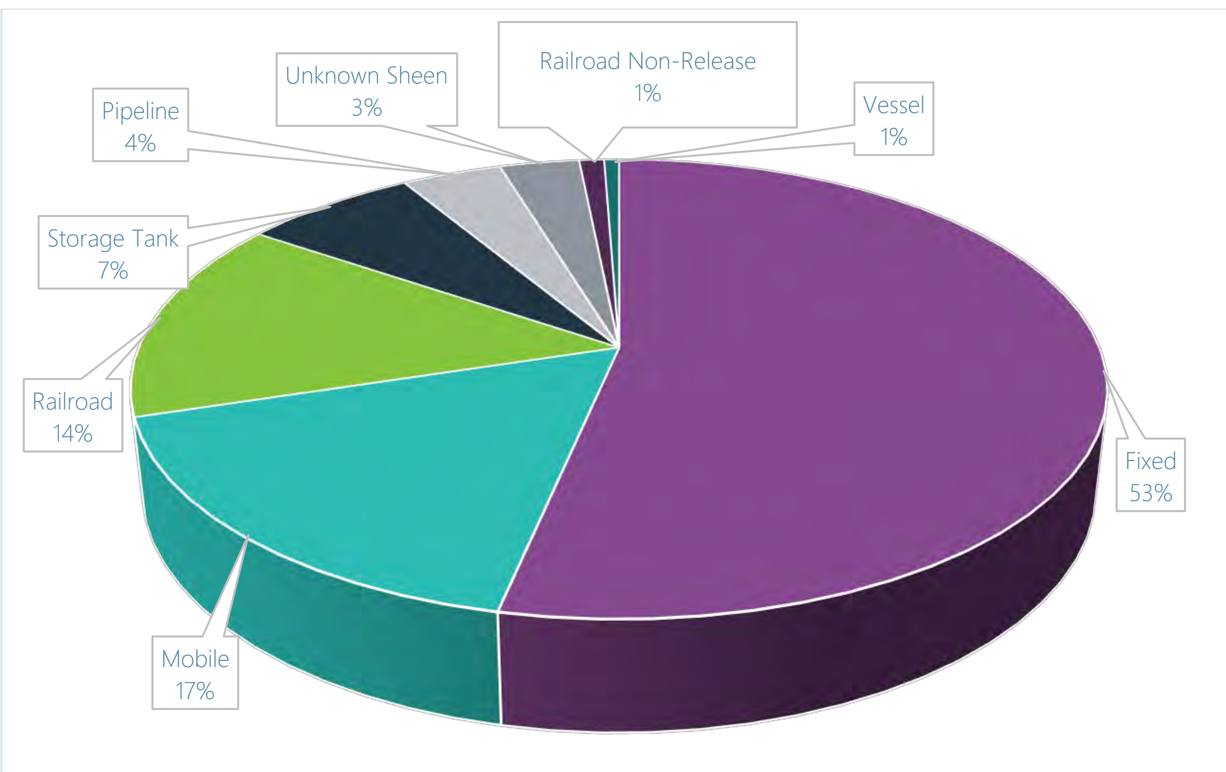
Figure 4.55 – Reported Hazardous Materials Incidents by Time Of Day 1990-2018



Source: USCG National Response Center http://nrc.uscg.mil/

As shown below, 60% of reported incidents take place at fixed facilities and storage tanks, while 33% take place during transportation (truck, railroad or water vessel), and 4% from pipelines.

Figure 4.56 – Reported Hazardous Materials Incidents by Type 1990-2018



Source: USCG National Response Center http://nrc.uscg.mil/

Probability of Future Occurrence

Based on historical occurrences recorded by the NRC, there have been 510 hazardous materials incidents reported in the Region from 1990 through 2018, an average of 18 a year. Thus, there is effectively a 100% chance that the Region will experience an incident in any given month.

However, as noted above 92% of those incidents have only minor, localized impacts. Only 46 incidents resulted in injuries, fatalities, property damage, or evacuations. That equates to an average of 1.6 damaging incidents occurring in the Region every year. The probability of a hazardous materials incident is the highest in Durham County, and lowest in Orange and Person Counties.

Probability: 3 – Likely

Vulnerability Assessment

People

People near facilities storing or transporting hazardous materials are at higher risk of exposure to a release incident. Additionally, any individuals working with or transporting hazardous materials are also at heightened risk. Depending on the materials, they may pose certain health hazards. If hazardous materials contaminate soils or water supply, people may be at risk of exposure through food or water.

Property

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

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

Environment

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

Consequence Analysis

Table 4.116 summarizes the potential detrimental consequences of hazardous materials incident.

Table 4.113 – Consequence Analysis – Hazardous Materials Incident

Category	Consequences
Public	Contact with hazardous materials could cause serious illness or death. Those living and working closest to hazardous materials sites face the greatest risk of exposure. Exposure may also occur through contamination of food or water supplies.
Responders	Responders face similar risks as the general public but a heightened potential for exposure to hazardous materials.

Category	Consequences
Continuity of Operations (including Continued Delivery of Services)	A hazardous materials incident may cause temporary road closures or other localized impacts but is unlikely to affect continuity of operations.
Property, Facilities and Infrastructure	Some hazardous materials are flammable, explosive, and/or corrosive, which could result in structural damages to property. Impacts would be highly localized.
Environment	Consequences depend on the type of material released. Possible ecological impacts include loss of wildlife, loss of habitat, and degradation of air and/or water quality.
Economic Condition of the Jurisdiction	Clean up, remediation, and/or litigation costs may apply. Long-term economic damage is unlikely.
Public Confidence in the Jurisdiction’s Governance	A hazardous materials incident may affect public confidence if the environmental or health impacts are enduring.

4.5.16 Infectious Disease

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Infectious Disease	Possible	Critical	Large	More than 24 hrs	More than 1 week	2.8

Hazard Background

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

Public health emergencies can occur as primary events by themselves, or they may be secondary to another disaster or emergency, such as tornado, flood, or hazardous material incident. For more information on those particular incidents, see Sections 4.5.10 (Tornado), 4.5.5 (Flood), and 4.5.15 (Hazardous Materials). The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Public health emergencies can be worldwide or localized in scope and magnitude.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Warning Time: 1 – More than 24 hours

Duration: 4 – More than one week

Location

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

Extent

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

Table 4.114 describes the World Health Organization's six main phases to a pandemic flu as part of their planning guidance.

Table 4.114 – World Health Organization's Pandemic Flu Phases

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

Source: World Health Organization

Impact: 3 – Critical

Spatial Extent: 4 – Large

Historical Occurrences

Public Health Emergencies – Influenza Pandemics

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

Spanish Flu (H1N1 virus) of 1918-1919

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

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

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

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

Asian Flu (H2N2 virus) of 1957-1958

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

Hong Kong Flu (H3N2 virus) of 1968-1969

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

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

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

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

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

Swine Flu (H1N1 virus) of 2009–2010

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

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

Public Health Emergencies – Other Pandemics

St. Louis Encephalitis, 1964-2005

Between 1964 and 2005, there were 4,651 confirmed cases of SLE in the United States. Seventy-five of these cases were in Missouri. According to the U.S. Geological Survey, there was one case of SLE in Missouri in 2006. It should be noted, however, that less than 1 percent of SLE infections are clinically apparent, so the vast majority of infections remain undiagnosed. Illnesses range from mild headaches and fever to convulsions, coma, and paralysis. The last major outbreak of SLE occurred in the Midwest from 1974 to 1977, when over 2,500 cases were reported in 35 states. The most recent outbreak of St. Louis encephalitis was in 1999 in New Orleans, Louisiana, with 20 reported cases. The disease is generally milder in children than in adults, with the elderly at highest risk for severe illness and death. Approximately 3 to 30 percent of cases are fatal; no vaccine against SLE exists. In 2011, one probably case was reported in Boone County, MO.

Meningitis, 1996-1997, 2005

During 1996 and 1997, 213,658 cases of meningitis were reported, with 21,830 deaths, in Africa. According to the Missouri Department of Health and Senior Services, there were 28 cases in Missouri in 2005.

Lyme Disease, 2015

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

Severe Acute Respiratory Syndrome, 2003

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

Zika Virus, 2015

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

Ebola, 2014-2016

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

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

Coronavirus Disease (COVID-19), 2020

During the update of this plan, the Coronavirus disease 2019, also known as COVID-19, outbreak became a worldwide pandemic. COVID-19 was caused by severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2). First identified in Wuhan, China in December 2019, the virus quickly spread throughout China and then globally. As of May 5, 2020 there were over 3.5 million cases worldwide resulting in over 250,000 deaths. In the United States, COVID-19 was first identified in late January in Washington State and rapidly spread throughout the Country, with large epicenters on both the east and west coasts.

In order to curb the spread of the virus, Governor Roy Cooper issued a statewide Stay at Home Order on March 27, 2020. According to the North Carolina Department of Health and Human services, as of May 5, 2020, there were over 12,000 confirmed cases and 450 deaths across 99 of the 100 counties in the State. In the Eno-Haw region as of May 5, 2020, there were a total of 1,152 cases, 126 in Alamance, 773 in Durham, 230 in Orange, and 23 in Person. Additionally, there were 44 deaths in total, 3 in Alamance, 23 in Durham, 18 in Orange, and 1 in Person. Case counts are rising in North Carolina and the Eno-Haw region at the time of this assessment.

Probability of Future Occurrence

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

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

Probability: 2 – Possible

Climate Change

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

Hot days can be unhealthy—even dangerous. High air temperatures can cause heat stroke and dehydration, and affect people's cardiovascular and nervous systems. Midwestern cities like St. Louis are vulnerable to heat waves, because many houses and apartments lack air conditioning, and urban areas are typically warmer than their rural surroundings. In recent decades, severe heat waves have killed hundreds of people across the Midwest. Heat stress is expected to increase as climate change brings hotter summer temperatures and more humidity. Certain people are especially vulnerable, including children, the elderly, the sick, and the poor.

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

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

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

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

Vulnerability Assessment

Methodologies and Assumptions

Vulnerability to infectious disease was assessed based on past occurrences nationally and internationally as well as publicly available information on these vulnerabilities, as well as attacks occurring in the region.

People

Disease spread and mortality is affected by a variety of factors, including virulence, ease of spread, aggressiveness of the virus and its symptoms, resistance to known antibiotics and environmental factors.

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

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

Property

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

Environment

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

Consequence Analysis

Table 4.115 summarizes the potential consequences of infectious disease.

Table 4.115 – Consequence Analysis – Infectious Disease

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

4.5.17 Radiological Emergency

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Radiological Emergency	Unlikely	Catastrophic	Small	Less than 6 hrs	More than 1 week	2.7

Hazard Background

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

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

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

Radiological emergencies at nuclear power plants are divided into classifications. Table 4.116 shows these classifications, as well as descriptions of each.

Table 4.116 – Radiological Emergency Classifications

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

Warning Time: 4 – Less than 6 hours

Duration: 4 – More than one week

Location

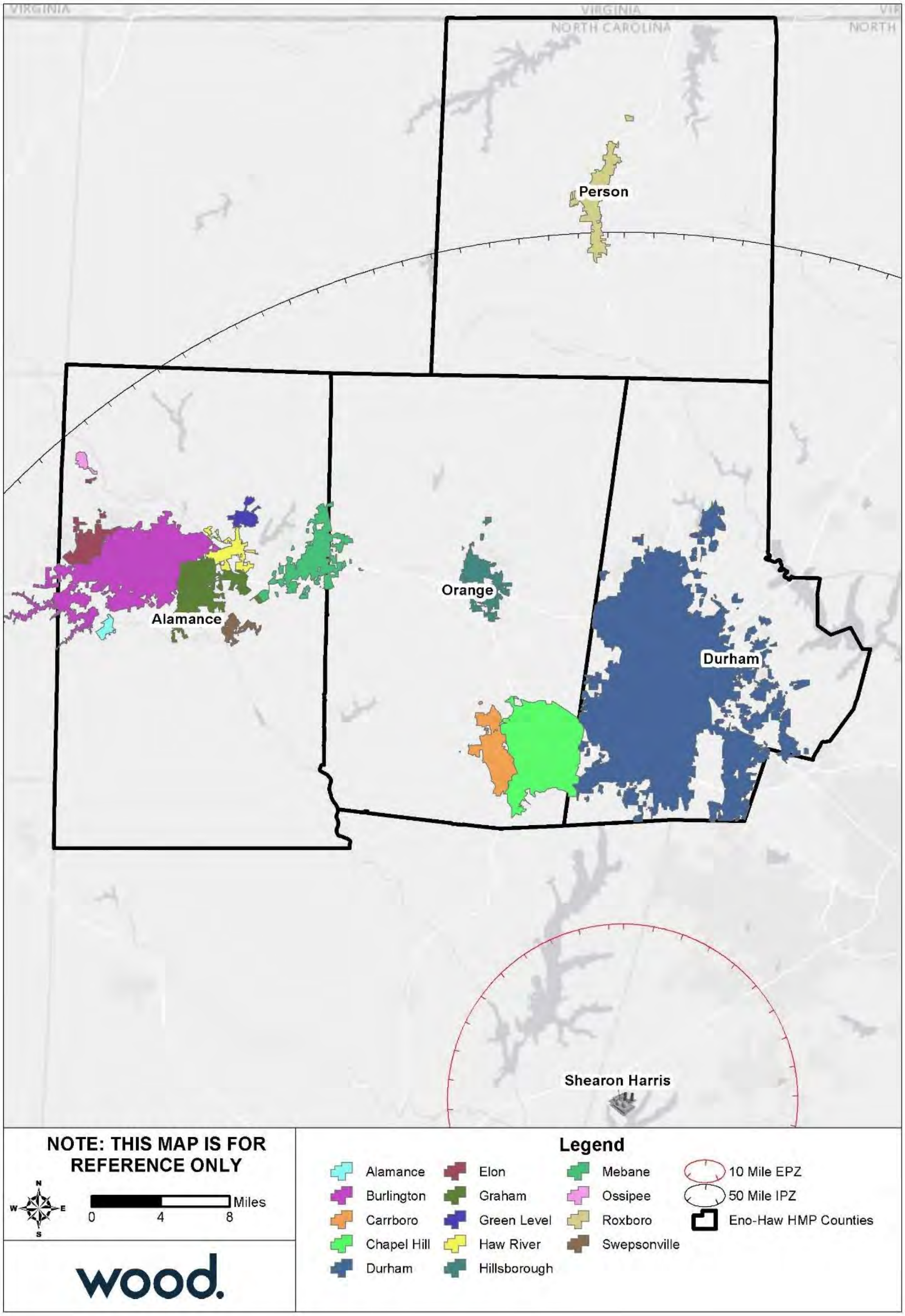
Harris Nuclear Plant, which is located in southwest Wake County south of the planning area, is a single-unit 928-megawatt power plant. The plant began commercial operation in 1987 and now employs approximately 800 people. Its reactor is a pressurized water reactor and the plant operates with a very high level of security. This is the location from which the most catastrophic nuclear accident might occur and will be the focal point of the nuclear analysis in this plan. However, it should also be noted that there is a 1-megawatt PULSTAR research reactor located on North Carolina State University's campus in downtown Raleigh. Although its impacts would potentially be less far-reaching than Harris Nuclear Plant's in the event of an accident, it should still be noted that the effects could be extremely detrimental.

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

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

Figure 4.57 shows the location of Harris Nuclear Plant and the approximate 10-mile Emergency Planning Zone (EPZ) buffer and 50-mile Ingestion Pathway Zone (IPZ) around the plant. While none of the counties or communities in the planning area fall into the 10-mile EPZ, areas of Alamance and Person counties, and the entirety of Orange and Durham counties are included in the 50-mile IPZ.

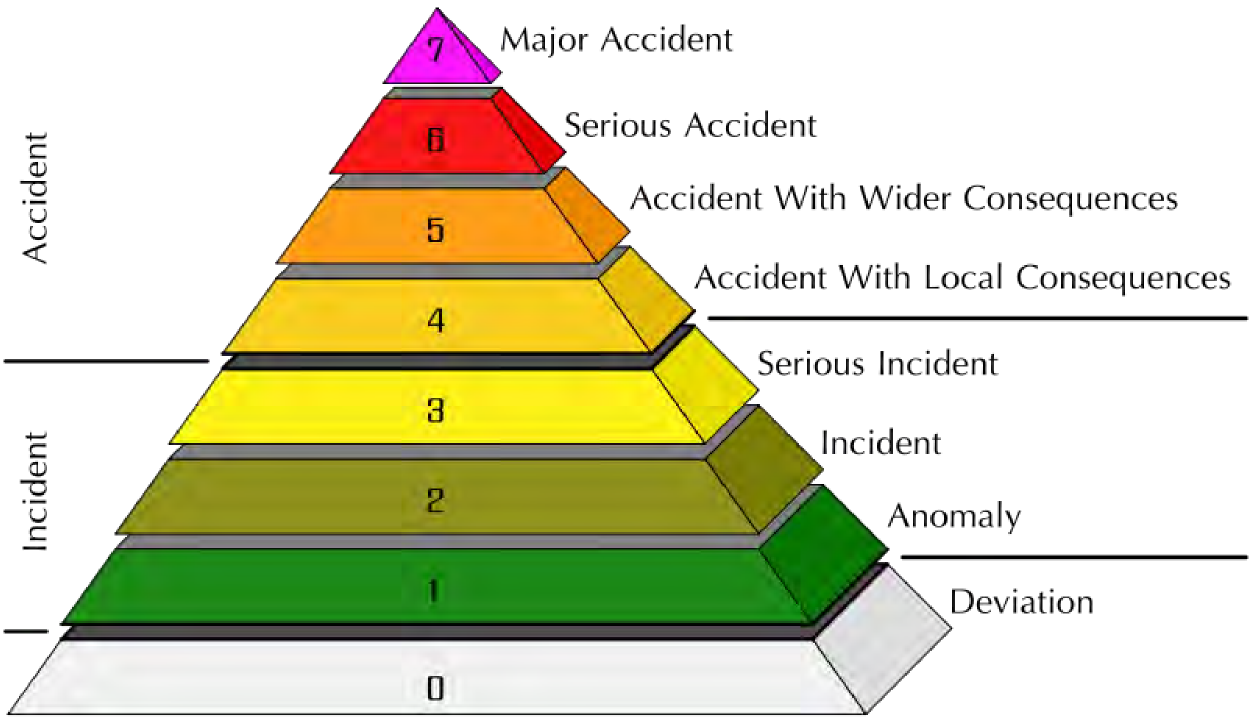
Figure 4.57 – Harris Nuclear Plant Location in Relation to Planning Area



The Nuclear Regulatory Commission defines two emergency planning zones around nuclear plants. Areas located within 10 miles of the station are considered to be within the zone of highest risk to a nuclear incident and this radius is the designated evacuation radius recommended by the Nuclear Regulatory Commission. Within the 10-mile zone, the primary concern is exposure to and inhalation of radioactive contamination. The most concerning effects in the secondary 50-mile zone are related to ingestion of food and liquids that may have been contaminated. All areas of the county that are not located within the 10-mile radius are located within this 50-mile radius that is still considered to be at risk from a nuclear incident.

Extent

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



Source: International Atomic Energy Association

Impact: 4 – Catastrophic

Spatial Extent: 2 – Small

Historical Occurrences

As reported in the 2018 State Hazard Mitigation Plan, Harris Nuclear Plant is one of only three plants in the country to have had no Nuclear Regulatory Commission findings as of September 2017. Therefore, there are no recent historical occurrences of any serious incidents at the Harris Plant. However, there have been events that warranted emergency declarations at both the Harris Nuclear Plant and the PULSTAR research reactor at North Carolina State University.

Probability of Future Occurrence

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

Probability: 1 – Unlikely

Vulnerability Assessment

People

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

Property

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

Environment

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

Consequence Analysis

Table 4.117 summarizes the potential detrimental consequences of radiological incident.

Table 4.117 – Consequence Analysis – Radiological Incident

Category	Consequences
Public	High levels of radiation could cause serious illness or death. Those living and working closest to the nuclear plant would face the greatest risk of exposure.
Responders	Responders face potential for heightened exposure to radiation, which could cause severe chronic illness and death.
Continuity of Operations (including Continued Delivery of Services)	An incident at the nuclear plant could interrupt power generation and cause power shortages. Regular operations would likely be affected by the response effort an event would require.
Property, Facilities and Infrastructure	The plant itself could be damaged by a radiological incident. Nearby property and facilities could be affected by contamination.
Environment	Water supplies, food crops, and livestock within 50 miles of the nuclear plant could be contaminated by radioactive material in the event of a major incident.
Economic Condition of the Jurisdiction	The local economy could be affected if a radiological incident caused contamination of nearby areas. Property values and economic activity could decline as a result.
Public Confidence in the Jurisdiction's Governance	A radiological incident would likely cause severe loss of public confidence given that the hazard is human-caused and highly regulated. Public confidence can also be affected by false alarms.

4.5.18 Terrorism / Mass Casualty

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Terrorism/Mass Casualty	Possible	Catastrophic	Negligible	Less than 6 hrs	More than 1 week	2.8

Hazard Background

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

These hazards can occur anywhere and demonstrate unlawful force, violence, and/or threat against persons or property causing intentional harm for purposes of intimidation, coercion or ransom in violation of the criminal laws of the United States. These actions may cause massive destruction and/or extensive casualties. The threat of terrorism, both international and domestic, is ever present, and an attack can occur when least expected. For this analysis, this hazard primarily focuses on an active shooter event.

The Southern Poverty Law Center reports 32 active hate groups in North Carolina. Table 4.118 shows active hate groups in North Carolina, according to the Southern Poverty Law Center (SPLC). The SPLC defines a hate group as any group with "beliefs or practices that attack or malign an entire class of people – particularly when the characteristics being maligned are immutable." It is important to note that inclusion on the SPLC list is not meant to imply that a group advocates or engages in violence or other criminal activity. This list is a living document, and the groups listed here are those present at the time of this plan update.

Table 4.118 – Hate Groups Active in North Carolina

Group	Type	Location
Nation of Islam	Black Nationalist, Nation of Islam	Greensboro
ACTBAC NC	Neo-confederate	Snow Camp
Israelite Church of God in Jesus Christ	Black Nationalist	Greensboro
American Guard	General Hate	Statewide
Traditionalist Worker Party	Neo-Nazi; Traditionalist Worker Party	Statewide
Vinlanders Social Club	Racist Skinhead; Vinlanders Social Club	Statewide
Vanguard America	Neo-Nazi	Statewide
Israelite School of Universal Practical Knowledge	Black Nationalist	Statewide
Crew 38	Racist Skinhead	Statewide
Soldiers of Odin	Anti-Muslim	Statewide
Blood and Honour Social Club	Racist Skinhead; Blood and Honour	Statewide
The Daily Stormer	Neo-Nazi	Statewide
Confederate Hammerskins	Racist Skinhead	Statewide
Blood and Honour U.S.A.	Racist Skinhead; Blood and Honour	Statewide
East Coast Nights of the True Invisible Empire	Ku Klux Klan	Statewide
Israel United in Christ	Black Nationalist	Concord
Nation of Islam	Black Nationalist; Nation of Islam	Durham
Nation of Islam	Black Nationalist; Nation of Islam	Charlotte
Great Millstone	Black Nationalist	Charlotte

Group	Type	Location
Loyal White Knights of the Ku Klux Klan	Ku Klux Klan	Pelham
Americans for Legal Immigration (ALIPAC)	Anti-Immigrant	Raleigh
Identity Dixie	Neo-Confederate	Statewide
Loyal White Knights of the Ku Klux Klan	Ku Klux Klan	Pelham
ACT for America	Anti-Muslim; Act for America	Fayetteville
Nation of Islam	Black Nationalist; Nation of Islam	Raleigh
Cumberland Conservatives	Anti-Muslim	North Carolina
North Carolinians for Immigration Reform and Enforcement	Anti-Immigrant	Wade
Confederate White Knights of the Ku Klux Klan	Ku Klux Klan	Vale
North Carolina Pastors Network	Anti-Muslim	Morgantown
Identity Evropa	White Nationalist; Identity Evropa	Boone
Revolutionary Black Panther Party	Black Nationalist	Wilmington
Nation of Islam	Black Nationalist; Nation of Islam	Wilmington

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

The Nation of Islam is located in Durham in Durham County, and it is likely that groups found statewide have a footprint in the region.

Warning Time: 4 – Less than 6 hours

Duration: 4 – More than one week

Generally, no warning is given for mass shootings. Duration is dependent on the parameters of the incident; while the incidents themselves are usually relatively short, residual impacts on the community can be long-lasting. This score takes into account a prolonged scenario with continuous impacts.

Location

An active shooter incident could occur at any location across the region, but are more likely to target highly populated areas, critical infrastructure, or symbolic locations. Churches, schools and malls have all been the site of recent attacks nationwide.

Extent

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

Impact: 4 – Catastrophic

Spatial Extent: 1 – Negligible

Historical Occurrences

According the non-profit Gun Violence Archive, 337 mass shootings across America in 2018 (defined as four or more people shot or killed in a single incident, not counting the shooter); ten were recorded in North Carolina, resulting in 13 fatalities and 39 injuries. Examples of mass shooting incidents include:

Old Salisbury Road Shooting, Winston-Salem, NC, July 1988. A gunman shot nine passersby from the centerline of Old Salisbury Road; four people were killed.

Carthage Nursing Home Shooting, Carthage, NC, March 2009. A gunman opened fire at Pinelake Health and Rehabilitation nursing home. The shooter killed eight people and wounded a ninth.

University of North Carolina Shooting, Charlotte, NC, April 2019. A shooting on the last day of classes for the spring semester sent six people to the hospital, resulting in two fatalities.

The following additional incidents were also of concern to the planning committee, as they could have escalated to mass casualty events:

August 2019 – The KKK held a rally in Hillsborough and later returned to spread propaganda and recruitment flyers throughout the Town. The rally and materials promoted racism, anti-gay statements, and other hate speech that has fueled other mass casualty events across the country in recent years.

March 2006 – An alumnus drove a sport-utility vehicle through the Pit, a central gathering location on the UNC Chapel-Hill campus, with the intention of killing students, faculty, and staff. No one was killed in the attack, but nine people were injured.

Probability of Future Occurrence

While difficult to estimate when a deliberate act like a shooting may occur, it can be inferred that the probability of an attack in any one area in the Region is very low at any given time. However, given the record of two incidents in the past 20 years that could have escalated to mass casualty events, the HMPC considers the probability of future incidents to be possible.

When identified, credible threats may increase the probability of an incident; these threats are generally tracked by law enforcement.

Probability: 2 – Possible

Vulnerability Assessment

People

People can and do suffer direct impacts from a shooting incident, with the potential for both injuries and fatalities. The number of injuries and fatalities are variable, dependent on many factors surrounding the attack including the location, the number of type of weapons used, the shooter's skill with weapons, the amount of people at the location and law enforcement response time.

Property

The potential for damage to property is highly dependent on the type of attack. Buildings and infrastructure may be damaged. Impacts are highly localized to the target of the attack.

Environment

Most shooting attacks do not cause widespread damage to the environment.

Consequence Analysis

Table 4.119 summarizes the potential detrimental consequences of a mass shooter threat.

Table 4.119 – Consequence Analysis – Terrorism / Mass Shooter

Category	Consequences
Public	Injuries and fatalities are probable; these impacts would be highly localized to the attack. Widespread stress and psychological suffering may occur.
Responders	Responders face increased risks during an effort to stop an attack or rescue others while an attack is underway.

Category	Consequences
Continuity of Operations (including Continued Delivery of Services)	Critical infrastructure may be targeted by an attack; therefore, continuity of operations may be affected.
Property, Facilities and Infrastructure	Impacts depend of the type of attack. Building damage could occur during attack.
Environment	Incident specific; widespread environmental damage not likely.
Economic Condition of the Jurisdiction	The local economy could be disrupted, depending on the location and scale of an attack.
Public Confidence in the Jurisdiction's Governance	Loss of public confidence likely should an attack be carried out; additional loss of confidence and trust may result if response and recovery are not swift and effective

4.6 CONCLUSIONS ON HAZARD RISK

Priority Risk Index

As discussed in Section 4.3 Risk Assessment Methodology and Assumptions, the Priority Risk Index was used to rate each hazard on a set of risk criteria and determine an overall standardized score for each hazard. The conclusions drawn from this process are summarized below.

Table 4.120 summarizes the degree of risk assigned to each identified hazard using the PRI method.

Table 4.120 – Summary of PRI Results

Hazard	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Dam Failure	Possible	Critical	Negligible	Less than 6 hrs	Less than 1 week	2.4
Drought	Likely	Minor	Large	More than 24 hrs	More than 1 week	2.5
Earthquake	Unlikely	Minor	Large	Less than 6 hrs	Less than 6 hrs	1.9
Extreme Heat	Highly Likely	Critical	Large	More than 24 hrs	Less than 1 week	3.3
Flood	Likely	Limited	Small	6 to 12 hrs	Less than 1 week	2.5
Hurricane & Tropical Storm	Likely	Critical	Large	More than 24 hrs	Less than 24 hrs	2.9
Landslide	Unlikely	Minor	Negligible	6 to 12 hours	Less than 6 hrs	1.2
Severe Weather: Hail[1]	Highly Likely	Minor	Small	Less than 6 hrs	Less than 6 hours	2.4
Severe Weather: Lightning[1]	Highly Likely	Minor	Negligible	Less than 6 hrs	Less than 6 hours	2.2
Severe Weather: Thunderstorm Winds[1]	Highly Likely	Limited	Large	Less than 6 hrs	Less than 6 hours	3.1
Severe Winter Storm	Highly Likely	Critical	Large	More than 24 hrs	More than 1 week	3.3
Tornado	Likely	Critical	Small	Less than 6 hrs	Less than 6 hours	2.7
Wildfire	Possible	Limited	Moderate	Less than 6 hrs	Less than 1 week	2.5
Civil Unrest	Possible	Limited	Small	Less than 6 hrs	Less than 1 week	2.3
Critical Infrastructure Failure	Possible	Critical	Small	Less than 6 hrs	More than 1 week	2.7
Cyber Threat	Possible	Limited	Small	Less than 6 hrs	More than 1 week	2.4
Hazardous Materials Incident	Likely	Minor	Negligible	Less than 6 hrs	Less than 24 hrs	2.0
Infectious Disease	Possible	Critical	Large	More than 24 hrs	More than 1 week	2.8
Radiological Emergency	Unlikely	Catastrophic	Small	Less than 6 hrs	More than 1 week	2.7
Terrorism/Mass Casualty	Possible	Catastrophic	Negligible	Less than 6 hrs	More than 1 week	2.8

[1]Note: Severe Weather hazards average to a score of 2.6 and are therefore considered together as a high risk hazard.

The results from the PRI have been classified into three categories based on the assigned risk value which are summarized in Table 4.121:

- **High Risk** – Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread.
- **Medium Risk** – Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
- **Low Risk** – Minimal potential impact. The occurrence and potential cost of damage to life and property is negligible or nonexistent. This is not a priority hazard for mitigation projects.

Table 4.121 – Summary of Hazard Risk Classification

High Risk (> 2.4)	Extreme Heat Severe Winter Storm Hurricane & Tropical Storm Critical Infrastructure Failure Infectious Disease Terrorism / Mass Casualty Tornado Radiological Emergency Severe Weather Drought Flood Wildfire
Moderate Risk (2.0 – 2.4)	Dam Failure Cyber Threat Civil Unrest Hazardous Materials Incident
Low Risk (< 2.0)	Earthquake Landslide

Note: Low risk hazards are not prioritized for mitigation.