Section 4: Risk Assessment

This section comprises the risk assessment portion of the Eno-Haw Regional Hazard Mitigation Plan, including identification of hazards, hazard profiling and analysis, and assessment of vulnerability. It consists of the following six subsections:

4.1 Overview

A risk assessment is performed as an important step toward determining the potential impacts of natural hazards on the people, built and natural environments, and economy of a given planning area. The *Risk Assessment* provides the foundation for the rest of the mitigation planning process, which is focused on identifying and prioritizing actions to reduce risk to hazards. In addition to informing the *Mitigation Strategy*, the *Risk Assessment* can also be used to establish emergency preparedness and response priorities, for land use and comprehensive planning, and for decision making by elected officials, city and county departments, businesses, and organizations in the community.

A typical risk assessment consists of three primary components. Some form of <u>hazard identification</u> process needs to take place, followed by detailed <u>hazard profiles</u> of the hazards that will be addressed in the plan. Then the profiled hazards are assessed to determine the <u>vulnerability</u> of the assets within the planning area to each hazard being addressed. It is also important to document key details regarding the methodologies and assumptions used to perform the risk assessment, the asset inventories used to perform the risk assessment, and finally conclusions on hazard risk. The conclusions on hazard risk essentially consist of a prioritized ranking of hazards of concern.

4.2 Hazard Selection

The Eno-Haw Region is vulnerable to a wide range of natural hazards that threaten life and property. Current regulations and interim guidance under the Disaster Mitigation Act of 2000 (DMA 2000) require, at a minimum, an evaluation of a full range of natural hazards.[1]

Upon a thorough review of the full range of natural hazards covered in the existing mitigation plans for the three participating counties in the Eno-Haw area, the hazards suggested under FEMA mitigation planning guidance, and the hazards addressed in the North Carolina State Hazard Mitigation Plan, the participating jurisdictions in the Eno-Haw Region identified 12 hazards that are to be addressed in the Eno-Haw Regional Hazard Mitigation Plan. These hazards were identified

[1] An evaluation of human-caused hazards (e.g., technological hazards, terrorism, etc.) is permitted, though not required, for plan approval. The Eno-Haw Region has chosen to focus solely on natural hazards for the purposes of this plan, except where technological hazards directly relate to a natural hazard (for example, a hazardous materials facility located in a mapped floodplain).

through an extensive process that included input from Eno-Haw Hazard Mitigation Planning Team (HMPT) members.

Table 4.1 lists the full range of natural hazards initially considered for inclusion in the Plan. This table includes a total of 16 individual hazards and documents the evaluation process used for determining which of the initially identified hazards were considered significant enough for further evaluation in the *Risk Assessment*. For each hazard considered, the table indicates whether or not the hazard was identified as a significant hazard to be assessed further, how this determination was made, and why this determination was made. The table works to summarize not only those hazards that were identified (and why) but also those that were not identified (and why not).

Table 4.1: Documentation of the Hazard Selection Process

Natural Hazard Considered	Was this hazard considered significant/appropriate enough to be addressed in the plan at this time?	How was this determination made?	Why was this determination made?
ATMOSPHERIC HAZARDS			
Hail	Yes, grouped with the thunderstorm hazard.	By consensus of the Eno-Haw HMPT.	The threat of property damage from hail is of sufficient concern to warrant study.
Hurricane/Tropical Storm	Yes	By consensus of the Eno-Haw HMPT.	Despite the inland location of the planning area, hurricanes and tropical storms are of sufficient concern to warrant study.
Lightning	Yes, grouped with the thunderstorm hazard.	By consensus of the Eno-Haw HMPT.	The threat of property damage or loss of life from lightning is of sufficient concern to warrant study.
Nor'easter	No	By consensus of the Eno-Haw HMPT.	No nor'easters are known to have significantly impacted the planning area in recent history.
Thunderstorm	Yes	By consensus of the Eno-Haw HMPT.	The threat of damage from thunderstorms is of sufficient concern to warrant study.
Tornado	Yes	By consensus of the Eno-Haw HMPT.	The threat of damage and loss of life from tornadoes is of sufficient concern to warrant study.
Winter Weather	Yes	By consensus of the Eno-Haw HMPT.	The threat of damage and loss of life from winter weather is of sufficient concern to warrant study.
HYDROLOGIC HAZARDS			
Dam/Levee Failure	Yes	By consensus of the Eno-Haw HMPT.	The threat of damage and loss of life from the failure of a dam or levee is of sufficient concern to warrant study.

Natural Hazard Considered	Was this hazard considered significant/appropriate enough to be addressed in the plan at this time?	How was this determination made?	Why was this determination made?
Drought/Extreme Heat	Yes	By consensus of the Eno-Haw HMPT.	The threat of damage and loss of life from the drought and extreme heat hazard is of sufficient concern to warrant study.
Erosion	No	By consensus of the Eno-Haw HMPT.	The threat of damage from erosion is not of sufficient concern to warrant study.
Flood	Yes	By consensus of the Eno-Haw HMPT.	The threat of damage and loss of life from flooding is of sufficient concern to warrant study.
GEOLOGIC HAZARDS			
Earthquake	Yes	By consensus of the Eno-Haw HMPT.	Even though the threat of damaging earthquake activity in the planning area is relatively low, the threat of damage and loss of life from earthquakes within the state is of sufficient enough concern to warrant study.
Landslide	Yes	By consensus of the Eno-Haw HMPT.	The threat of damage and loss of life from landslides is of sufficient concern to warrant study.
Sinkholes	No	By consensus of the Eno-Haw HMPT.	Due to a lack of local concerns and recent occurrences, coupled with a lack of useable data.
OTHER HAZARDS			
Climate Change	Yes	By consensus of the Eno-Haw HMPT.	The HMPT feels that it is necessary to address changes in the climate and the effects those changes may have on identified natural hazards.
Wildfire	Yes	By consensus of the Eno-Haw HMPT.	The threat of damage and loss of life from wildfires is of sufficient concern to warrant study.

The final list of hazards to be presented in the Plan, as agreed upon by the HMPT, is as follows:

Hydrologic Hazards (Water Hazards)

- Flood
- Dam/Levee Failure
- Drought/Extreme Heat

Atmospheric Hazards (Severe Storms)

- Thunderstorm, Lightning, and Hail
- Tornado
- Winter Weather
- Hurricane and Tropical Storm

Geologic Hazards

- Landslide
- Earthquake

Other Hazards

- Wildfire

This list is repeated at the beginning of subsection 4.5.

Another consideration in the selection of the hazards to be addressed in the Plan is the history of major disaster declarations in the planning area. According to the FEMA Disaster Declarations web page, there have been 43 major disaster declarations issued in the state of North Carolina since 1954. Twelve of these declarations involved one or more of the counties included in the planning area (**Table 4.2**).

Table 4.2: Major Disaster Declarations for Alamance, Orange, and Durham Counties from 1954 to 2014

Declaration Number	Date	Incident Description	County(s) in the Planning Area Declared
4167	3/31/2014	Severe Winter Storm	Alamance, Orange
1969	4/19/2011	Severe Storms, Tornadoes, and Flooding	Alamance
1553	9/18/2004	Hurricane Ivan	Alamance
1490	9/18/2003	Hurricane Isabel	Durham
1457	3/27/2003	Ice Storm	Alamance, Orange
1448	12/12/2002	Severe Ice Storm	Alamance, Orange, Durham
1312	1/31/2000	Winter Storm	Alamance, Orange, Durham
1292	9/16/1999	Hurricanes Floyd and Irene	Alamance, Orange, Durham
1211	3/22/1998	Severe Storms, Tornadoes, and Flooding	Durham
1134	9/6/1996	Hurricane Fran	Alamance, Orange, Durham
1087	1/13/1996	Blizzard	Alamance, Orange, Durham
827	5/17/1989	Tornadoes	Durham

Source: Federal Emergency Management Agency.

As shown in Table 4.2, the earliest major disaster declaration to occur in the planning area was in 1989. The last was in 2014. The 12 major disaster declarations shown above cover the hazards of flood, hurricane/tropical storm, severe storms, severe winter weather, and tornado relevant to the planning area. This history of disaster declarations is consistent with the hazards identified by the HMPT to be addressed in the Plan.

4.2 Methodologies and Assumptions

Certain assumptions are inherent in any risk assessment. For the Eno-Haw Regional Hazard Mitigation Plan, three primary assumptions were discussed by the HMPT from the beginning of the risk assessment process: (1) that the best readily available data would be used, including, to the extent possible, data derived from the North Carolina iRISK program, (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 information and results provided where appropriate and practical.

The following list provides key points by hazard that are relevant to understanding the risk assessment presented in this section:

Flood

- 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.
- Parcels were received from all four participating counties. 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).
- Limitations: There can be multiple buildings located on one parcel. However, the parcel only provides one value for building value and year built, and it is not known from the provided data if the building value is cumulative or for the primary structure on the parcel. For the analysis, building value was only counted once per parcel, regardless of the number of structures. This was done to prevent grossly over-estimating the value of buildings at risk. For example, a parcel has three buildings with a value of $300,000. If two of those buildings intersect the 1-percent-annual-chance flood hazard area, the assumed building value at risk is $300,000 not $600,000. Even though only two out of three buildings are at risk, there is no way to determine the individual value of each building, so the building value for the whole parcel is counted. The value at risk is also the value of the entire building, and does not take into account flood damage based on elevation, number of floors, or value of contents.

Dam Failure

- The approximate extent of the dam failure hazard was identified by developing a potential inundation zone for 18 dams selected for study. This consists of 14 high hazard and 4 intermediate hazard dams. This breaks down to 28% of high hazard dams and 11% of intermediate hazard dams in the planning area studied. A combination of factors led to the selection of these 18 dams for study, including availability of detailed flood models, hazard classification, location in the planning area, etc.
- The potential inundation zone was developed by estimating the initial maximum depth of flooding just downstream of the dam and by then estimating the rate at which the flood depth will decrease with increasing distance downstream. Empirical formulas were used to estimate the initial maximum depth of flood as a function of the height of water impounded by the dam and the rate of decrease of the height of flooding downstream as a function of downstream distance, measured from the dam along the stream centerline.
- The estimated flood depths were then used to develop a water surface profile along the stream centerline. This water surface profile was converted to a planar surface which was intersected with a digital terrain model that represents the topography of the stream corridor and floodplain. This intersection yields a map of the approximate inundation zone that would result from a dam failure.

Lightning

- Based on NCDC data, the number of cloud-to-ground lightning flashes was calculated for each day, month, and year as well as for the 1987-to-present period of record. Additionally, the number of flashes was calculated for each hour and summarized by month, year, and period of record. Grids were created to show only positive polarity flashes for all time periods. The summary grids are defined as a 4 km Albers Equal Area grid, fit to the continental United States. The data was re-sampled to 150-meter cells using bilinear interpolation (for cartographic purposes).
- Average annual lightning strikes are the 25-year-average of annual average lightning strikes from 1987-2012. Accuracy depends on the distribution of lightning detection sensors which is unknown.

Winter Weather

- Winter storm maps are an interpolation of recorded values (historical maximums and 30-year-average) derived from individual point locations.

Wildfire

- Wildfire hazard areas were determined using the Wildland Fire Susceptibility Index (WFSI).
    - 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 data used for the wildfire risk analysis is a value between 0 and 1. It was developed consistent with the mathematical calculation process for determining the probability of an acre burning. 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.

- Parcels were received from all four participating counties. This data provided building value and year built. Building value was used to determine the value of buildings at risk.
- 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 a high wildfire hazard area. The ratio estimates that 20 people are at risk within that hazard area (5% of the total population for that census block).
- There can be multiple buildings on one parcel. However, the parcel only provides one value for building value and year built, and it is not known from the provided data if the building value is cumulative or for the primary structure on the parcel. For the analysis, building value was only counted once per parcel, regardless of the number of structures. This was done to prevent grossly over-estimating the value of buildings at risk. For example, a parcel has three buildings with a value of $300,000. If two of those buildings intersect the high risk area, the assumed building value at risk is $300,000 not $600,000. Even though only two out of three buildings are at risk, there is no way to determine the individual value of each building, so the building value for the whole parcel is counted. The value at risk is also the value of the entire building, and does not take into account the value of contents.

4.4 Inventory of Community Assets

Each participating jurisdiction assisted in the identification of assets to be used for analysis to determine what assets may be potentially at risk to the hazards covered in the Plan. These assets are defined broadly as anything that is important to the function and character of the community. For the purposes of this *Risk Assessment*, the individual types of assets include:

- Population
- Parcels and Buildings
- Critical Facilities
- Infrastructure
- High Potential Loss Properties (assessed value greater than $1 million)
- Historic Properties

Although all assets may be affected by certain hazards (such as hail or tornadoes), some assets are more vulnerable because of their location (e.g., the floodplain), certain physical characteristics (e.g., slab-on-grade construction), or socioeconomic uses (e.g., major employers). The following subsections document the numbers and values used for the *Risk Assessment*.

4.4.1 Population

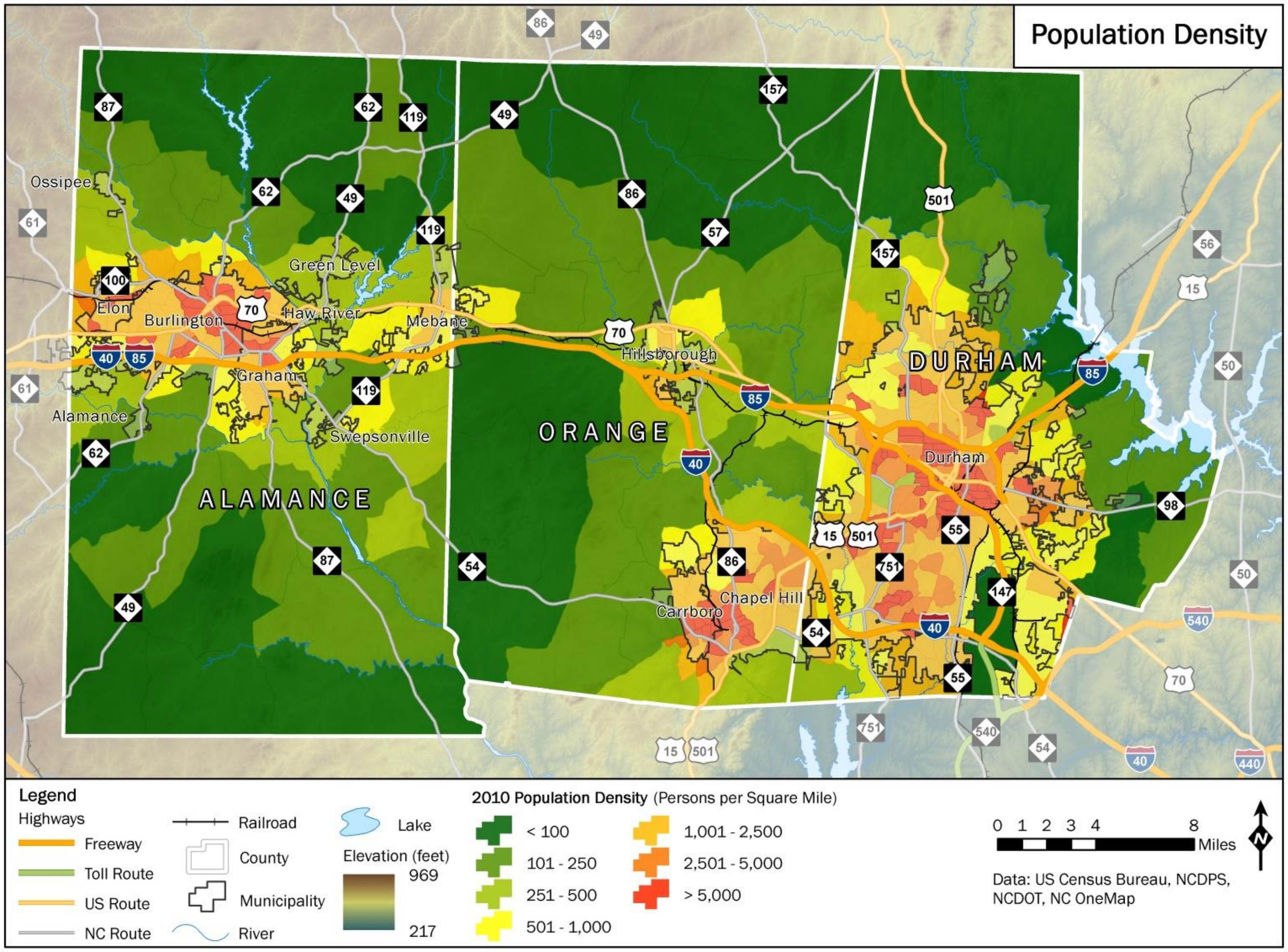
The population counts shown in **Table 4.3** are derived from 2010 census data and include a breakdown of two subpopulations assumed to be at greater risk to natural hazards than the "general" population: elderly (ages 65 and older) and children (under the age of 5). **Figure 4.1** shows population density per square mile, along with the distribution of potentially at-risk populations, across the planning area.

Table 4.3: Population Counts with Vulnerable Population Breakdown

Jurisdiction	2010 Census Population	Elderly (Age 65 and Over)	Children (Age 5 and Under)
Alamance County (Unincorporated Area)	**59,157**	**8,404**	**3,351**
Alamance	951	119	64
Burlington	49,963	7,863	3,541
Elon	9,419	1,543	192
Graham	14,153	2,071	1,051
Green Level	2,100	257	184
Haw River	2,298	337	189
Mebane	11,393	1,231	875
Ossipee	543	70	26
Swepsonville	1,154	186	51
Subtotal Alamance	*151,131*	*22,081*	*9,524*
Orange County (Unincorporated Area)	**50,899**	**5,838**	**2,921**
Carrboro	19,582	1,029	1,134
Chapel Hill	57,233	5,281	2,391
Hillsborough	6,087	741	444
Subtotal Orange	*133,801*	*12,889*	*6,890*
Durham County (Unincorporated Area)	**39,257**	**5,971**	**2,232**
Durham	228,330	20,146	17,583
Subtotal Durham	*267,587*	*26,117*	*19,815*
TOTAL ENO-HAW	**552,519**	**61,087**	**36,229**

Source: U.S. Census Bureau.

Figure 4.1: Population Density in the Eno-Haw Region



4.4.2 Building Counts and Values

The building counts and building values shown in **Table 4.4** represent the built environment inventories used for the analyses included in the *Risk Assessment*.

Table 4.4: Building Counts and Values by Jurisdiction

Jurisdiction	Building Count	Building Value
Alamance County (Unincorporated Area)	**43,080**	**$5,586,400,446**
Alamance	495	$73,196,526
Burlington	24,549	$5,063,017,835
Elon	2,502	$691,238,509
Graham	6,553	$1,171,777,377
Green Level	1,010	$77,017,878
Haw River	1,505	$271,031,840
Mebane	4,040	$970,860,836
Ossipee	354	$139,783,779
Swepsonville	658	$111,000,138
Subtotal Alamance	*84,746*	*$14,155,325,164*
Orange County (Unincorporated Area)	**28,936**	**$3,877,609,317**
Carrboro	5,354	$1,303,094,105
Chapel Hill	14,372	$5,059,801,377
Hillsborough	2,835	$504,852,574
Subtotal Orange	*51,497*	*$10,745,357,373*
Durham County (Unincorporated Area)	**24,667**	**$3,735,835,447**
Durham	79,277	$18,116,234,138
Subtotal Durham	*103,944*	*$21,852,069,585*
TOTAL ENO-HAW	**240,187**	**$46,752,752,122**

Source: NC iRISK.

4.4.3 Critical Facilities

Table 4.5 shows counts of critical facilities under a variety of categories attributed to each participating jurisdiction. **Figure 4.2** shows the general locations of critical facilities across the planning area.

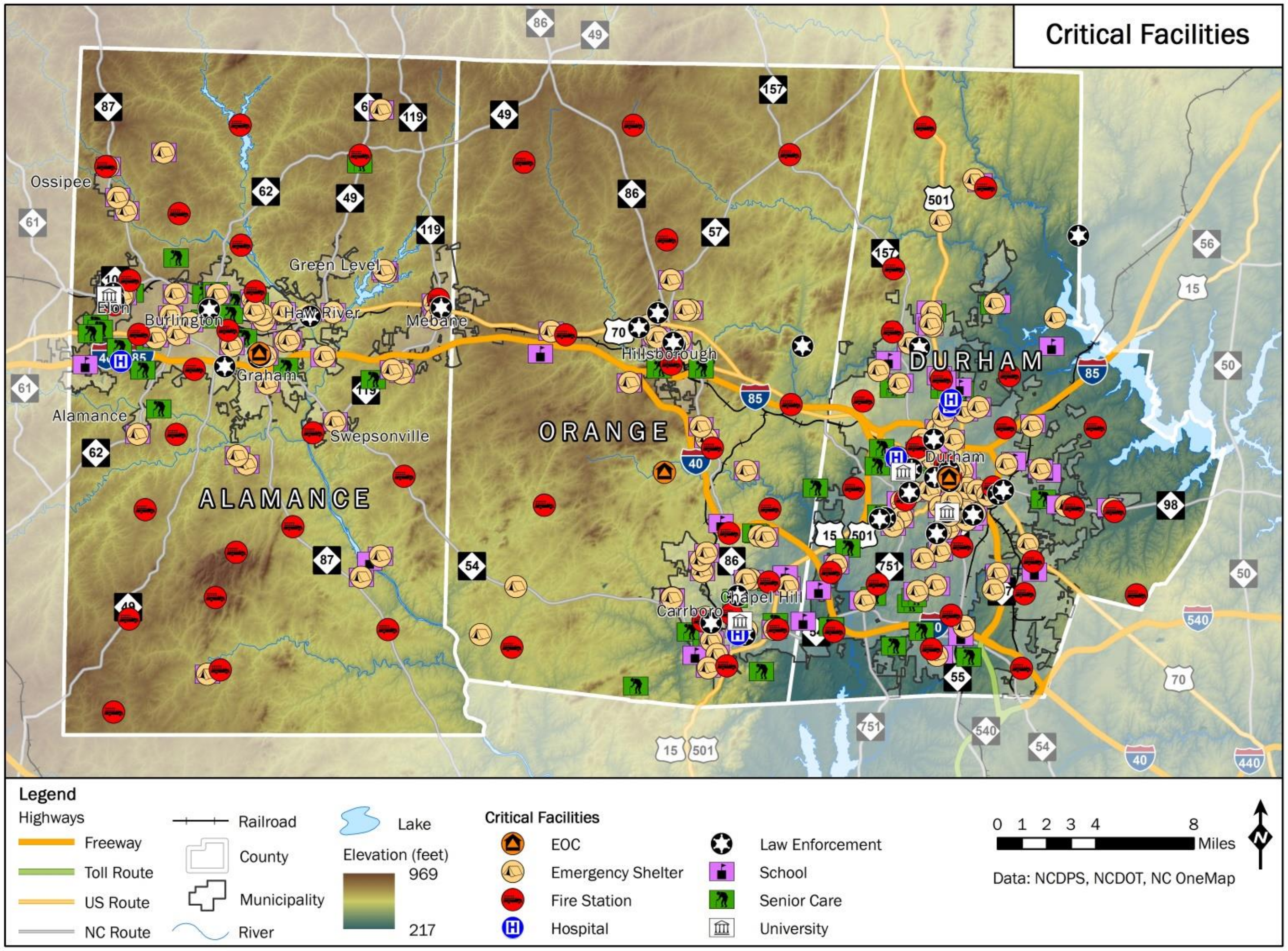
Table 4.5: Critical Facilities Counts by Jurisdiction

Jurisdiction	EOCs	Fire Stations	Hospitals[2]	Police	Schools	Senior Care	Shelters	Universities
Alamance County (Unincorporated)	**0**	**15**	**0**	**0**	**15**	**5**	**14**	**0**
Alamance	0	0	0	0	0	0	0	0
Burlington	0	5	1	2	13	13	12	0
Elon	0	2	0	2	1	4	2	1
Graham	1	1	0	3	5	3	5	0
Green Level	0	0	0	1	0	0	0	0
Haw River	0	1	0	1	1	0	1	0
Mebane	0	2	0	1	2	0	2	0
Ossipee	0	1	0	0	1	0	1	0
Swepsonville	0	1	0	0	1	0	1	0
Subtotal Alamance	*1*	*28*	*1*	*10*	*39*	*25*	*38*	*1*
Orange County (Unincorporated)	1	**14**	0	2	14	4	13	0
Carrboro	0	2	0	1	5	2	1	0
Chapel Hill	0	5	1	3	14	7	14	1
Hillsborough	0	3	0	1	4	2	3	0
Subtotal Orange	*1*	*24*	*1*	*7*	*34*	*15*	*31*	*1*
Durham County (Unincorporated)	**0**	**8**	**0**	**1**	**8**	**3**	**9**	**0**
Durham	1	19	3	15	51	20	46	2
Subtotal Durham	*1*	*27*	*3*	*16*	*59*	*23*	*55*	*2*
TOTAL ENO-HAW	**3**	**79**	**5**	**33**	**132**	**63**	**124**	**4**

Source: NC iRISK and NC OneMap.

[2] Hospital and university counts are counts per campus and may not reflect actual number of buildings.

Figure 4.2: Critical Facilities Locations in the Eno-Haw Region



4.4.4 Infrastructure

Certain infrastructure elements as shown in **Table 4.6** were identified for analysis. These include major roads[3], railroads, power plants, and water/wastewater facilities.

Table 4.6: Infrastructure Counts and Measurements (in Miles) by Jurisdiction

Jurisdiction	Major Roads	Railroad[4]	Power Plants	Water/Wastewater Facilities
Alamance County (Unincorporated)	**106.7**	**5.6**	**1**	**4**
Alamance	1.1	0.0	0	0
Burlington	36.5	5.7	0	1
Elon	2.2	1.6	0	0
Graham	13.0	2.6	0	0
Green Level	1.8	0.0	0	0
Haw River	5.2	1.9	0	0
Mebane	7.7	1.5	0	1
Ossipee	1.2	0.0	0	0
Swepsonville	0.8	0.0	0	0
Subtotal Alamance	*176.2*	*19.0*	*1*	*6*
Orange County (Unincorporated)	**136.6**	**28.6**	**0**	**1**
Carrboro	4.2	2.0	0	1
Chapel Hill	26.9	2.9	1	1
Hillsborough	3.6	1.3	0	1
Subtotal Orange	*171.2*	*34.7*	*1*	*4*
Durham County (Unincorporated)	**83.3**	**20.3**	**0**	**1**
Durham	142.5	36.6	0	3
Subtotal Durham	*225.8*	*56.9*	*0*	*4*
TOTAL ENO-HAW	**573.3**	**110.6**	**2**	**14**

Source: NCFMP; NCDOT.

The general locations of infrastructure elements across the planning area is shown in **Figure 4.3** along with High Potential Loss Properties, discussed in the following section.

[3] The major roads and railroads accounted for in this table are the same as those depicted on the "Community Profile" map found in Section 2.
[4] Does not include inactive/abandoned railroads.

4.4.5 High Potential Loss Properties

Table 4.7 shows counts of high potential loss properties attributed to each participating jurisdiction. **Figure 4.3** shows the general locations of these properties across the planning area.

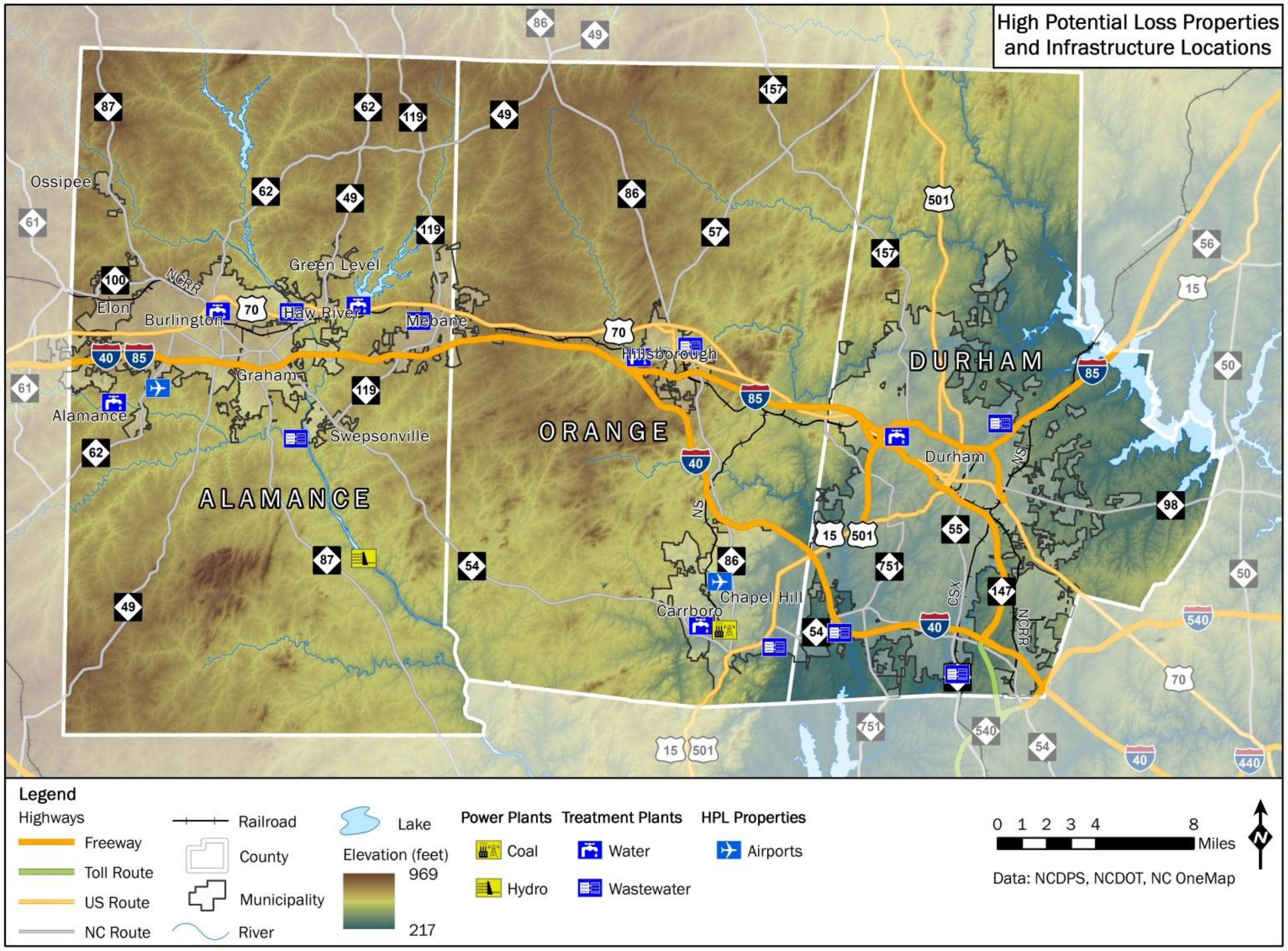
Table 4.7: High Potential Loss Properties by Jurisdiction

Jurisdiction	Major Airports	Dams[5]	>$1m
Alamance County (Unincorporated)	1	81	378
Alamance	0	0	7
Burlington	0	7	571
Elon	0	3	126
Graham	0	2	153
Green Level	0	0	1
Haw River	0	0	26
Mebane	0	4	100
Ossipee	0	0	8
Swepsonville	0	1	10
Subtotal Alamance	*1*	*98*	*1,380*
Orange County (Unincorporated)	0	35	94
Carrboro	0	3	69
Chapel Hill	1	4	550
Hillsborough	0	3	42
Subtotal Orange	*1*	*45*	*755*
Durham County (Unincorporated)	0	40	234
Durham	0	43	1,635
Subtotal Durham	*0*	*83*	*1,869*
TOTAL ENO-HAW	**2**	**226**	**4,004**

Source: NCDENR; NC OneMap.

[5] Locations of dams are provided in the dam failure section and are not shown on the following map.

Figure 4.3: Locations of Infrastructure Elements and High Potential Loss Properties



4.4.6 Historic Properties

Historic property counts including historic districts, buildings, sites (such as farms, cemeteries, etc.) and landmarks were derived from the National Register of Historic Places (National Park Service) database and are shown in **Table 4.8**.

Table 4.8: Historic Property Counts by Jurisdiction

Jurisdiction	Districts[6]	Buildings (Outside of Districts)	Sites/Other	Landmarks
Alamance County (Unincorporated Area)	**2**	**13**	**0**	**0**
Alamance	1	1	1	0
Burlington	6	19	1	0
Elon	1	1	0	0
Graham	3	3	0	0
Green Level	0	0	0	0
Haw River	1	0	1	0
Mebane	4	10	2	0
Ossipee	0	0	0	0
Swepsonville	0	0	0	0
Subtotal Alamance	*18*	*47*	*5*	*0*
Orange County (Unincorporated Area)	**1**	**4**	**1**	**0**
Carrboro	2	1	1	0
Chapel Hill	5	6	5	2
Hillsborough	1	21	4	1
Subtotal Orange	*9*	*32*	*11*	*3*
Durham County (Unincorporated Area)	**0**	**4**	**1**	**0**
Durham	24	48	8	3
Subtotal Durham	*24*	*52*	*9*	*3*
TOTAL ENO-HAW	**51**	**131**	**25**	**6**

Source: National Park Service National Register of Historic Places.

Based on this information, there are a total of 51 historic districts, 131 buildings outside of historic districts, 25 other historic sites, and 6 historic landmarks in the planning area. Geospatial data and site-specific property values are not currently available and therefore further risk analysis is not possible at this time. However, the HMPT has taken into account these historic property counts in the development of potential mitigation actions.

[6] Districts may include multiple buildings. Counts of individual buildings located in each historic district are not currently available.

4.5 Hazard Profiles, Analysis, and Vulnerability

As stated in subsection 4.2, the following hazards are addressed in this *Risk Assessment* and are presented in the following order in the subsections to follow:

Hydrologic Hazards (Water Hazards)
- Flood
- Dam/Levee Failure
- Drought/Extreme Heat

Atmospheric Hazards (Severe Storms)
- Thunderstorm, Lightning, and Hail
- Tornado
- Winter Weather
- Hurricane and Tropical Storm

Geologic Hazards
- Landslide
- Earthquake

Other Hazards
- Wildfire

4.5.1 Hydrologic Hazards (Water Hazards)

Hydrologic hazards are essentially "water-based" hazards that include flood, dam/levee failure, and drought/extreme heat. It is important to note that some hydrologic hazards result from the activity of atmospheric hazards, such as thunderstorms producing large amounts of rain, etc. The flood component of such composite hazards is covered here, whereas the wind component is covered under the Atmospheric Hazards subsection.

4.5.1.1 Flood

Flood Hazard Description

Flooding is the most frequent and costly natural hazard in the United States, a hazard that has caused more than 10,000 deaths since 1900. Nearly 90% of presidential disaster declarations result from natural events where flooding was a major component.

<u>Riverine flooding</u> is generally the result of excessive precipitation and one of the primary types of flooding analyzed for hazard mitigation planning purposes due to the availability of Digital Flood Insurance Rate Maps (DFIRMs) and other regulatory and non-regulatory flood risk mitigation products. The severity of a riverine flooding event is typically determined by a combination of several major factors, including: stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and the degree of vegetative clearing and impervious surface. Riverine floods can be long-term events that may last for several days.

Another major type of flooding and one that has caused multiple flood events in the planning area is flash flooding. Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. However, flash flooding events may also occur from a dam or levee failure within minutes or hours of heavy amounts of rainfall, or from a sudden release of water held by a retention basin or other stormwater control facility. Flash flooding is common in urbanized areas where much of the ground is covered by impervious surfaces and stormwater management issues can become a factor.

The periodic flooding of lands adjacent to rivers and streams (land known as floodplain) is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. The recurrence interval of a flood is defined as the average time interval, in years, expected between a flood event of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence intervals, and floodplains are designated by the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain will be inundated by the 10-year flood and the 100-year floodplain by the 100-year flood. Another way of expressing the flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1-percent-annual-chance of occurring in any given year. The 500-year flood has a 0.2-percent-annual-chance of occurring in any given year.

Flood Hazard Analysis

There are numerous rivers and streams flowing through the planning area, including the Eno River, Haw River, Great Alamance Creek, and others. When heavy or prolonged rainfall events occur, these rivers and streams are susceptible to some degree of flooding. There have been a number of past flooding events throughout the planning area, ranging widely in terms of location, magnitude, and impact. The most frequent flooding events have been localized in nature, resulting from heavy rains in a short period of time over urbanized areas that are not able to adequately handle stormwater runoff. These events typically do not threaten lives or property and do not result in emergency or disaster declarations, therefore historical data is limited to the larger, most notable events.

Location Within the Planning Area

Figures 4.4 through **4.16** show the flood hazard boundaries associated with each municipal jurisdiction based on effective DFIRM data. These effective dates are 1/02/2008 for Alamance County, 5/16/2008 for Orange County, and 5/16/2008 for Durham County. The flood zones depicted on these maps, particularly the 1-percent-annual-chance and 0.2-percent-annual-chance floodplains, are the flood hazard boundaries used for the subsequent flood hazard analysis.

Extent (Magnitude and Severity)

This regional hazard analysis focuses on the two primary flood hazard extents shown in Figures 4.4 through 4.16: the 1-percent-annual-chance flood (100-year return period), and the 0.2-percent-annual-chance flood (500-year return period).

The U.S. Geological Survey maintains historical peak river stage information for three stations in Alamance County, eight stations in Durham County, and eight stations in Orange County. The station with the highest number of peaks in the Eno-Haw Region is the Flat River at Bahama station in Durham County (81 peaks dating from 1926 to 2006). The highest number of peaks in Alamance County (and the second highest in the region) is the Haw River at Haw River station with 78 peaks from 1929 to 2006. The highest number of peaks in Orange County (and the third highest in the region) is the Eno River at Hillsborough station with 64 peaks from 1928 to 2006.

Figure 4.4: Flood Hazard Areas in the Village of Alamance

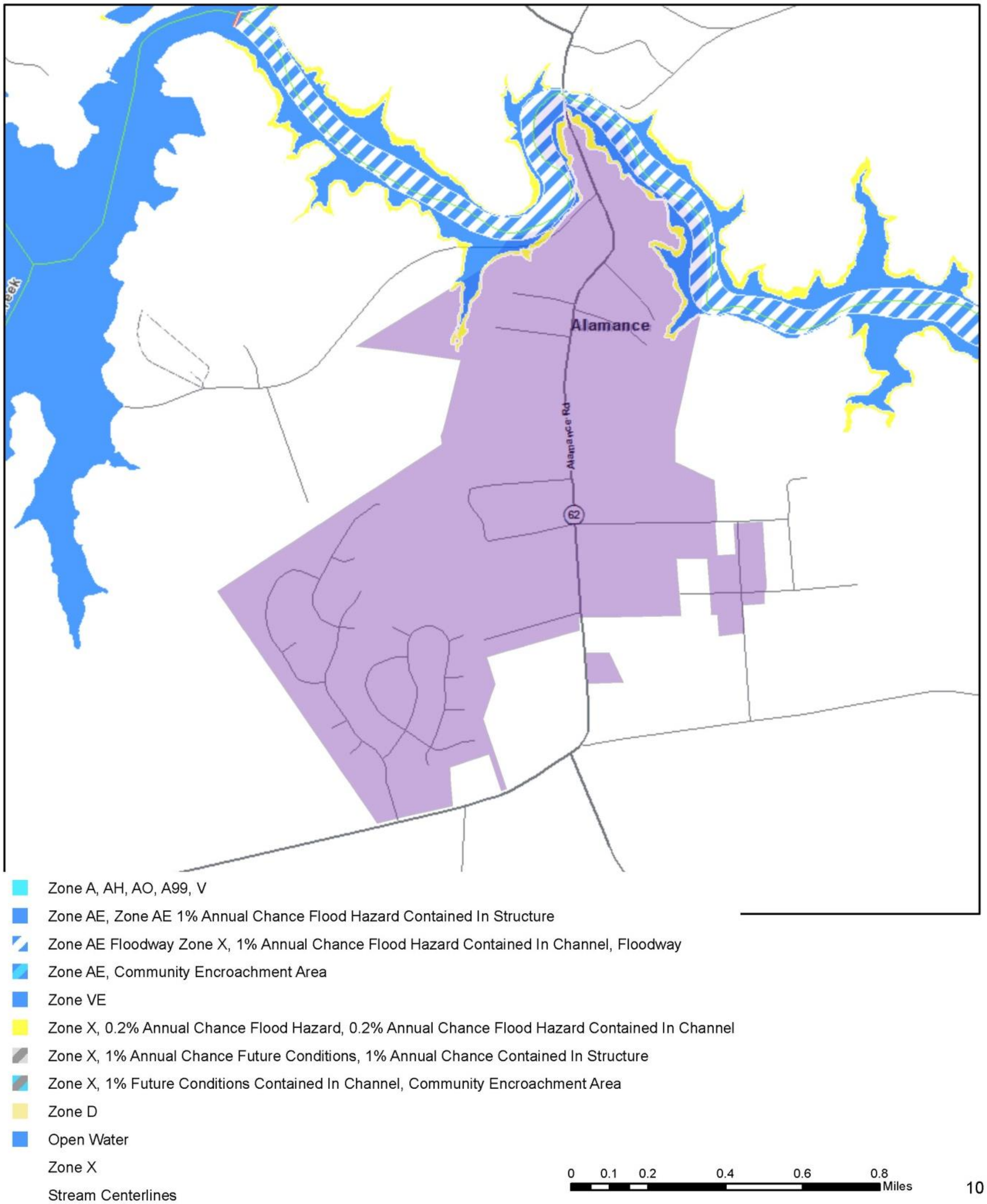


Figure 4.5: Flood Hazard Areas in the City of Burlington

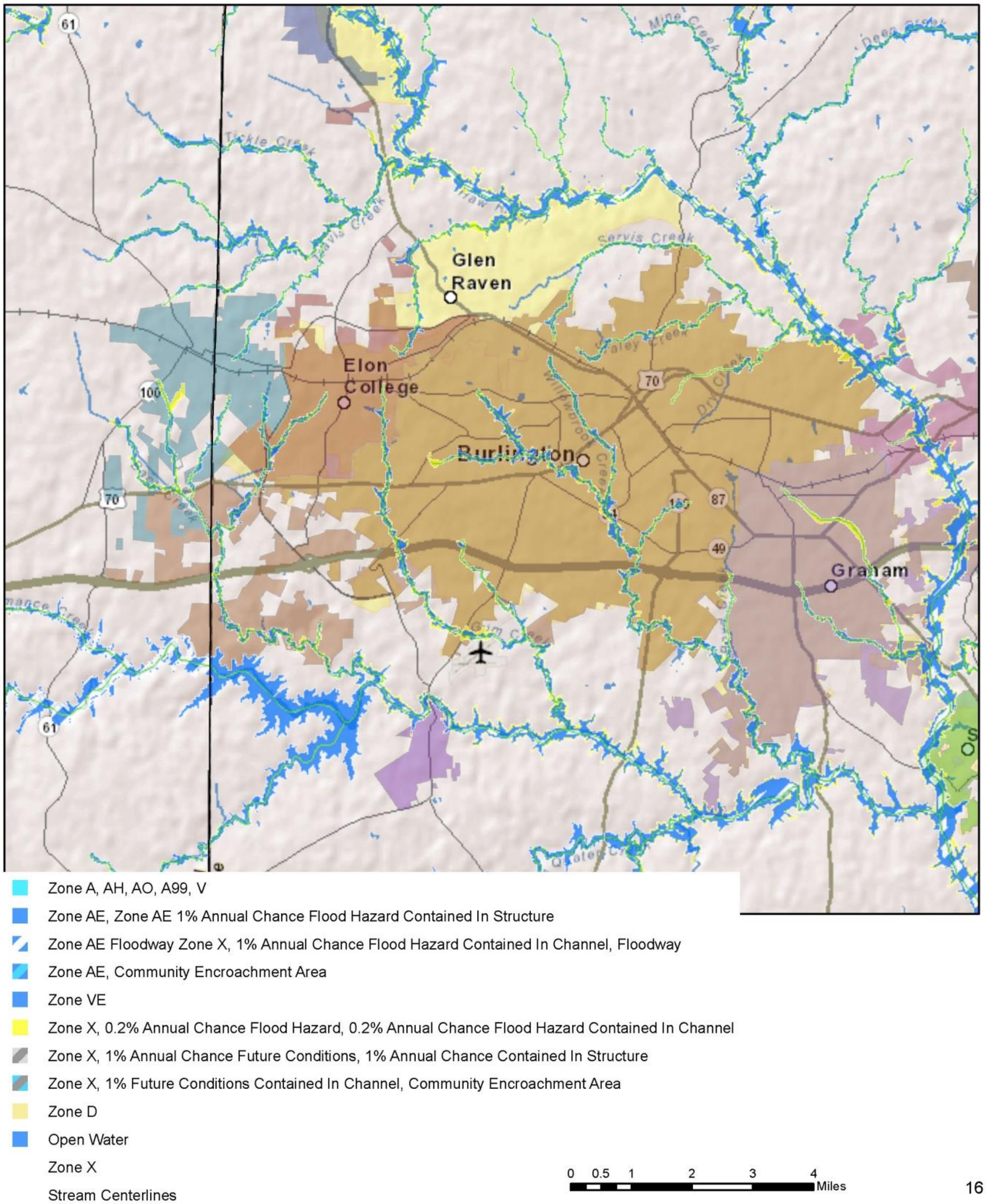


Figure 4.6: Flood Hazard Areas in the Town of Elon

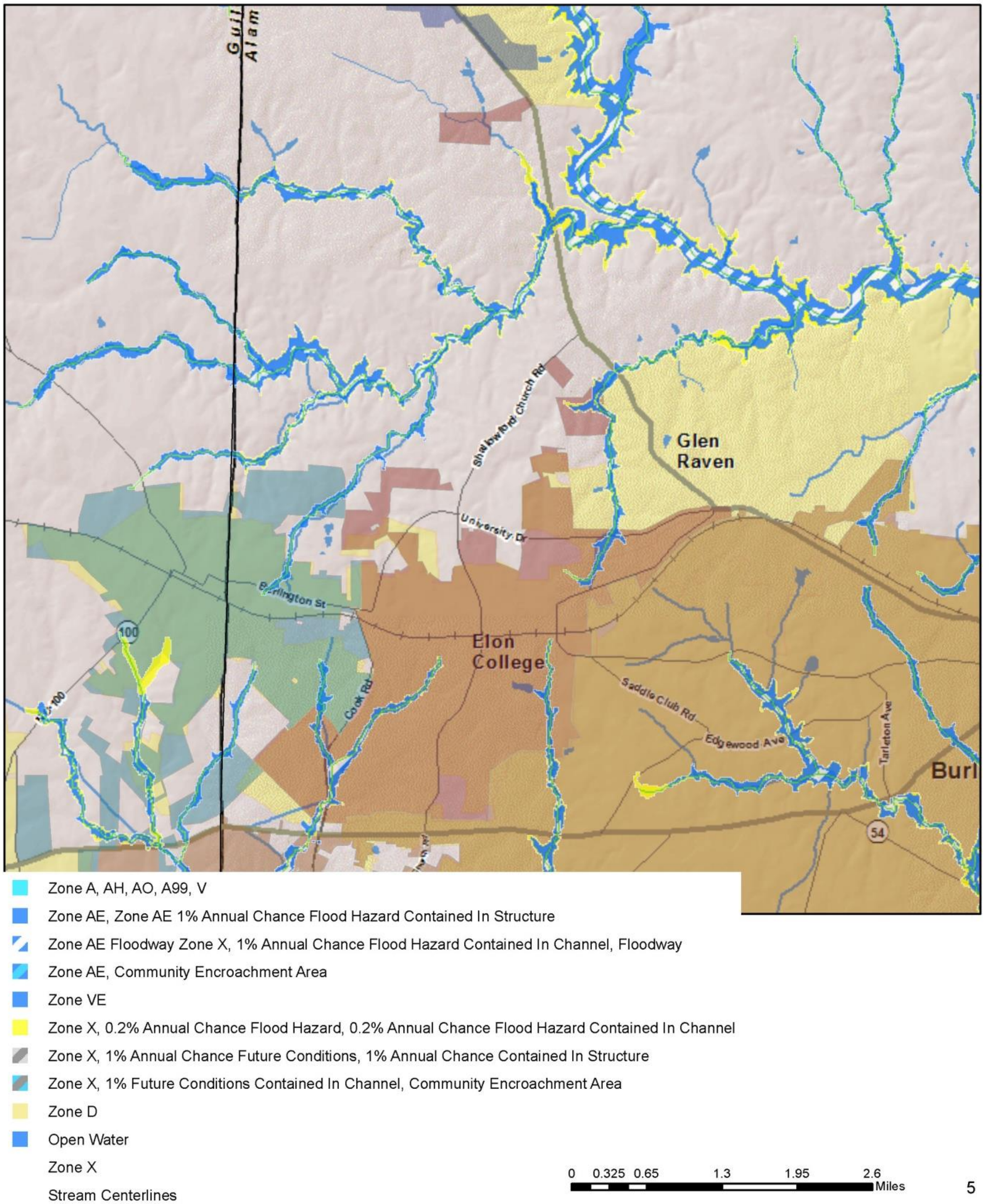


Figure 4.7: Flood Hazard Areas in the City of Graham

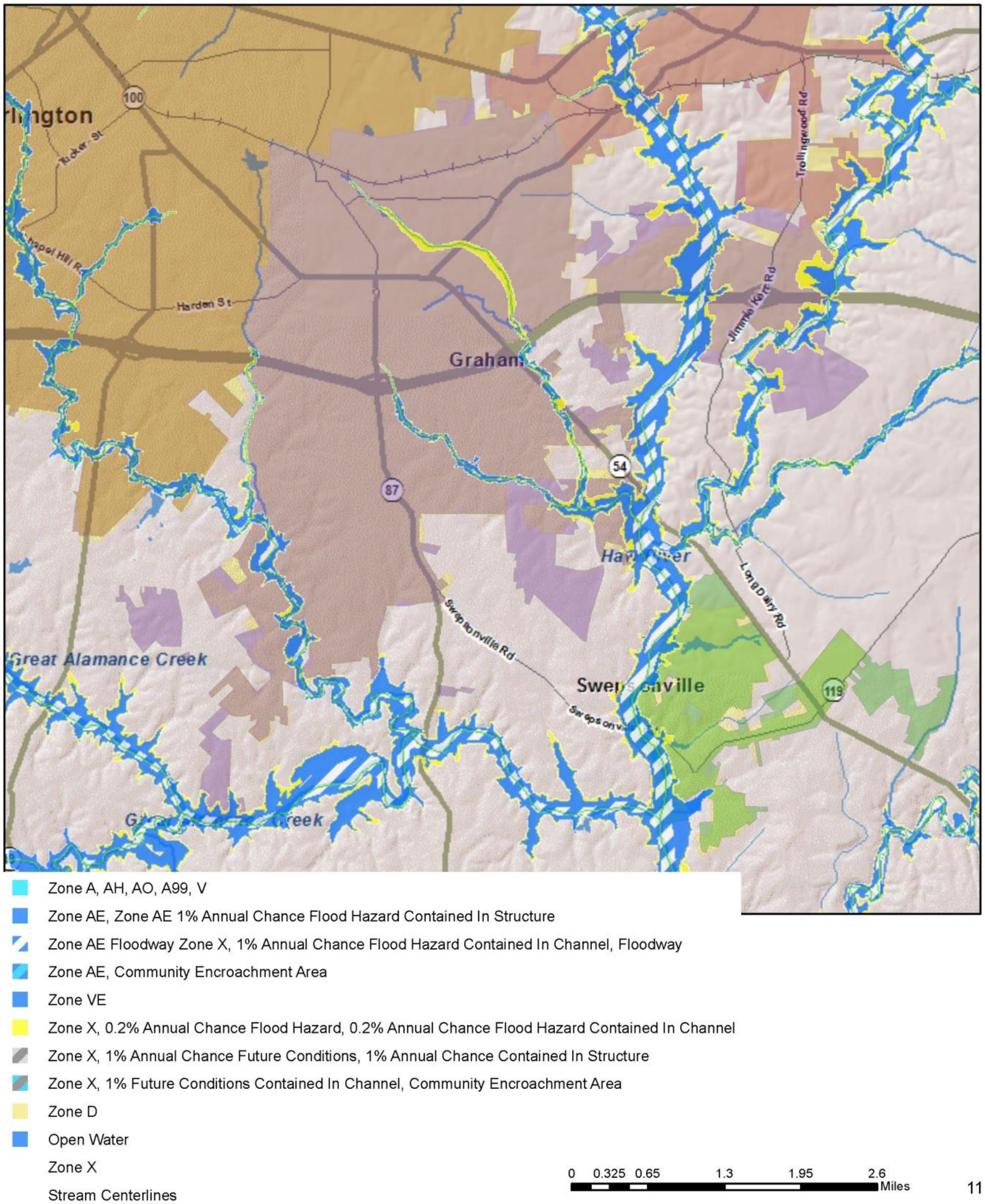


Figure 4.8: Flood Hazard Areas in the Town of Green Level

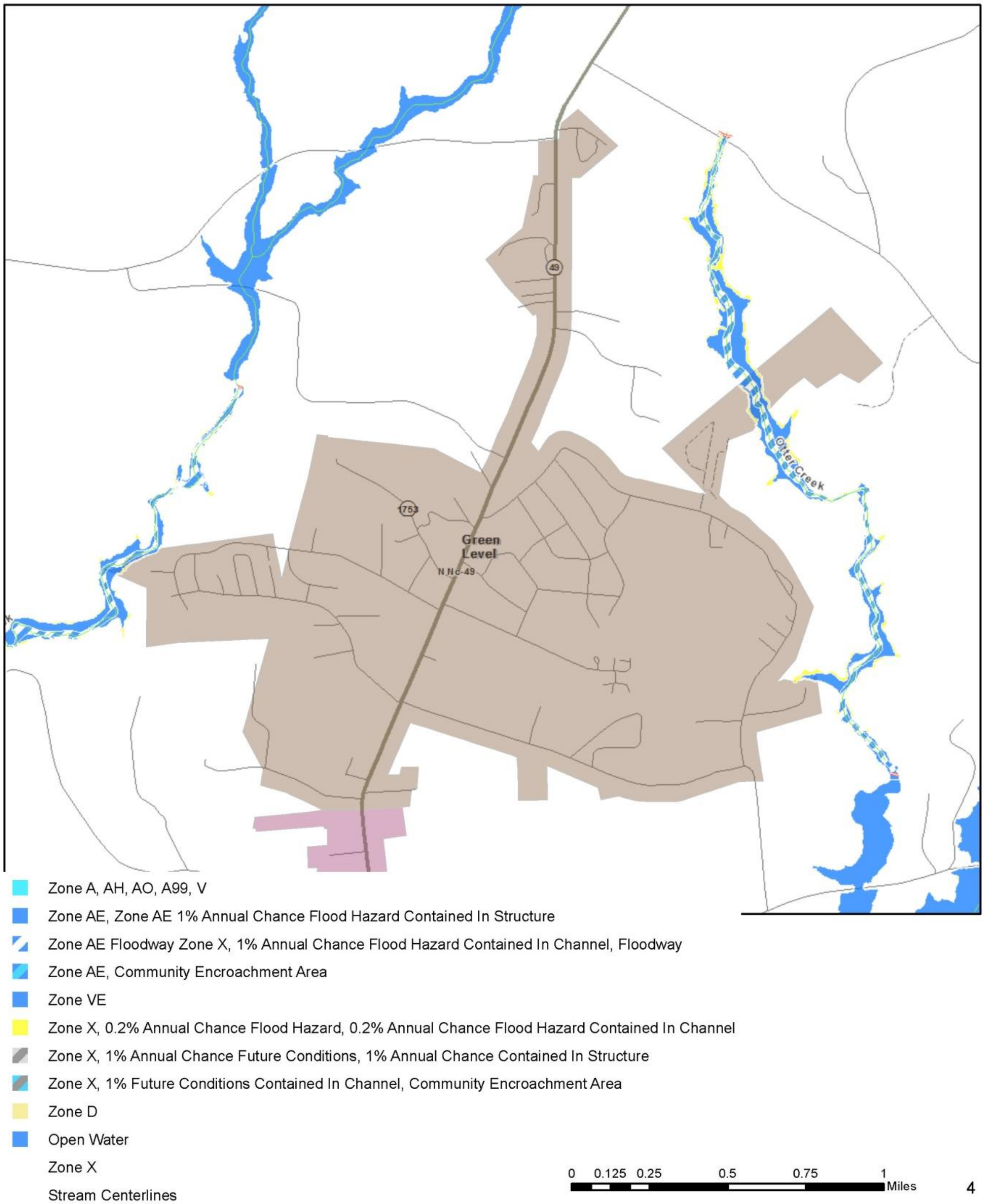


Figure 4.9: Flood Hazard Areas in the Town of Haw River

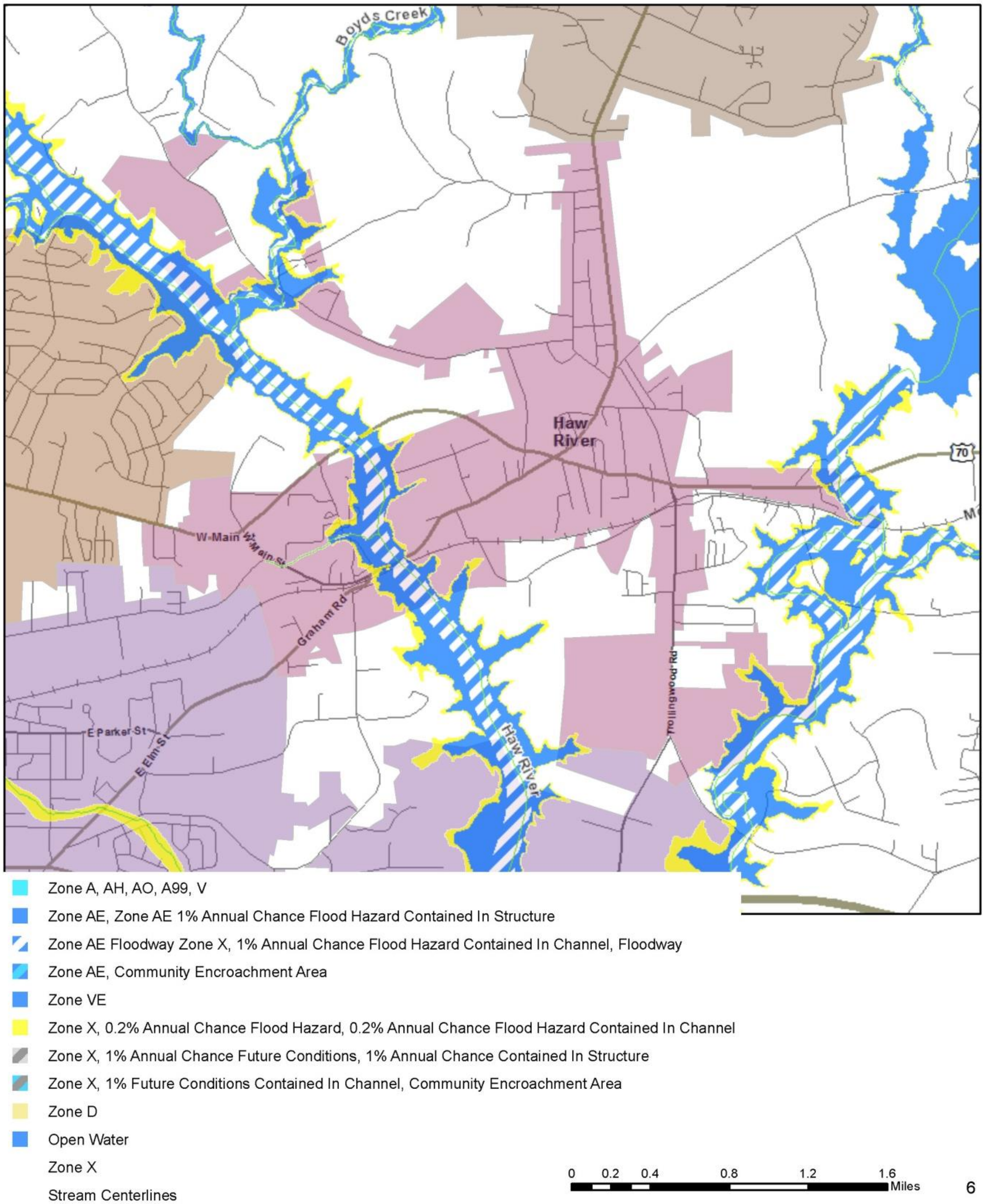


Figure 4.10: Flood Hazard Areas in the City of Mebane

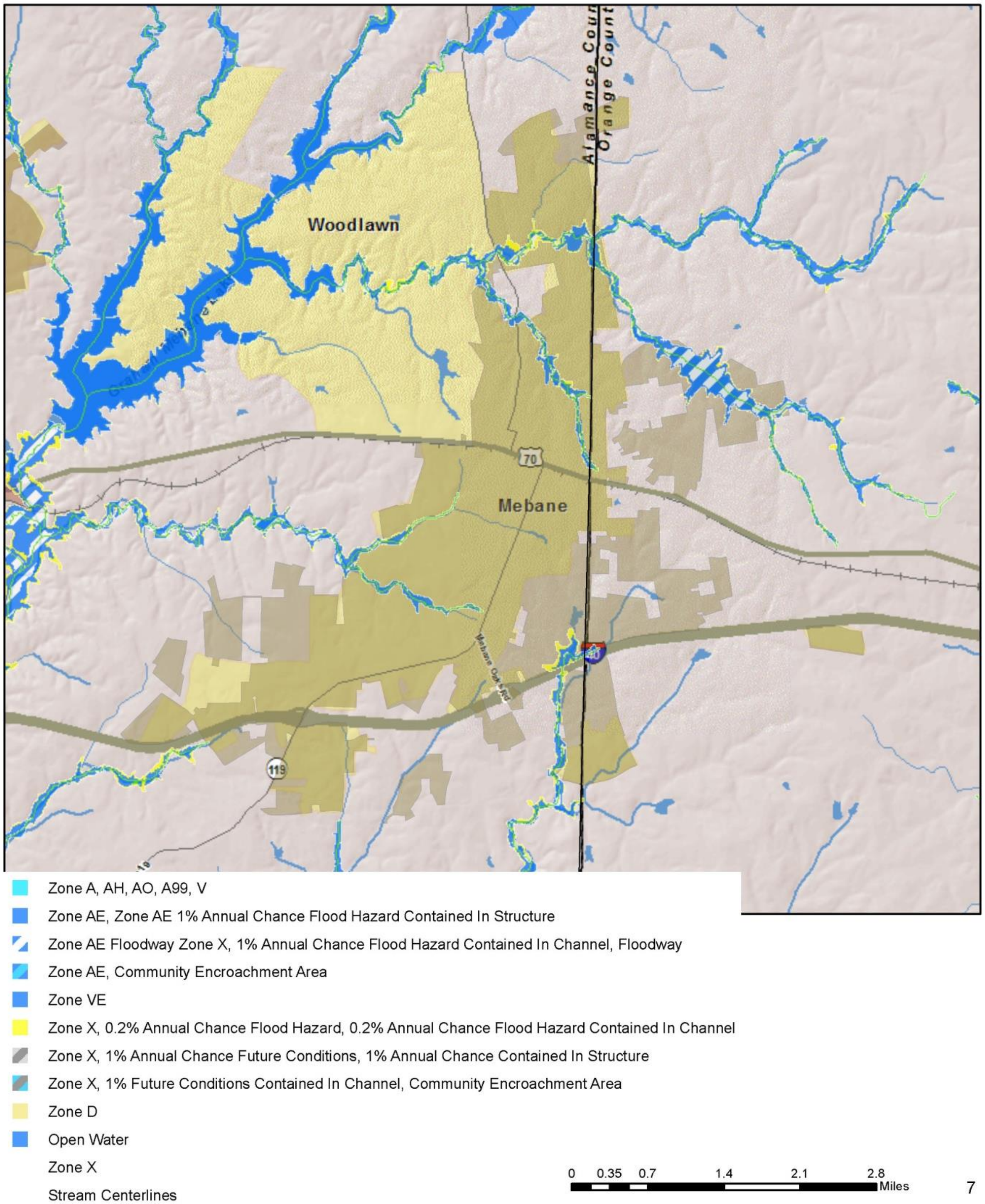


Figure 4.11: Flood Hazard Areas in the Town of Ossipee

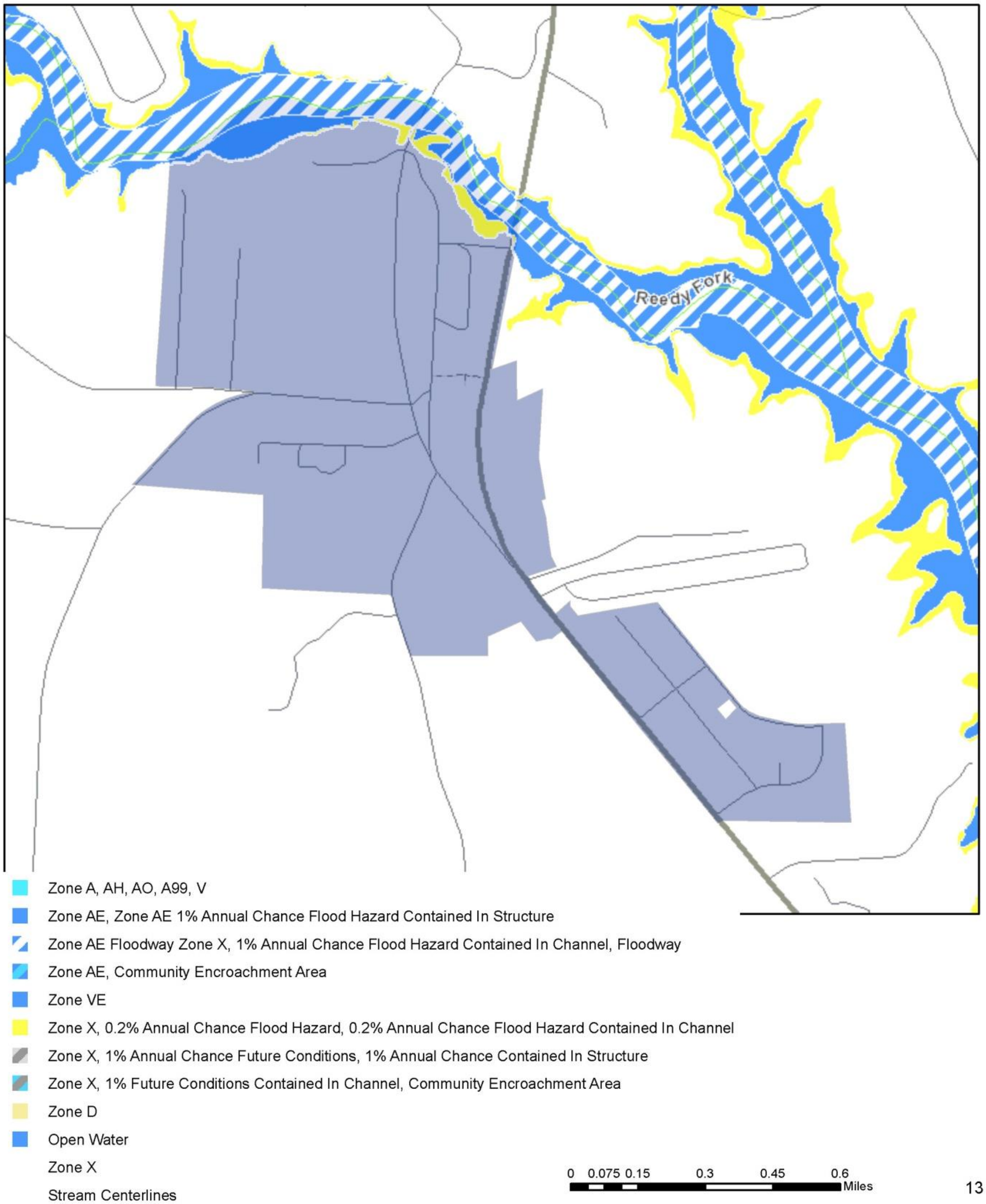


Figure 4.12: Flood Hazard Areas in the Town of Swepsonville

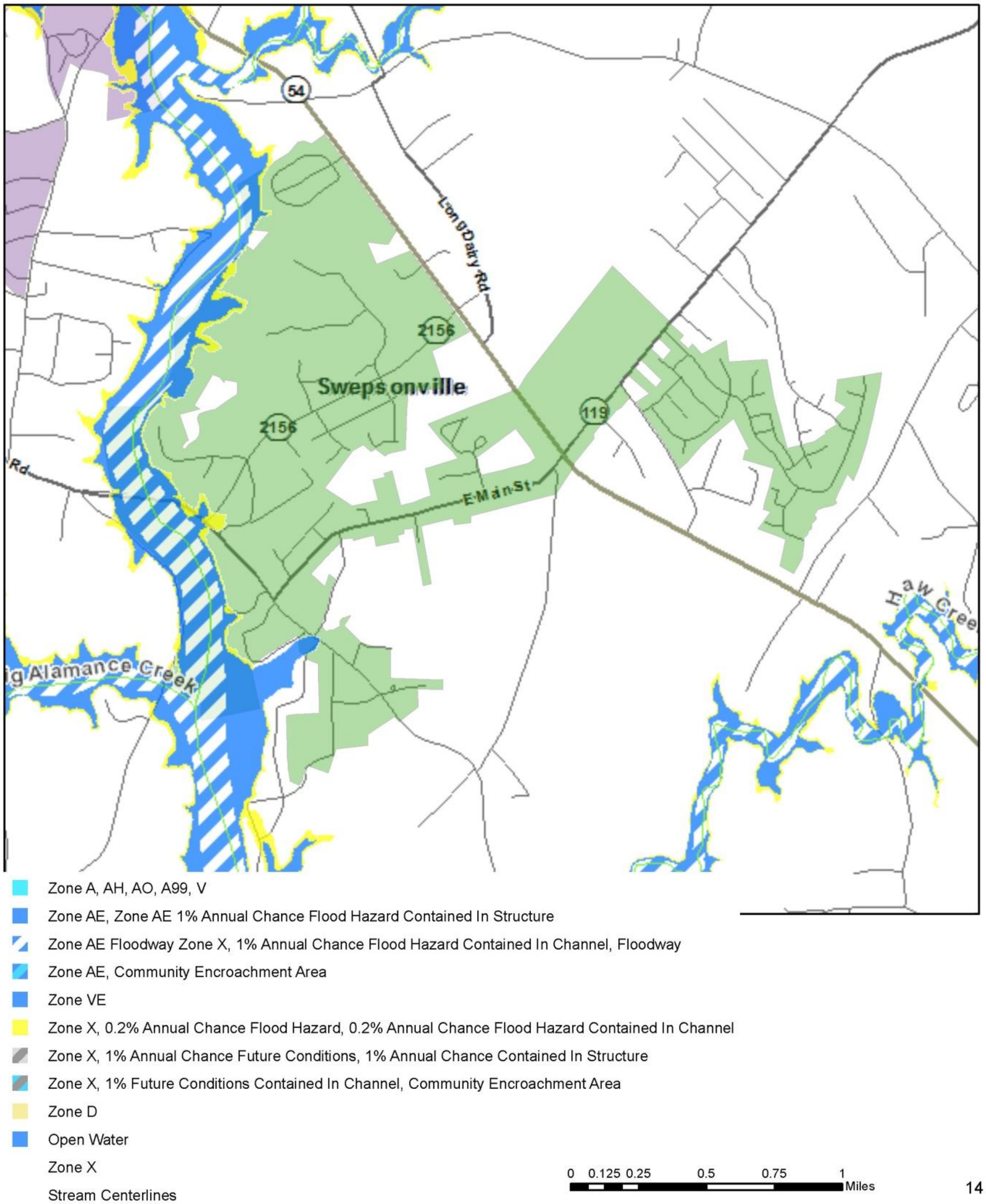


Figure 4.13: Flood Hazard Areas in the Town of Carrboro

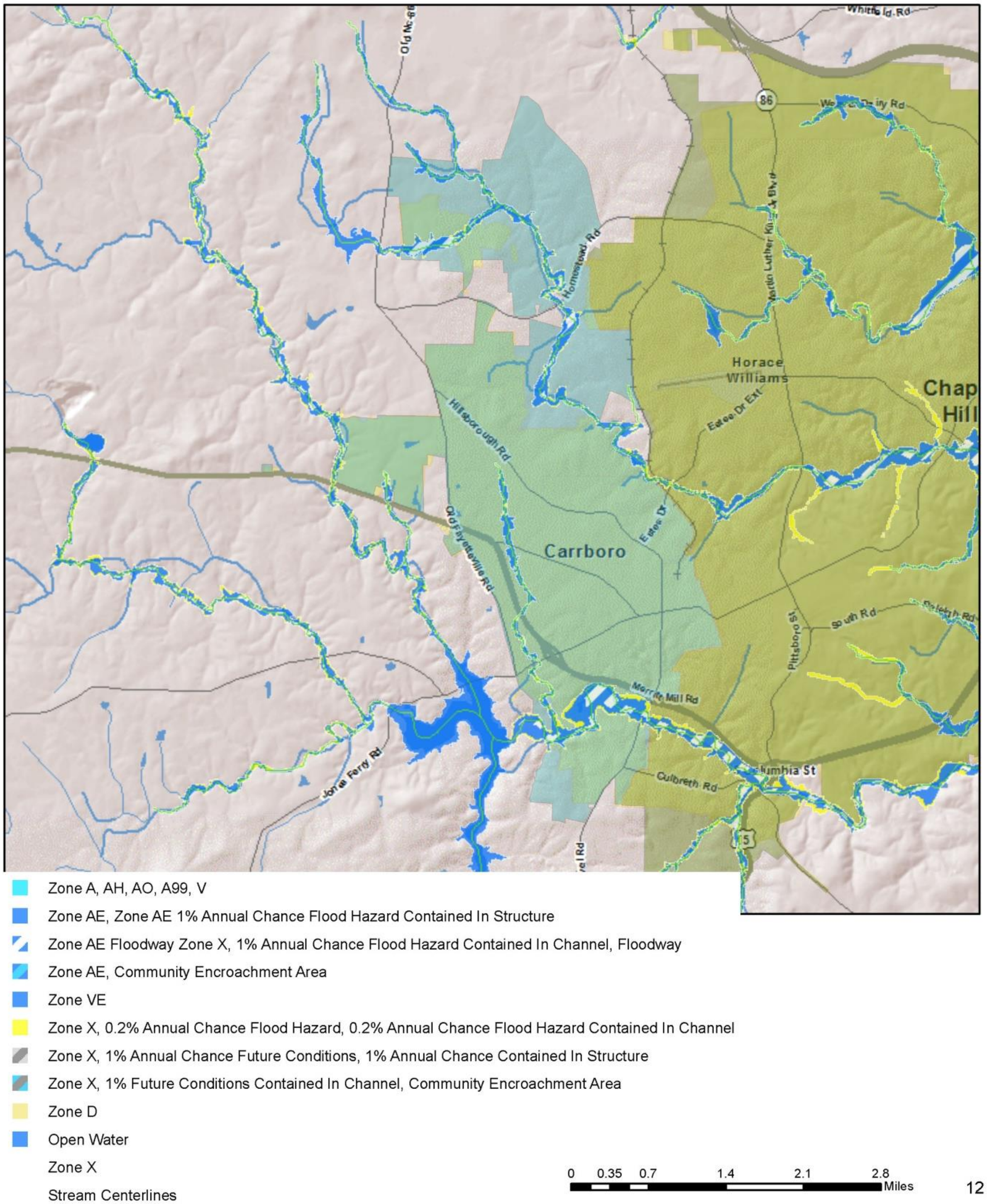


Figure 4.14: Flood Hazard Areas in the Town of Chapel Hill

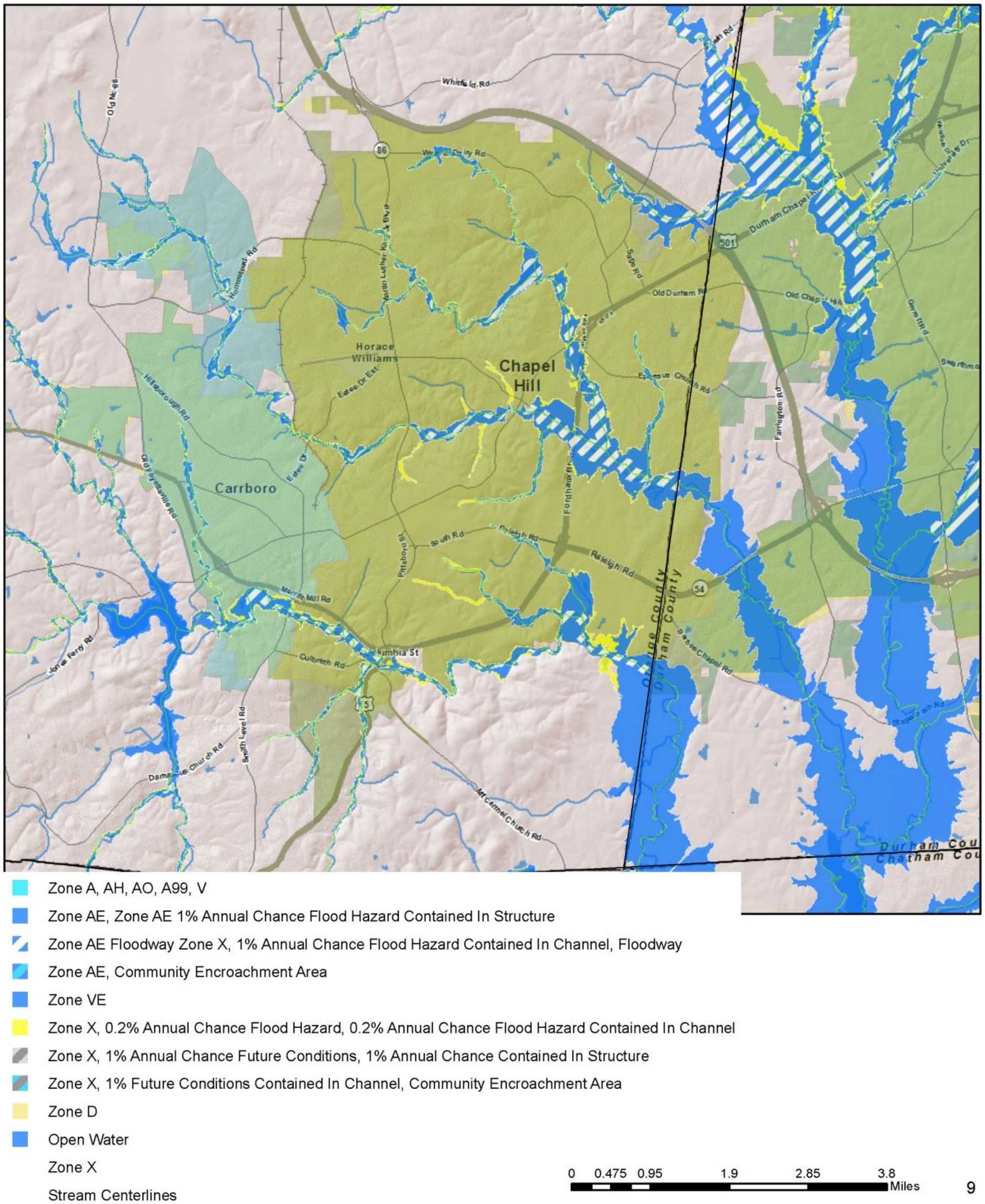


Figure 4.15: Flood Hazard Areas in the Town of Hillsborough

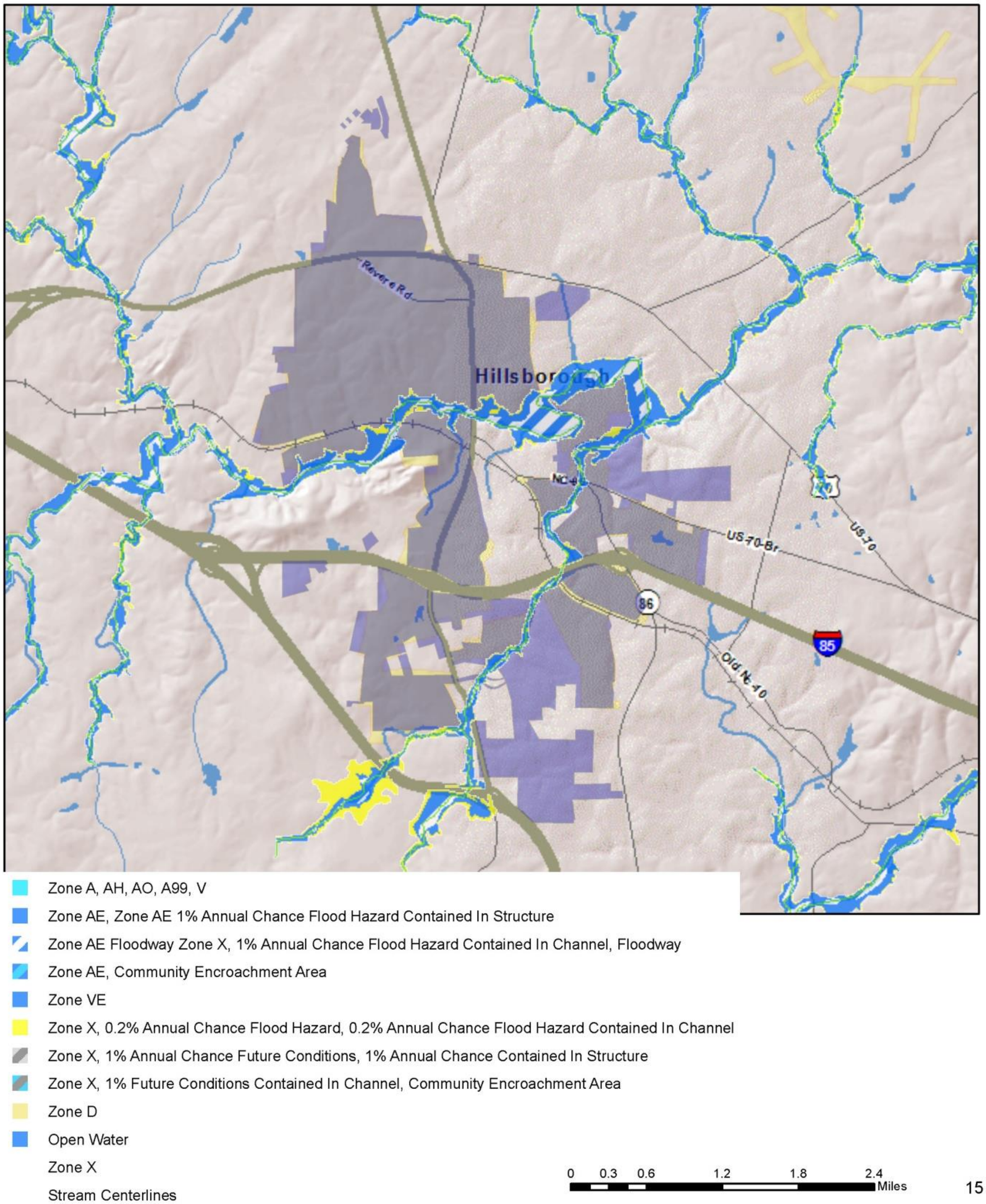
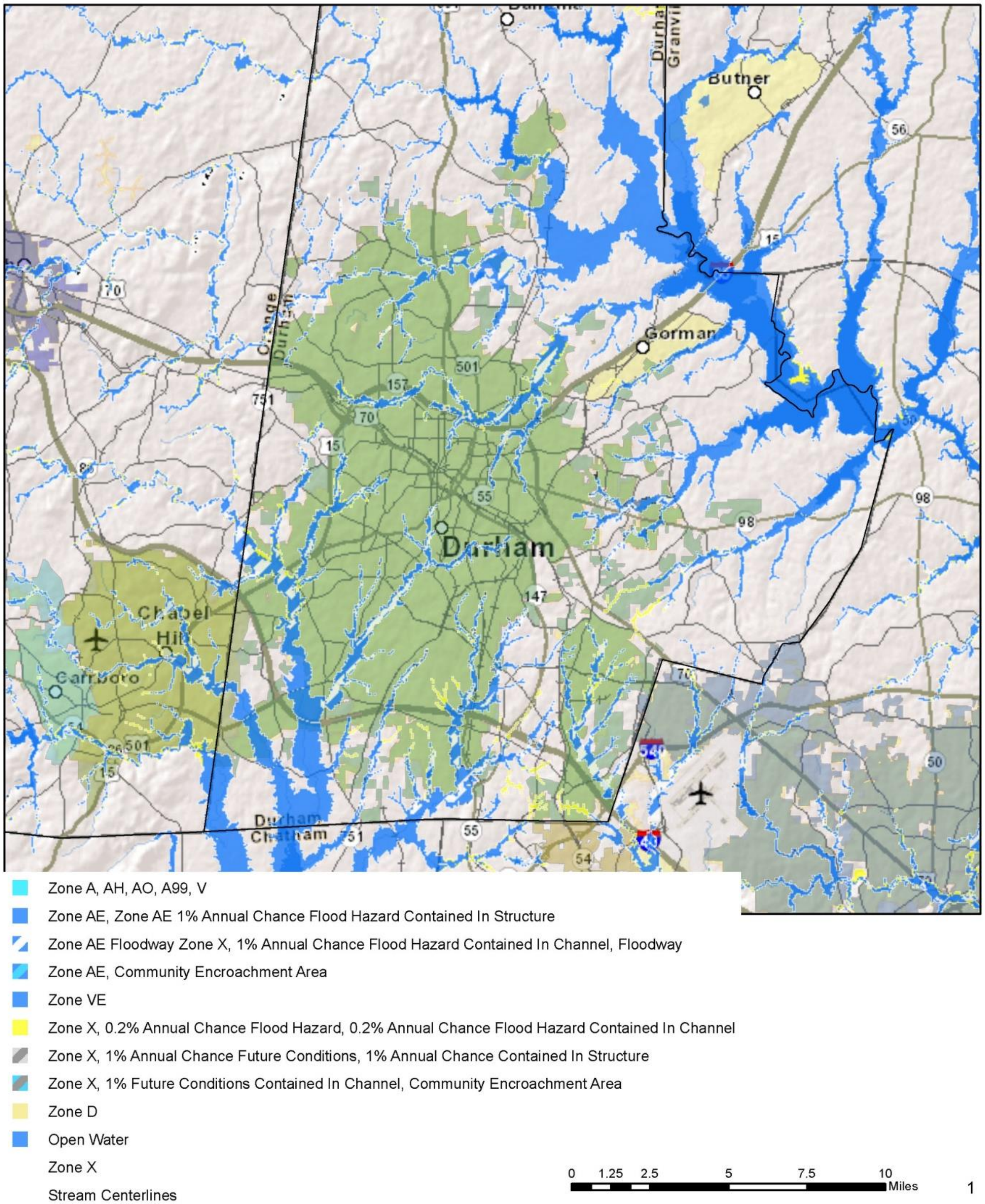


Figure 4.16: Flood Hazard Areas in the City of Durham



Historical Occurrences

The following historical occurrences ranging from 1996 to December 2014 have been identified based on the National Climatic Data Center (NCDC) Storm Events database (**Table 4.9**). It should be noted that only those historical occurrences listed in the NCDC database are shown here and that other, unrecorded or unreported events may have occurred within the planning area during this timeframe.

Table 4.9: Historical Occurrences of Flooding (1996-2014)

Location	Date	Type	Deaths	Injuries	Reported Property Damage	Reported Crop Damage
ALAMANCE COUNTY						
Countywide	9/6/1996	Flash Flood	0	0	0	0
Burlington	4/28/1997	Flash Flood	0	0	0	0
Elon College	6/14/1997	Flash Flood	0	0	0	0
Alamance (Zone)	2/4/1998	Flood	0	0	0	0
Countywide	9/4/1998	Flash Flood	0	0	0	0
Snow Camp	1/24/1999	Flood	0	0	0	0
Countywide	9/5/1999	Flash Flood	0	0	0	0
Countywide	7/23/2000	Flash Flood	0	0	0	0
Alamance (Zone)	3/20/2003	Flood	0	0	0	0
Alamance (Zone)	4/10/2003	Flood	0	0	0	0
Burlington	6/16/2003	Flash Flood	0	0	0	0
Mebane	7/13/2003	Flash Flood	0	0	1,400,000	0
Snow Camp	8/4/2003	Flash Flood	0	0	0	0
Alamance	8/5/2003	Flash Flood	0	0	0	0
Burlington	8/9/2003	Flash Flood	0	0	0	0
Graham	6/9/2004	Flash Flood	0	0	0	0
Mebane	12/10/2004	Flash Flood	0	0	0	0
Graham	6/7/2005	Flash Flood	0	0	0	0
Burlington	6/23/2006	Flash Flood	0	0	0	0
Altamahaw	8/27/2008	Flash Flood	0	0	0	0
Elon College	8/27/2008	Flash Flood	0	0	0	0
Swepsonville	9/6/2008	Flash Flood	0	0	0	0
Just XRDS	9/6/2008	Flash Flood	0	0	500,000	0
Alamance County	6/28/2011	Flash Flood	0	0	0	0
Burlington Airport	6/25/2013	Flash Flood	0	0	0	0
Saxapahaw	3/7/2014	Flood	0	0	0	0
Subtotal Alamance	*26 Events*		*0*	*0*	*1,900,000*	*0*
ORANGE COUNTY						
Countywide	9/6/1996	Flash Flood	0	0	0	0
Chapel Hill	3/19/1998	Flash Flood	0	0	0	0
Countywide	9/5/1999	Flash Flood	0	0	0	0
Countywide	9/28/1999	Flash Flood	0	0	0	0
Chapel Hill	7/23/2000	Flash Flood	0	0	6,400,000	0

Location	Date	Type	Deaths	Injuries	Reported Property Damage	Reported Crop Damage
Miles	7/13/2003	Flash Flood	0	0	0	0
Orange (Zone)	3/20/2003	Flood	0	0	0	0
North Portion	8/9/2003	Flash Flood	0	0	0	0
Hillsborough	8/17/2004	Flash Flood	0	0	0	0
Hillsborough	6/14/2006	Flash Flood	0	0	0	0
Efland	6/24/2006	Flash Flood	0	0	0	0
Chapel Hill	7/25/2006	Flash Flood	0	0	0	0
Blackwood	9/6/2008	Flash Flood	0	0	150,000	0
Blackwood	1/25/2010	Flash Flood	0	0	0	0
Chapel Hill	5/27/2011	Flash Flood	0	0	0	0
Chapel Hill Wllms Ar	9/6/2012	Flash Flood	0	0	0	0
Chapel Hill Wllms Ar	6/30/2013	Flash Flood	0	0	0	0
Chapel Hill Wllms Ar	6/30/2013	Flash Flood	0	0	3,600,000	0
Chapel Hill	6/30/2013	Flash Flood	0	0	500,000	0
Chapel Hill	5/15/2014	Flash Flood	0	0	0	0
Glenn	5/15/2014	Flash Flood	0	0	10,000	0
Subtotal Orange	*21 Events*		*0*	*0*	*10,660,000*	*0*
DURHAM COUNTY						
Bahama	6/20/1996	Flash Flood	0	0	0	0
Bahama	6/24/2006	Flash Flood	0	0	0	0
Bahama	6/24/2006	Flash Flood	0	0	0	0
Bahama	8/27/2008	Flash Flood	0	0	100,000	0
Braggtown	7/15/2014	Flash Flood	0	0	2,500	0
Countywide	9/6/1996	Flash Flood	0	0	0	0
Countywide	7/24/1997	Flash Flood	0	0	0	0
Countywide	9/5/1999	Flash Flood	0	0	0	0
Countywide	9/16/1999	Flash Flood	0	0	0	0
Countywide	9/27/1999	Flash Flood	0	0	0	0
Countywide	9/28/1999	Flash Flood	0	0	0	0
Countywide	9/30/1999	Flash Flood	0	0	0	0
Countywide	8/9/2003	Flash Flood	0	0	0	0
Durham	8/7/1996	Flash Flood	0	0	20,000	0
Durham	9/6/1996	Flash Flood	0	0	0	0
Durham	4/28/1997	Flash Flood	0	0	0	0
Durham	3/19/1998	Flash Flood	0	0	0	0
Durham	7/23/2000	Flash Flood	0	0	0	0
Durham	8/4/2000	Flash Flood	0	0	0	0
Durham	6/22/2001	Flash Flood	0	0	0	0
Durham	10/11/2002	Flash Flood	0	0	0	0
Durham	10/11/2002	Flash Flood	0	0	0	0
Durham	5/23/2004	Flash Flood	0	0	0	0

Location	Date	Type	Deaths	Injuries	Reported Property Damage	Reported Crop Damage
Durham	8/12/2004	Flash Flood	0	0	0	0
Durham	7/13/2006	Flash Flood	0	0	0	0
Durham	11/16/2006	Flash Flood	0	0	0	0
Durham	6/11/2014	Flash Flood	0	0	0	0
Durham County	9/1/2013	Flash Flood	0	0	0	0
East Durham	9/6/2011	Flash Flood	0	0	0	0
Few	5/15/2014	Flash Flood	0	0	0	0
Hayes	6/30/2013	Flash Flood	0	0	0	0
Hope Valley	6/7/2013	Flash Flood	0	0	0	0
Hope Valley	6/30/2013	Flash Flood	0	0	7,500	0
Hope Valley	7/21/2014	Flash Flood	0	0	0	0
Hope Valley	7/21/2014	Flash Flood	0	0	0	0
Hope Valley	7/21/2014	Flash Flood	0	0	0	0
Huckleberry Spg	5/28/2010	Flash Flood	0	0	50,000	0
Lowes Grove	5/27/2011	Flash Flood	0	0	0	0
Oak Grove	9/6/2008	Flash Flood	0	0	0	0
Oak Grove	12/2/2009	Flash Flood	0	0	0	0
Orange Factory	9/6/2008	Flash Flood	0	0	0	0
Quail Roost	8/2/2004	Flash Flood	0	0	0	0
Quail Roost	5/22/2010	Flash Flood	0	0	0	0
Durham (Zone)	3/20/2003	Flood	0	0	0	0
Durham (Zone)	4/10/2003	Flood	0	0	0	0
Quail Roost	3/7/2014	Flood	0	0	0	0
Subtotal Durham	*46 Events*		*0*	*0*	*180,000*	*0*
TOTAL ENO-HAW	**93 Events**		**0**	**0**	**12,740,000**	**0**

Source: National Climatic Data Center Storm Events Database.

Based on the information presented above, 94 instances of flooding conditions have been recorded by NCDC since 1996, causing an estimated total of $12,740,000 in losses to property, $0 in losses to agricultural crops, 0 deaths, and 0 injuries within the planning area.

Table 5.2 in Section 5: *Capability Assessment* lists the number of insured losses and total claims payments for historical flood damages in each jurisdiction as recorded under the NFIP. **Table 4.10** below provides the NFIP entry date for each participating jurisdiction. As explained in subsection 4.3, the NFIP entry date for each jurisdiction was used to determine buildings that were built pre-FIRM and are therefore assumed to be at greater risk to the flood hazard.

Table 4.10: NFIP Entry Dates

Jurisdiction	NFIP Entry Date
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
Orange County (Unincorporated)	3/16/1981
Carrboro	6/25/1976
Chapel Hill	4/17/1978
Hillsborough	5/15/1980
Durham County (Unincorporated)	2/15/1979
Durham	1/3/1979

Source: Federal Emergency Management Agency Community Status Book Report: Communities Participating in the National Flood Program, December 2014

Probability of Future Occurrences

Based on the information provided above, it is assumed that the probability of future flood hazard occurrences in the planning area is highly likely.

Flood Hazard Vulnerability

The following tables provide counts and values by jurisdiction relevant to flood hazard vulnerability in the Eno-Haw Region.

Table 4.11: Exposure to the 1-Percent-Annual-Chance (100-year) Flood

Jurisdiction	Number of Developed Parcels At Risk		Number of Undeveloped Parcels At Risk		Number of Buildings At Risk		Value of Buildings At Risk	Number of Pre-FIRM Buildings At Risk		Population At Risk		Elderly Population At Risk		Children At Risk	
	Num	Per	Num	Per	Num	Per[7]		Num	Per[8]	Num	Per	Num	Per	Num	Per
Alamance County (Unincorporated)	**2,876**	**8.8%**	**1,502**	**4.6%**	**284**	**0.7%**	**$293,958,871**	**100**	**0.7%**	**554**	**0.9%**	**87**	**1.0%**	**32**	**1.0%**
Alamance	19	4.5%	7	1.7%	3	0.6%	$13,066	1	0.4%	2	0.3%	0	0.3%	0	0.2%
Burlington	798	3.8%	254	1.2%	354	1.4%	$84,253,135	276	1.7%	705	1.4%	111	1.4%	50	1.4%
Elon	88	3.9%	49	2.2%	40	1.6%	$4,842,266	35	2.6%	93	1.0%	15	1.0%	2	1.0%
Graham	162	2.7%	80	1.3%	61	0.9%	$29,492,751	13	0.3%	138	1.0%	20	1.0%	10	1.0%
Green Level	4	0.6%	5	0.7%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Haw River	38	3.5%	33	3.1%	23	1.5%	$27,511,975	22	2.2%	39	1.7%	6	1.8%	2	1.2%
Mebane	156	3.1%	60	1.2%	50	1.2%	$6,214,764	7	0.4%	115	1.0%	12	1.0%	9	1.0%
Ossipee	3	1.1%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Swepsonville	15	2.2%	10	1.5%	2	0.3%	$479,403	1	0.3%	0	0.0%	0	0.0%	0	0.0%
Subtotal Alamance	*4,159*	*5.9%*	*2,000*	*2.9%*	*817*	*1.0%*	*$446,766,231*	*513*	*1.0%*	*1,646*	*1.1%*	*251*	*1.1%*	*105*	*1.1%*
Orange County (Unincorporated)	**1,520**	**5.4%**	**1,137**	**4.0%**	**92**	**0.3%**	**$49,762,167**	**25**	**0.2%**	**186**	**0.4%**	**20**	**0.3%**	**9**	**0.3%**
Carrboro	219	4.2%	61	1.2%	96	1.8%	$16,733,580	24	1.9%	212	1.1%	11	1.1%	12	1.1%
Chapel Hill	781	5.9%	209	1.6%	418	2.9%	$259,524,171	345	5.1%	776	1.4%	71	1.4%	33	1.4%
Hillsborough	72	2.5%	47	1.6%	12	0.4%	$3,278,290	11	0.6%	20	0.3%	2	0.3%	1	0.3%
Subtotal Orange	*2,592*	*5.2%*	*1,454*	*2.9%*	*618*	*1.2%*	*$329,298,208*	*405*	*2.0%*	*1,194*	*0.9%*	*104*	*0.8%*	*55*	*0.8%*
Durham County (Unincorporated)	**1,376**	**6.6%**	**1,341**	**6.1%**	**313**	**1.3%**	**$206,467,097**	**104**	**0.7%**	**522**	**1.3%**	**55**	**0.9%**	**38**	**1.7%**
Durham	3,305	4.1%	1,334	1.7%	1,121	0.9%	$202,230,834	772	2.0%	2,623	1.1%	231	1.1%	202	1.1%
Subtotal Durham	*4,681*	*4.6%*	*2,675*	*2.6%*	*1,434*	*1.0%*	*$408,697,931*	*876*	*1.6%*	*3,145*	*1.2%*	*286*	*1.1%*	*240*	*1.2%*
TOTAL ENO-HAW	**11,432**	**5.2%**	**6,129**	**2.8%**	**2,869**	**1.2%**	**$1,184,762,370**	**1,794**	**1.5%**	**5,985**	**1.1%**	**641**	**1.1%**	**400**	**1.1%**

Source: GIS Analysis

[7] Percent of total number of buildings in jurisdiction.
[8] Percent of total number of pre-FIRM buildings in jurisdiction.

Table 4.12: Exposure to the 0.2-Percent-Annual-Chance (500-year) Flood

Jurisdiction	Number of Developed Parcels At Risk		Number of Undeveloped Parcels At Risk		Number of Buildings At Risk		Value of Buildings At Risk	Number of Pre-FIRM Buildings At Risk		Population At Risk		Elderly Population At Risk		Children At Risk	
	Num	Per	Num	Per	Num	Per		Num	Per	Num	Per	Num	Per	Num	Per
Alamance County (Unincorporated)	**205**	**0.6%**	**89**	**0.3%**	**254**	**0.6%**	**$106,351,154**	**133**	**0.6%**	**494**	**0.8%**	**78**	**0.9%**	**29**	**0.9%**
Alamance	8	1.9%	2	0.5%	2	0.4%	$0	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Burlington	99	0.5%	27	0.1%	113	0.5%	$40,784,437	65	0.4%	187	0.4%	29	0.4%	13	0.4%
Elon	1	0.0%	2	0.1%	6	0.2%	$3,652,535	3	0.2%	7	0.1%	1	0.1%	0	0.1%
Graham	111	1.8%	52	0.9%	87	1.3%	$30,950,322	50	1.2%	183	1.3%	27	1.3%	14	1.3%
Green Level	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Haw River	23	2.1%	7	0.6%	24	1.6%	$3,964,186	13	1.3%	44	1.9%	7	2.1%	3	1.4%
Mebane	8	0.2%	3	0.1%	7	0.2%	$677,520	0	0.0%	17	0.1%	2	0.1%	1	0.1%
Ossipee	0	0.0%	0	0.0%	2	0.6%	$5,000	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Swepsonville	5	0.7%	1	0.1%	9	1.4%	$4,262,006	2	0.6%	12	1.1%	2	1.0%	1	1.4%
Subtotal Alamance	*460*	*0.7%*	*183*	*0.3%*	*504*	*0.6%*	*$190,647,160*	*266*	*0.5%*	*944*	*0.6%*	*145*	*0.7%*	*61*	*0.6%*
Orange County (Unincorporated)	**87**	**0.3%**	**37**	**0.1%**	**44**	**0.2%**	**$7,530,250**	**24**	**0.2%**	**88**	**0.2%**	**10**	**0.2%**	**4**	**0.1%**
Carrboro	44	0.8%	2	0.0%	56	1.0%	$10,343,839	1	0.1%	127	0.6%	7	0.7%	7	0.6%
Chapel Hill	101	0.8%	17	0.1%	86	0.6%	$36,268,012	55	0.8%	155	0.3%	14	0.3%	6	0.3%
Hillsborough	8	0.3%	2	0.1%	7	0.2%	$1,400,088	6	0.3%	7	0.1%	1	0.1%	1	0.1%
Subtotal Orange	*240*	*0.5%*	*58*	*0.1%*	*193*	*0.4%*	*$55,542,189*	*86*	*0.4%*	*377*	*0.3%*	*32*	*0.2%*	*18*	*0.3%*
Durham County (Unincorporated)	**137**	**0.6%**	**82**	**0.4%**	**43**	**0.2%**	**$6,728,401**	**20**	**0.1%**	**71**	**0.2%**	**8**	**0.1%**	**5**	**0.2%**
Durham	478	0.6%	97	0.1%	351	0.4%	$66,955,672	122	0.3%	821	0.4%	72	0.4%	63	0.4%
Subtotal Durham	*615*	*0.6%*	*179*	*0.2%*	*394*	*0.4%*	*$44,603,175*	*142*	*0.3%*	*892*	*0.3%*	*80*	*0.3%*	*68*	*0.3%*
TOTAL ENO-HAW	**1,315**	**0.6%**	**420**	**0.2%**	**1,091**	**0.5%**	**$319,873,422**	**494**	**0.4%**	**2,213**	**0.4%**	**257**	**0.4%**	**147**	**0.4%**

Source: GIS Analysis

Table 4.13: Numbers of Critical Facilities Exposed to the 1-Percent-Annual-Chance (100-year) Flood

Jurisdiction	EOCs	Fire Stations	Hospitals	Police Stations	Schools	Senior Care	Shelters
Alamance County (Unincorporated)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Alamance	0	0	0	0	0	0	0
Burlington	0	0	0	0	0	0	0
Elon	0	0	0	0	0	0	0
Graham	0	0	0	0	0	0	0
Green Level	0	0	0	0	0	0	0
Haw River	0	0	0	0	0	0	0
Mebane	0	0	0	0	0	0	0
Ossipee	0	0	0	0	0	0	0
Swepsonville	0	0	0	0	0	0	0
Subtotal Alamance	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Orange County (Unincorporated)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Carrboro	0	0	0	0	0	0	0
Chapel Hill	0	0	0	0	0	0	0
Hillsborough	0	0	0	0	0	0	0
Subtotal Orange	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Durham County (Unincorporated)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Durham	0	1	0	0	1	0	1
Subtotal Durham	*0*	*1*	*0*	*0*	*1*	*0*	*1*
TOTAL ENO-HAW	**0**	**1**	**0**	**0**	**1**	**0**	**1**

Source: FEMA DFIRM data; iRISK; NC OneMap.

Table 4.14: Numbers of Critical Facilities Exposed to the 0.2-Percent-Annual-Chance (500-year) Flood

Jurisdiction	EOCs	Fire Stations	Hospitals	Police Stations	Schools	Senior Care	Shelters
Alamance County (Unincorporated)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Alamance	0	0	0	0	0	0	0
Burlington	0	0	0	0	0	0	0
Elon	0	0	0	0	0	0	0
Graham	0	0	0	0	0	0	0
Green Level	0	0	0	0	0	0	0
Haw River	0	0	0	0	0	0	0
Mebane	0	0	0	0	0	0	0
Ossipee	0	0	0	0	0	0	0
Swepsonville	0	0	0	0	0	0	0
Subtotal Alamance	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Orange County (Unincorporated)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Carrboro	0	0	0	0	0	0	0
Chapel Hill	0	0	1	0	0	0	0
Hillsborough	0	0	0	0	0	0	0
Subtotal Orange	*0*	*0*	*1*	*0*	*0*	*0*	*0*
Durham County (Unincorporated)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Durham	0	0	0	0	0	0	0
Subtotal Durham	*0*	*0*	*0*	*0*	*0*	*0*	*0*
TOTAL ENO-HAW	**0**	**0**	**1**	**0**	**0**	**0**	**0**

Source: FEMA DFIRM data; iRISK; NC OneMap.

Table 4.15: Numbers of High Potential Loss Properties Exposed to the Flood Hazard

Jurisdiction	Airports		>$1m	
	1%	0.2%	1%	0.2%
Alamance County (Unincorporated)	**0**	**0**	**13**	**5**
Alamance	0	0	0	0
Burlington	0	0	7	5
Elon	0	0	0	3
Graham	0	0	4	5
Green Level	0	0	0	0
Haw River	0	0	2	1
Mebane	0	0	0	0
Ossipee	0	0	0	0
Swepsonville	0	0	0	1
Subtotal Alamance	*0*	*0*	*26*	*20*
Orange County (Unincorporated)	**0**	**0**	**2**	**0**
Carrboro	0	0	1	0
Chapel Hill	0	0	38	5
Hillsborough	0	0	1	0
Subtotal Orange	*0*	*0*	*42*	*5*
Durham County (Unincorporated)	**0**	**0**	**20**	**1**
Durham	0	0	59	22
Subtotal Durham	*0*	*0*	*79*	*23*
TOTAL ENO-HAW	**0**	**0**	**147**	**48**

Source: GIS analysis.

Table 4.16 provides a summary count by jurisdiction of Repetitive Loss (RL) properties and associated losses as identified by FEMA through the NFIP.

Table 4.16: Numbers of Repetitive Loss (RL) Properties and Losses by Jurisdiction

Jurisdiction	Total Number of RL Properties	Total Number of RL Losses	Total Amount of Claims Payments
Alamance County (Unincorporated)	**5**	**11**	**$234,162**
Alamance	0	0	$0
Burlington	3	11	$179,966
Elon	0	0	$0
Graham	0	0	$0
Green Level	0	0	$0
Haw River	0	0	$0
Mebane	0	0	$0
Ossipee	0	0	$0
Swepsonville	0	0	$0
Subtotal Alamance	*8*	*22*	*$414,128*
Orange County (Unincorporated)	**0**	**0**	**$0**
Carrboro	0	0	$0
Chapel Hill	18	63	$3,799,140
Hillsborough	0	0	$0
Subtotal Orange	*18*	*63*	*$3,799,140*
Durham County (Unincorporated)	**1**	**2**	**$17,955**
Durham	20	50	$640,252
Subtotal Durham	*21*	*52*	*$658,207*
TOTAL ENO-HAW	**47**	**137**	**$4,871,475**

Source: Federal Emergency Management Agency National Flood Insurance Program, January 2015.

All of the RL properties identified above are residential with the exception of one non-residential building located in the Town of Chapel Hill.

4.5.1.3 Dam/Levee Failure

Dam/Levee Failure Hazard Description

Dam/levee failure is the breakdown, collapse, or other failure of a dam or levee structure characterized by the uncontrolled release of impounded water that results in downstream flooding. In the event of a dam or levee failure, the energy of the water stored behind even a small structure is capable of causing loss of life and severe property damage if development exists downstream. There are varying degrees of failure, and an unexpected or unplanned breach is considered one type of failure. A breach is an opening through a dam or levee which drains the water impounded behind it. A controlled breach is a planned, constructed opening and not considered a failure event, while an uncontrolled breach is the unintentional discharge from the impounded water body and considered a failure.

Dam/levee failure can result from natural events, human-caused events, or a combination of the two. Natural occurrences that may cause dam or levee failure include hurricanes, floods, earthquakes, and landslides; human-caused actions may include the deterioration of the foundation or the materials used in construction. In recent years, dams have also received considerably more attention in the emergency management community as potential targets for terrorist acts.

Dam/levee failure presents a significant potential for disaster, in that significant loss of life and property would be expected in addition to the possible loss of power and water resources. The most common cause of failure is prolonged rainfall that produces flooding. Failures due to other natural events such as hurricanes, earthquakes, or landslides are significant because there is generally little or no advance warning. The best way to mitigate dam or levee failure is through the proper construction, inspection, maintenance, and operation of these structures, as well as maintaining and updating Emergency Action Plans (EAPs) for use in the event of a dam failure.

Dam/Levee Failure Hazard Analysis

Dam failure analysis in the state of North Carolina has inherent limitations. Typically, the structures that have the greatest potential for damage and loss of life, and that have the best data available for flood inundation mapping, are the least likely to fail and are of least concern to local mitigation planning teams. It is often times the smaller, unmapped, unregulated, non-inventoried dams that cause the most problems when they fail.

Location Within the Planning Area

Table 4.17 shows counts of high and intermediate hazard dams in each participating jurisdiction. In total there are 50 high hazard dams in the planning area and 35 intermediate hazard dams. **Figure 4.17** shows the locations of all state-regulated dams in and immediately around the planning area. The majority of high and intermediate hazard dams in Alamance and Orange counties are in unincorporated areas of the county. The majority of high and intermediate hazard dams in Durham County are in the City of Durham.

Table 4.17: Counts of High Hazard and Intermediate Hazard Dams by Jurisdiction

Jurisdiction	High	Intermediate
Alamance County (Unincorporated)	**7**	**7**
Alamance	0	0
Burlington	4	0
Elon	1	1
Graham	0	0
Green Level	0	0
Haw River	0	0
Mebane	1	1
Ossipee	0	0
Swepsonville	0	0
Subtotal Alamance	*13*	*9*
Orange County (Unincorporated)	**7**	**6**
Carrboro	2	1
Chapel Hill	3	1
Hillsborough	1	1
Subtotal Orange	*13*	*9*
Durham County (Unincorporated)	**6**	**6**
Durham	18	11
Subtotal Durham	*24*	*17*
TOTAL ENO-HAW	**50**	**35**

Source: North Carolina Dams Program, North Carolina Department of Environment and Natural Resources (NCDENR).

Extent (Magnitude and Severity)

Two factors influence the potential severity of a dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream. The potential extent of dam failure may be classified according to their "hazard potential," meaning the probable damage that would occur *if* the structure failed, in terms of loss of human life and economic loss or environmental damage. The State of North Carolina classifies dam structures under its regulations according to hazard potential as described in **Table 4.18**. It is important to note that these classifications are not based on the adequacy or structural integrity of existing dam structures.

Table 4.18: Classification of Hazard Potential for North Carolina Dams

Hazard Classification	Description	Quantitative Guidelines
Low	1) Interruption of road service, low volume roads 2) Economic damage	1) Less than 25 vehicles per day 2) Less than $30,000
Intermediate	1) Damage to highways, interruption of service 2) Economic damage	1) 25 to less than 250 vehicles per day 2) $30,000 to less than $200,000
High	1) Probable loss of human life due to breached roadway or bridge on or below the dam 2) Economic damage	1) Probable loss of 1 or more human lives 2) More than $200,000

Source: North Carolina Dams Program, North Carolina Department of Environment and Natural Resources (NCDENR).

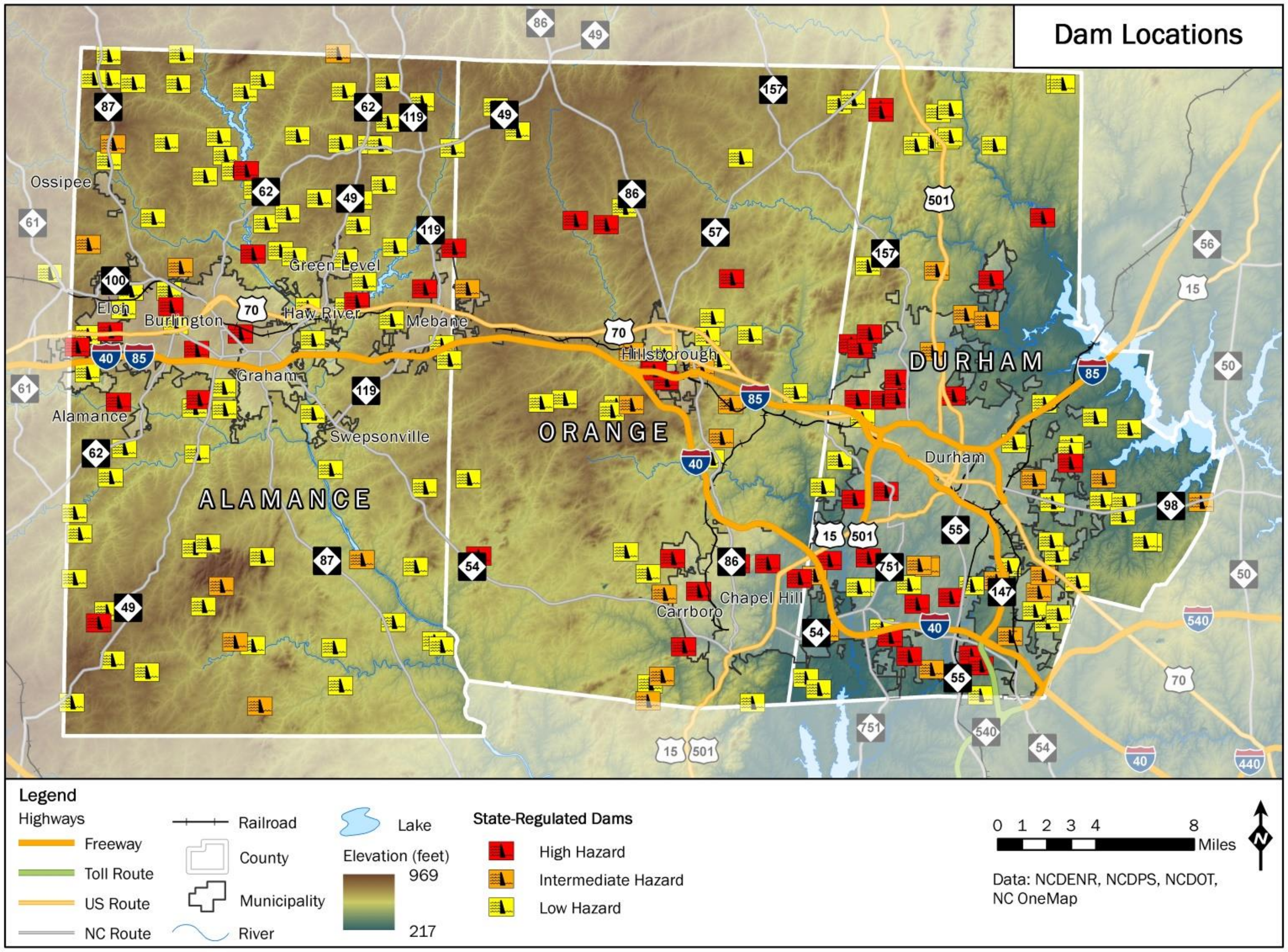
Historical Occurrences

There are no records of historical dam failure occurrences in or affecting the planning area.

Probability of Future Occurrences

The probability of a dam failure occurrence at a large dam structure, such as ones owned by Duke Energy Corporation in other parts of North Carolina, is considered to be unlikely due to safe guards, maintenance schedules, plans, and other regulatory devices. The probability of occurrence at smaller, privately owned dam structures is much more likely; however, data is not currently available for these smaller structures, both in terms of point locations and mapped inundation areas.

Figure 4.17: Locations of State-Regulated Dams



Dam/Levee Failure Hazard Vulnerability

The following tables provide counts and values by jurisdiction relevant to potential dam failure exposure in the Eno-Haw Region.

Table 4.19: Exposure to High Hazard Dam Failure Inundation Areas

Jurisdiction	Number of Developed Parcels At Risk		Number of Undeveloped Parcels At Risk		Number of Buildings At Risk		Value of Buildings At Risk	Population At Risk		Elderly Population At Risk		Children At Risk	
	Num	Per	Num	Per	Num	Per		Num	Per	Num	Per	Num	Per
Alamance County (Unincorporated)	**12**	**0.0%**	**9**	**0.0%**	**2**	**0.0%**	**$69,945**	**2**	**0.0%**	**0**	**0.0**	**0**	**0.0%**
Alamance	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Burlington	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Elon	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Graham	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Green Level	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Haw River	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Mebane	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Ossipee	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Swepsonville	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Subtotal Alamance	*12*	*0.0%*	*9*	*0.0%*	*2*	*0.0%*	*$69,945*	*2*	*0.0%*	*0*	*0.0*	*0*	*0.0%*
Orange County (Unincorporated)	**36**	**0.1%**	**40**	**0.1%**	**4**	**0.0%**	**$384,608**	**10**	**0.0%**	**1**	**0.0**	**0**	**0.0%**
Carrboro	16	0.3%	12	0.2%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Chapel Hill	172	1.3%	31	0.2%	54	0.4%	$13,536,183	124	0.2%	11	0.2	5	0.2%
Hillsborough	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0	0	0.0%
Subtotal Orange	*224*	*0.5%*	*83*	*0.2%*	*58*	*0.1%*	*$13,920,791*	*134*	*0.1%*	*12*	*0.1*	*5*	*0.1%*
Durham County (Unincorporated)	**84**	**0.4%**	**75**	**0.3%**	**9**	**0.0%**	**$1,306,496**	**17**	**0.0%**	**2**	**0.0**	**1**	**0.1%**
Durham	96	0.1%	14	0.0%	26	0.0%	$2,646,422	56	0.0%	5	0.0	4	0.0%
Subtotal Durham	*180*	*0.2%*	*89*	*0.1%*	*35*	*0.0%*	*$3,952,918*	*73*	*0.0%*	*7*	*0.0*	*5*	*0.0%*
TOTAL ENO-HAW	**416**	**0.2%**	**181**	**0.1%**	**95**	**0.0%**	**$17,943,654**	**209**	**0.0%**	**20**	**0.0**	**10**	**0.0%**

Table 4.20: Exposure to Intermediate Hazard Dam Failure Inundation Areas

Jurisdiction	Number of Developed Parcels At Risk		Number of Undeveloped Parcels At Risk		Number of Buildings At Risk		Value of Buildings At Risk	Population At Risk		Elderly Population At Risk		Children At Risk	
	Num	Per	Num	Per	Num	Per		Num	Per	Num	Per	Num	Per
Alamance County (Unincorporated)	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**$0**	**0**	**0.0**	**0**	**0.0%**	**0**	**0.0%**
Alamance	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Burlington	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Elon	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Graham	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Green Level	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Haw River	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Mebane	2	0.0%	3	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Ossipee	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Swepsonville	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Subtotal Alamance	*2*	*0.0%*	*3*	*0.0%*	*0*	*0.0%*	*$0*	*0*	*0.0*	*0*	*0.0%*	*0*	*0.0%*
Orange County (Unincorporated)	**4**	**0.0%**	**2**	**0.0%**	**0**	**0.0%**	**$0**	**0**	**0.0**	**0**	**0.0%**	**0**	**0.0%**
Carrboro	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Chapel Hill	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Hillsborough	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0	0	0.0%	0	0.0%
Subtotal Orange	*4*	*0.0%*	*2*	*0.0%*	*0*	*0.0%*	*$0*	*0*	*0.0*	*0*	*0.0%*	*0*	*0.0%*
Durham County (Unincorporated)	**13**	**0.1%**	**18**	**0.1%**	**1**	**0.0%**	**$21,661**	**2**	**0.0**	**0**	**0.0%**	**0**	**0.0%**
Durham	8	0.0%	11	0.0%	1	0.0%	$264,793	2	0.0	0	0.0%	0	0.0%
Subtotal Durham	*21*	*0.0%*	*29*	*0.0%*	*2*	*0.0%*	*$287,454*	*4*	*0.0*	*0*	*0.0%*	*0*	*0.0%*
TOTAL ENO-HAW	**27**	**0.0%**	**34**	**0.0%**	**2**	**0.0%**	**$287,454**	**4**	**0.0**	**0**	**0.0%**	**0**	**0.0%**

4.5.1.4 Drought/Extreme Heat

Drought/Extreme Heat Hazard Description

Drought is a natural climatic condition caused by an extended period of limited rainfall beyond that which occurs naturally in a broad geographic area. High temperatures, high winds, and low humidity can worsen drought conditions, and can make areas more susceptible to wildfire. Human demands and actions can also hasten drought-related impacts.

Droughts are frequently classified as one of the following four types: meteorological, agricultural, hydrological, or socio-economic. Meteorological droughts are typically defined by the level of "dryness" when compared to an average, or normal amount of precipitation over a given period of time. Agricultural droughts relate common characteristics of drought to their specific agricultural-related impacts (when the amount of moisture in soil does not meet the needs of a particular crop). Hydrological drought is directly related to the effect of precipitation shortfalls on surface and groundwater supplies. Human factors, particularly changes in land use, can alter the hydrologic characteristics of a basin. Socio-economic drought is the result of water shortages that affect people and limit the ability to supply water-dependent products in the marketplace.

Drought conditions typically do not cause property damage or threaten lives, but rather drought effects are most directly felt by agricultural sectors. At times, drought may also cause community-wide impacts as a result of acute water shortages (regulatory use restrictions, drinking water supply, and salt water intrusion). The magnitude of such impacts correlates directly with local groundwater supplies, reservoir storage, and development densities. Drought conditions can also contribute to or exacerbate extreme heat concerns, particularly with regard to elderly populations.

Drought/Extreme Heat Hazard Analysis

One of the most significant droughts in recent North Carolina history occurred in 2007-2008. According to the NC Drought Management Advisory Council, the drought of 2007-2008 was the most severe in this state over the past 100 years of modern records, based on numerous drought indicators that have been recorded in the state since the 19th century. Therefore it is known that serious droughts can occur in the state, but not all droughts are expected to be as severe as the 2007-2008 drought.

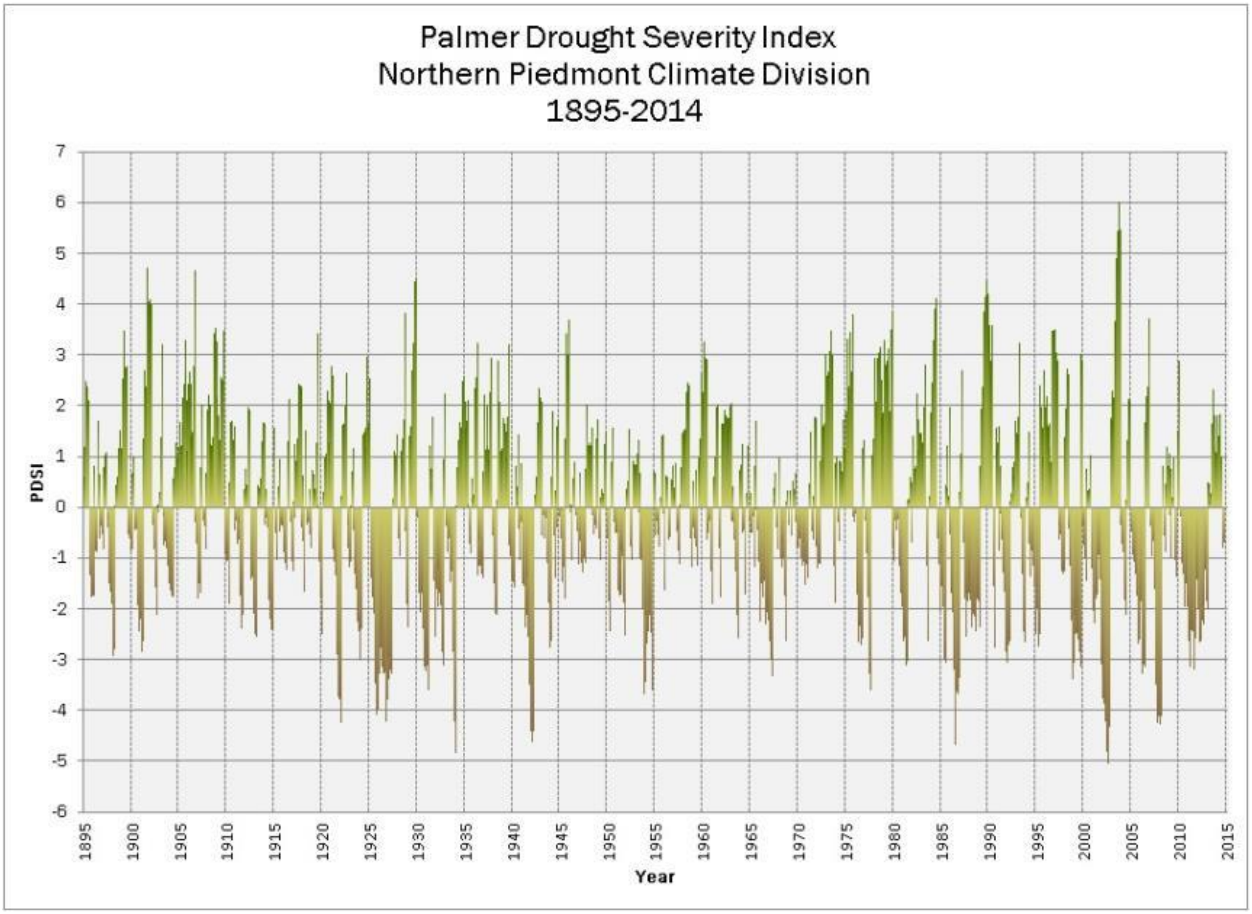
Location Within the Planning Area

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

Extent (Magnitude and Severity)

As supported by the historical occurrences presented in the following subsection, the magnitude and severity of the drought/extreme heat hazard in the planning area is considered to be relatively mild. No deaths, injuries, property damages, or crop damages have been reported according to NCDC since 1998 so it is difficult to assign any specific severity rating to this hazard. **Figure 4.18** shows the Palmer Drought Severity Index (PDSI) for the Northern Piedmont Climate Division for from 1895 through 2014, which is an indication of periodic highs and lows for drought conditions.

Figure 4.18: Palmer Drought Severity Index for the Northern Piedmont Climate Division



Source: National Oceanic and Atmospheric Administration

Historical Occurrences

Despite the fact that portions of the state have been impacted by more than 500 drought events over the past 65 years, NCDC does not attribute any specific drought events to Alamance, Orange, or Durham counties since 1950.

Probability of Future Occurrences

Based on the fact that the state as a whole is known to have experienced a large number of historical drought occurrences in the past 65 years (more than 500), it is likely that the Eno-Haw Region will continue to experience periods of drought to some extent whether officially recorded or not officially recorded. It is considered to be unlikely however that the Region will experience extreme conditions that would result in deaths, injuries, or significant property damage. Even though historical records are not available that point to specific amounts of historical crop losses, it is assumed that drought events have the potential to adversely affect the agricultural economy of the Eno-Haw Region.

Drought/Extreme Heat Hazard Vulnerability

All of the inventoried assets in the Eno-Haw Region are technically exposed to the drought/extreme heat hazard. However, it is not possible through GIS or anecdotal methods to determine specific numbers and values of individual assets that are more vulnerable to this hazard, especially in terms of the built environment. Further, all crops and other natural assets are considered to be equally at risk based on the data available and therefore no specific breakdown of these types of assets is possible. Any anticipated future damages or losses are expected to be minimal based on historical occurrences and other factors as described above.

4.5.2 Atmospheric Hazards (Severe Storms)

Atmospheric hazards generally have their own individual characteristics, geographic areas that may be affected, time of year they are most likely to occur, severity, and associated risk. Atmospheric hazards include thunderstorm, lightning, and hail; tornado; winter weather; and hurricane and tropical storm. In many cases, a natural hazard event involving atmospheric hazards involves more than one individual atmospheric hazard. For example, severe thunderstorms can produce lightning, hail, tornadoes, and damaging winds. Atmospheric hazards are presented separately from other categories of hazards but they may be interrelated. For example, severe thunderstorms can produce flooding, and other extreme weather events can lead to problems with dams and levees, cause landslides, etc.

4.5.2.1 Thunderstorm, Lightning, and Hail

Thunderstorm, Lightning, and Hail Hazard Description

Thunderstorms are caused when air masses of varying temperatures meet. Rapidly rising warm moist air serves as the "engine" for thunderstorms. These storms can occur singularly, in lines, or in clusters. They can move through an area very quickly or linger for several hours. According to the National Weather Service, more than 100,000 thunderstorms occur each year, though only about 10% of these storms are classified as "severe." Although thunderstorms generally affect a small area when they occur, they can be very dangerous because of their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. While thunderstorms can occur in all regions of the United States, they are most common in the central and southern states because atmospheric conditions in those regions are most ideal for generating these powerful storms.

Lightning is a discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm, creating a "bolt" when the buildup of charges becomes strong enough. This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning rapidly heats the sky as it flashes, but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder. On average, 73 people are killed each year by lightning strikes in the United States.

Hail is a product of thunderstorms or intense showers. Hail is generally white and translucent, consisting of liquid or snow particles encased with layers of ice. Hail is formed within the high portion of a well-organized thunderstorm. When hailstones become too heavy to be caught in an updraft and carried back into the clouds of a thunderstorm (hailstones can be caught in numerous updrafts, adding a coating of ice to the original frozen droplets each time), they then fall as hail, and a hailstorm occurs.

Thunderstorm, Lightning, and Hail Hazard Analysis

Thunderstorms are common throughout the state of North Carolina, and have been known to occur during all calendar months. In terms of thunderstorm winds, the planning area is in a fairly uniform region with regard to 100-year winds. Wind speeds during a 100-year thunderstorm event are expected to be around 90 miles per hour throughout the three-county area (**Figure 4.19**). However, some differences do become apparent when looking at the 700-year return period (**Figures 4.20** through **4.22**). During a 700-year wind event, the majority of the planning area would be expected to experience winds around 100 miles per hour with a large portion of Durham County experiencing winds up to 105 miles per hour and a small portion of Alamance County dropping to around 95 miles per hour.

Figure 4.19: Regional Thunderstorm Wind Hazard Map Showing the 100-year Return Period

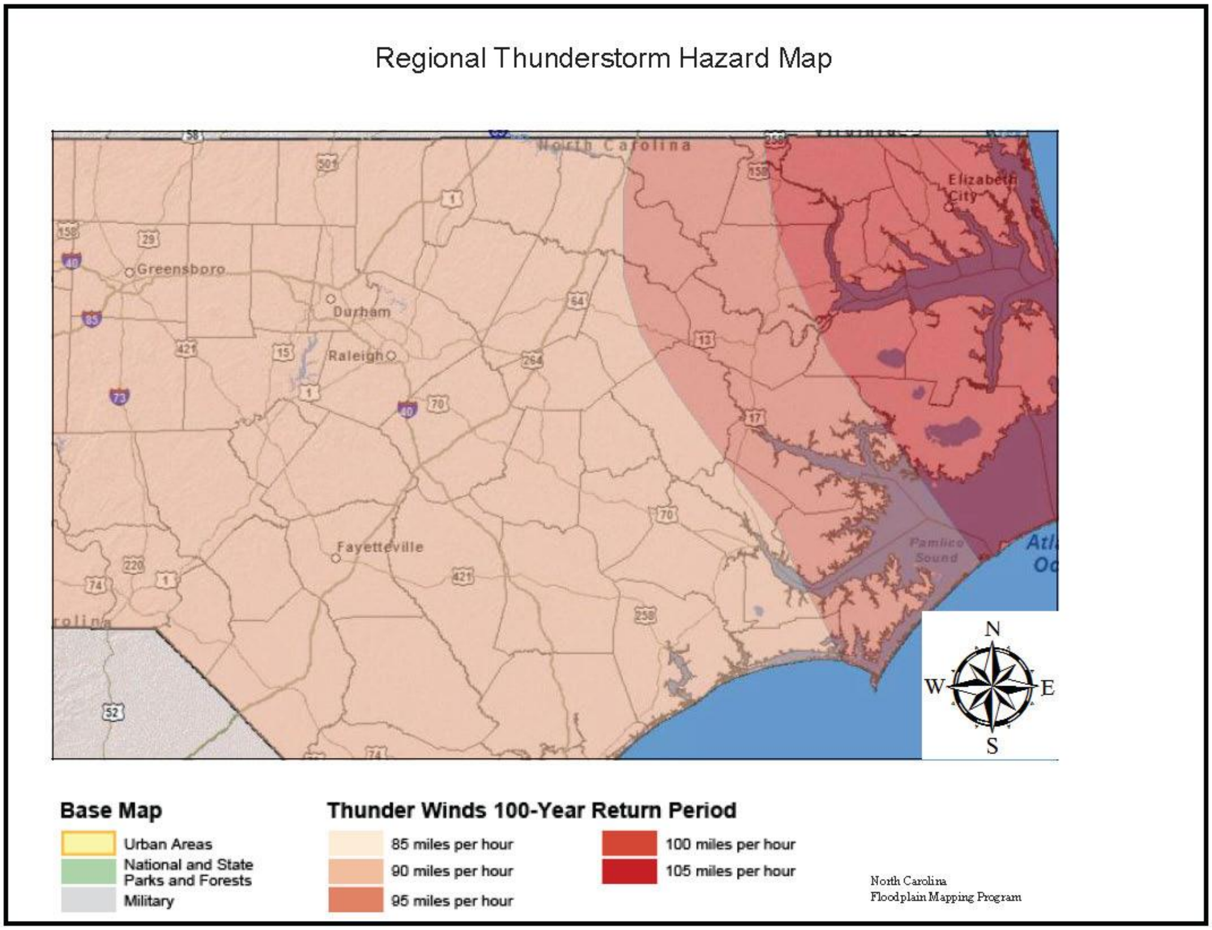


Figure 4.20: Alamance County Thunderstorm Wind Hazard Map (700-year Return Period)

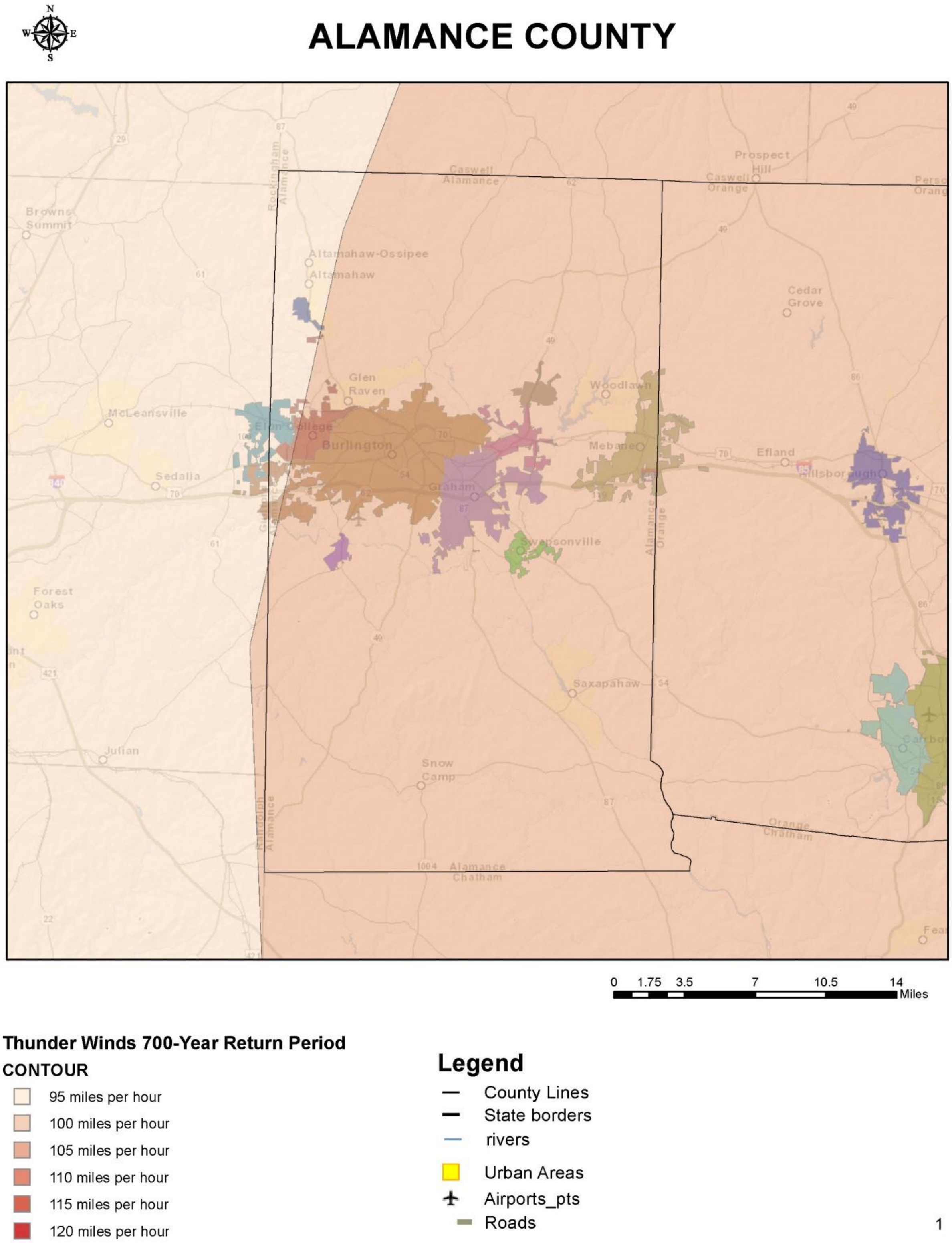


Figure 4.21: Orange County Thunderstorm Wind Hazard Map (700-year Return Period)

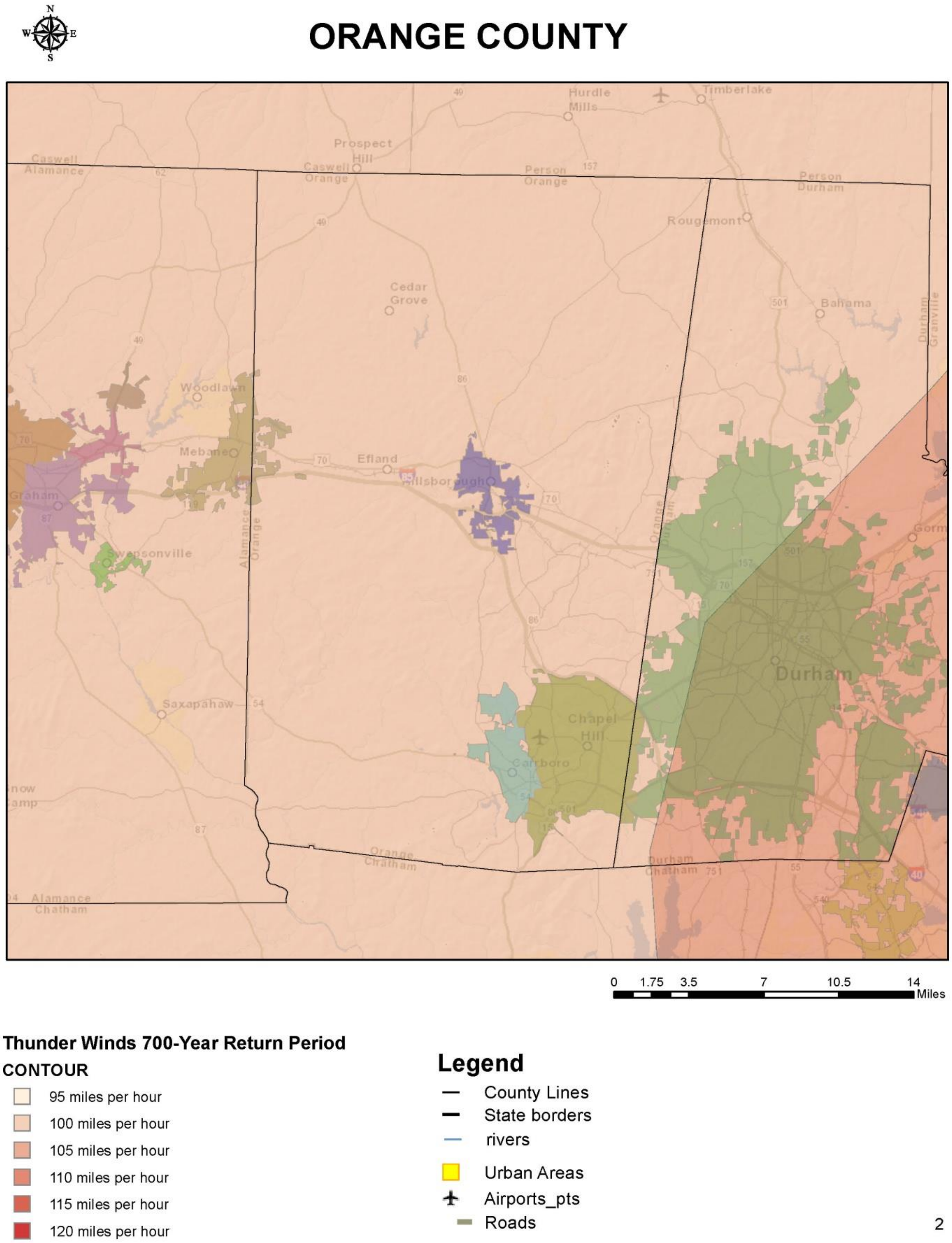
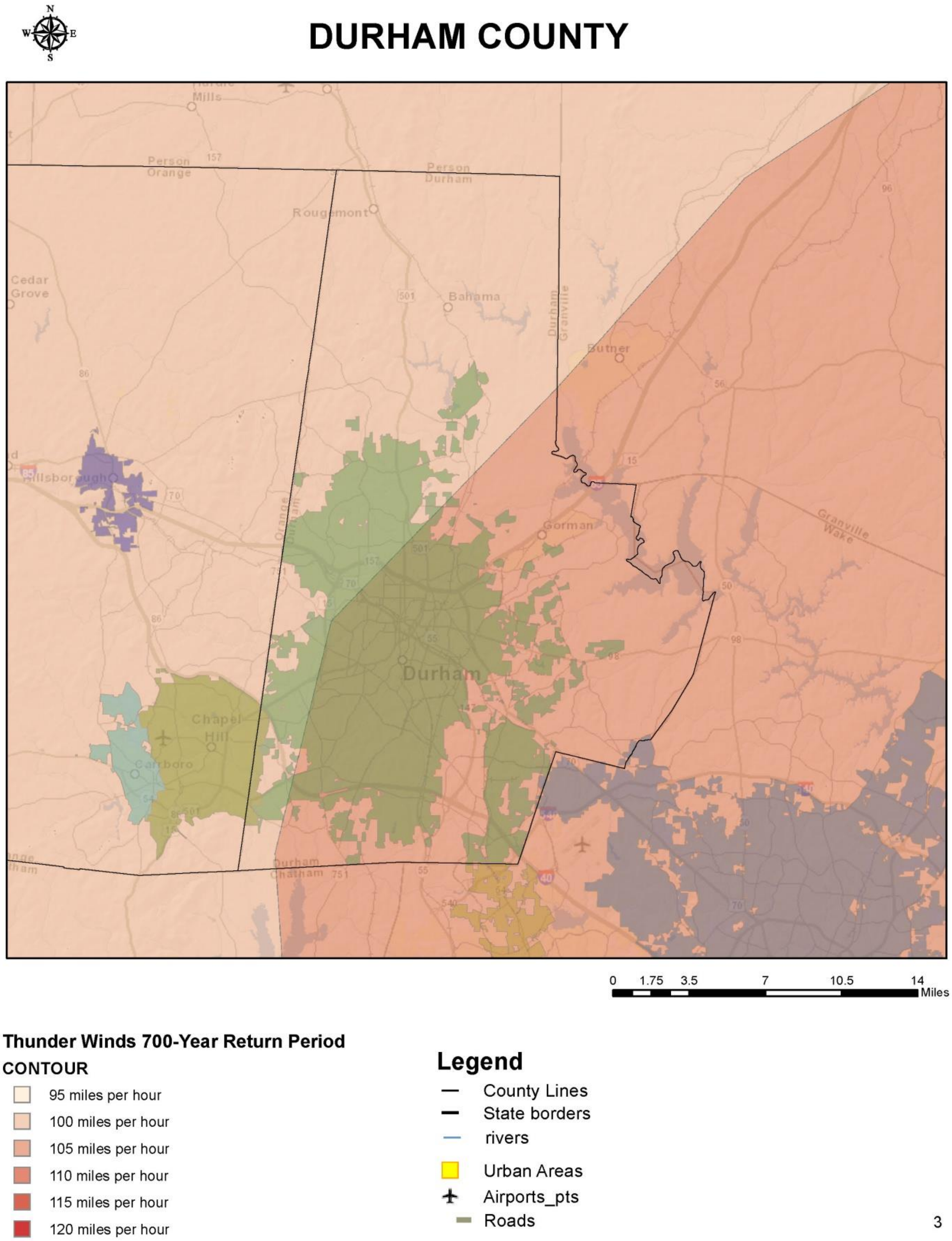


Figure 4.22: Durham County Thunderstorm Wind Hazard Map (700-year Return Period)



Location Within the Planning Area

Thunderstorms, including lightning and hail, are widespread atmospheric disturbances that are not isolated to a specific geographic location. Therefore it is assumed that the entire planning area is exposed to these hazards, with some variation in wind speeds as depicted in the maps on the preceding pages. It is also possible to map historic average annual cloud-to-ground lightning strikes and historic hail reportings by diameter as an indication of where in the Eno-Haw Region these hazards have previously been observed and to what degree (**Figure 4.23**).

Extent (Magnitude and Severity)

Thunderstorms, lightning, and hail are known to be damaging hazard occurrences in the Eno-Haw Region that can result in multiple injuries. There is currently no specific overall scale to rank the potential severity of severe events of this type but it is assumed that the magnitude and severity of future occurrences will be similar to that of historical occurrences.

The highest recorded thunderstorm winds in Alamance County (according to NCDC) were 70 knots, recorded in Burlington and in Haw River on May 25, 2000. The highest recorded thunderstorm winds in Orange County were 69 knots, recorded in an unincorporated area of the county on April 26, 1986. The highest recorded thunderstorm winds in Durham County were 80 knots, recorded in an unincorporated area of the county on July 21, 1962. Therefore, based on historical data winds up to 80 knots can be expected in the planning area.

The largest recorded size of a hailstone in Alamance County (according to NCDC) is 2.5 inches reported in Altamahaw on May 1, 1998. The largest recorded size of a hailstone in Orange County (according to NCDC) is 2.75 inches reported in an unincorporated area of the county on May 14, 1967. The largest recorded size of a hailstone in Durham County (according to NCDC) is 2.75 inches reported in an unincorporated area of the county on April 24, 1955. Therefore, based on historical data hailstones up to 2.75 inches can be expected in the planning area.

There are some national studies that suggest that the risk of severe thunderstorms that produce torrential rain, damaging winds, large hail, and tornadoes may increase due to changes in the climate. However, there is currently no evidence to suggest at what rate this may occur within the Eno-Haw Region.

Historical Occurrences

The following historical occurrences ranging from 1950 to the present have been identified based on the NCDC Storm Events database (**Table 4.21**). It should be noted that only historical occurrences listed in the NCDC database are shown here and that other, unrecorded or unreported events may have occurred within the planning area during this timeframe.

Table 4.21: Summary of Historical Thunderstorm, Lightning, and Hail Occurrences by Participating Jurisdiction (1950 through October 2014)

Jurisdiction	Number of Thunder-storm High Wind Events	Number of Lightning Events	Number of Hail Events	Deaths	Injuries	Reported Property Damage	Reported Crop Damage
Alamance County (Unincorporated)	78	2	37	0	3	343,000	150,000
Alamance	3	0	3	0	0	0	0
Burlington	13	1	11	0	0	85,000	0
Elon	11	0	3	0	0	333,000	0
Graham	7	2	10	0	0	4,000	0
Green Level	0	0	0	0	0	0	0
Haw River	3	0	4	0	0	0	0
Mebane	15	2	5	0	0	125,000	0
Ossipee	0	0	0	0	0	0	0
Swepsonville	11	0	4	0	0	1,000	0
Subtotal Alamance	141	7	77	0	3	891,000	150,000
Orange County (Unincorporated)	101	2	46	0	0	73,500	0
Carrboro	2	1	2	0	0	15,000	0
Chapel Hill	27	2	9	1	2	2,465,500	0
Hillsborough	18	2	13	0	1	81,500	0
Subtotal Orange	148	7	70	1	3	250,500	0
Durham County (Unincorporated)	109	4	12	2	2	448,000	0
Durham	46	3	4	0	0	193,750	0
Subtotal Durham	155	7	16	2	2	488,750	0
TOTAL ENO-HAW	**444**	**21**	**163**	**3**	**8**	**1,630,250**	**150,000**

Source: National Climatic Data Center Storm Events Database

According to NCDC, 444 recorded instances of thunderstorm, lightning, and hail conditions have affected the planning area since 1950, causing an estimated $1,630,250 in property damages, $150,000 in crop damages, 3 deaths, and 8 reported injuries.

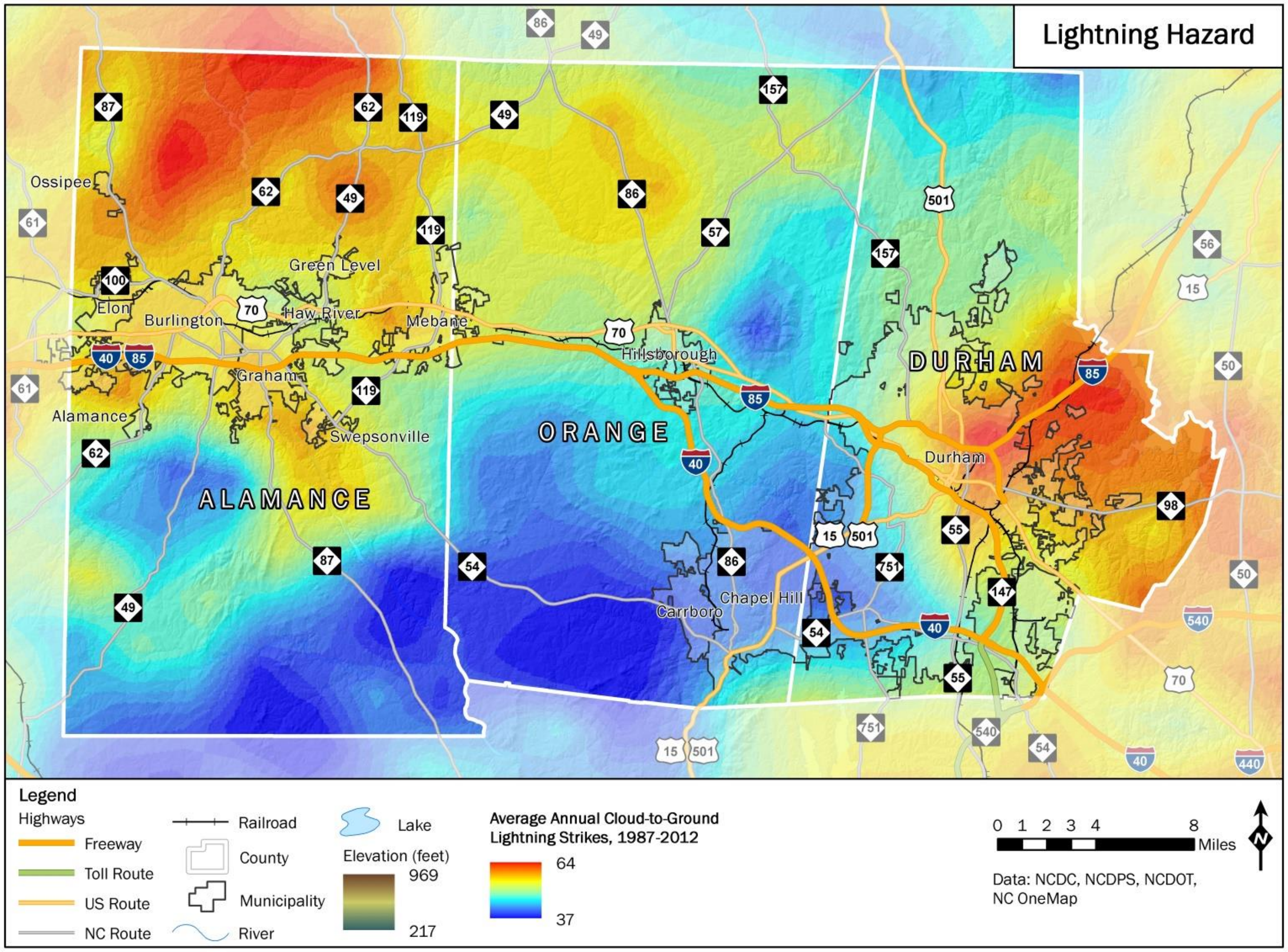
Probability of Future Occurrences

The probability of future occurrences of thunderstorm, lightning, and hail events is considered to be highly likely based on historical occurrences. There are some national studies that suggest that the frequency of severe thunderstorms that produce torrential rain, damaging winds, large hail, and tornadoes may increase due to changes in the climate. However, there is currently no evidence to suggest at what rate this may occur within the Eno-Haw Region.

Thunderstorm, Lightning, and Hail Hazard Vulnerability

All of the inventoried assets in the Eno-Haw Region are exposed to thunderstorm, lightning, and hail. Any specific vulnerabilities of individual assets depend greatly on individual design, building characteristics, and any existing mitigation measures currently in place. Such site-specific vulnerability determinations are outside the scope of this risk assessment but may be considered during future plan updates.

Figure 4.23: Historic Lightning Observations in the Eno-Haw Region



4.5.2.2 Tornado

Tornado Hazard Description

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. Tornadoes are most often generated by thunderstorm activity (but sometimes result from hurricanes and other tropical storms) when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris, also accompanied by lightning or large hail. According to the National Weather Service, tornado wind speeds normally range from 40 to more than 300 mph. The most violent tornadoes have rotating winds of 250 mph or more, and are capable of causing extreme destruction and turning normally harmless objects into deadly missiles.

The damage caused by tornadoes ranges from gale force to "incredible," depending on the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damage to structures of light construction such as residential homes (particularly mobile homes). **Table 4.22** shows the Enhanced Fujita Scale for Tornado Damage[9] which was implemented in 2007 to replace the original Fujita Scale and to more accurately measure tornado strength and associated damages.

Table 4.22: Enhanced Fujita Scale for Tornado Damage

Storm Category	Damage Level	3 Second Gust (mph)	Description of Damages
EF0	Gale	65–85	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages to sign boards.
EF1	Weak	86–110	The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages might be destroyed.
EF2	Strong	111–135	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
EF3	Severe	136–165	Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted.
EF4	Devastating	166–200	Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
EF5	Incredible	200+	Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile sized missiles fly through the air in excess of 100 meters; trees debarked; steel re-enforced concrete structures badly damaged.

Source: National Oceanic and Atmospheric Administration, Federal Emergency Management Agency

The original Fujita Tornado Damage Scale[10] is not shown here in order to avoid confusion. However, it is worth noting that tornado events that occurred prior to 2007 may be referenced by

[9] The Enhanced Fujita Scale for Tornado Damage can be accessed online at http://www.spc.noaa.gov/faq/tornado/ef-scale.html.

[10] The original Fujita Tornado Damage Scale can be accessed online at http://www.spc.noaa.gov/faq/tornado/f-scale.html.

the original F-Scale numbers and associated damages may differ to some extent from those presented above.

Each year, an average of more than 800 tornadoes is reported nationwide, resulting in an average of 80 deaths and 1,500 injuries. They are more likely to occur during the months of March through May and can occur at any time of day, but are likely to form in the late afternoon and early evening. Most tornadoes are a few dozen yards wide and touch down briefly, but even small short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes might carve out a path over a mile wide and several miles long.

The tornadoes associated with tropical cyclones are most frequent in September and October when the incidence of tropical storm systems is greatest. This type of tornado usually occurs around the perimeter of the storm, and most often to the right and ahead of the storm path or the storm center as it comes ashore. These tornadoes commonly occur as part of large outbreaks and generally move in an easterly direction.

Tornado Hazard Analysis

When compared with other states, North Carolina ranks #22 in number of tornado events, #20 in tornado deaths, #17 in tornado injuries, and #21 in damages. These rankings are based upon data collected for all states and territories for tornado events between 1950 and 1994 (SPC, 2003). According to the State Climate Office of North Carolina, most tornado occurrences in North Carolina (43%) are minimal (EF0) in intensity, followed by EF1 (37%).

Location Within the Planning Area

Tornadoes are unpredictable manifestations and are not isolated to a specific geographic location. Therefore it is assumed that the entire planning area is exposed to this hazard. However, it is possible to map historic tornado point locations and damage paths as an indicator of where tornadoes are known to have occurred in the planning area in the past (**Figure 4.24**).

Extent (Magnitude and Severity)

Tornadoes of any magnitude and severity are possible within the planning area. Since 1951, the highest magnitude tornado to impact the Eno-Haw Region has been an F3 on the Fujita Scale for Tornado Damage which occurred November 23, 1992 (see *Historical Occurrences* subsection below).

Historical Occurrences

The following historical occurrences ranging from 1950 to the present have been identified based on the NCDC Storm Events Database (**Table 4.23**). It should be noted that only historical occurrences listed in the NCDC database are shown here and that other, unrecorded or unreported events may have occurred within the planning area during this timeframe.

Table 4.23: Historical Occurrences of Tornadoes (1950 through October 2014)

Location	Date	Magnitude	Deaths	Injuries	Reported Property Damage	Reported Crop Damage
ALAMANCE COUNTY						
Alamance County	3/19/1975	F1	0	1	$25,000	$0
Alamance County	7/21/1977	F1	0	0	$250,000	$0
Alamance County	5/26/1983	F1	0	0	$25,000	$0
Union Ridge	3/4/2008	EF0	0	0	$150,000	$0
Altamahaw	4/16/2011	EF1	0	0	$580,000	$0
Subtotal Alamance			0	1	$1,030,000	$0
ORANGE COUNTY						
Orange County	7/13/1975	F1	0	1	$2,500	$0
Orange County	3/29/1991	F2	0	0	$0	$0
Orange County	11/23/1992	F3	2	10	$250,000	$0
Orange County	1/28/1994	F0	0	0	$0	$0
Carrboro	6/19/2000	F0	0	0	$0	$0
Carrboro	9/8/2004	F0	0	0	$0	$0
Schley	1/14/2005	F0	0	0	$0	$0
Carrboro	10/27/2010	EF1	0	0	$250,000	$0
Subtotal Orange			2	11	$502,500	$0
DURHAM COUNTY						
Durham County	12/31/1975	F0	0	0	$250	$0
Durham County	4/4/1984	F2	0	4	$2,500,000	$0
Durham County	5/5/1989	F2	0	0	$25,000,000	$0
Durham County	7/16/1989	F1	0	0	$25,000	$0
Bahama	3/20/1998	F2	0	1	$600,000	$0
Gorman	5/14/2006	F0	0	0	$0	$0
Hope Valley	5/15/2014	EF1	0	0	$250,000	$0
Subtotal Durham			1	5	$28,375,000	$0
TOTAL ENO-HAW			**3**	**17**	**$29,907,500**	**$0**

Source: National Climatic Data Center Storm Events Database

According to the information provided in the preceding table, 20 recorded instances of tornadoes have affected the planning area since 1950, causing an estimated $29,907,500 in property damage, $0 in crop damages, 3 deaths, and 17 injuries. The highest magnitude tornado on record in the planning area is an F3 (11/23/1992 in Orange County). The lowest magnitude on record is an F0.

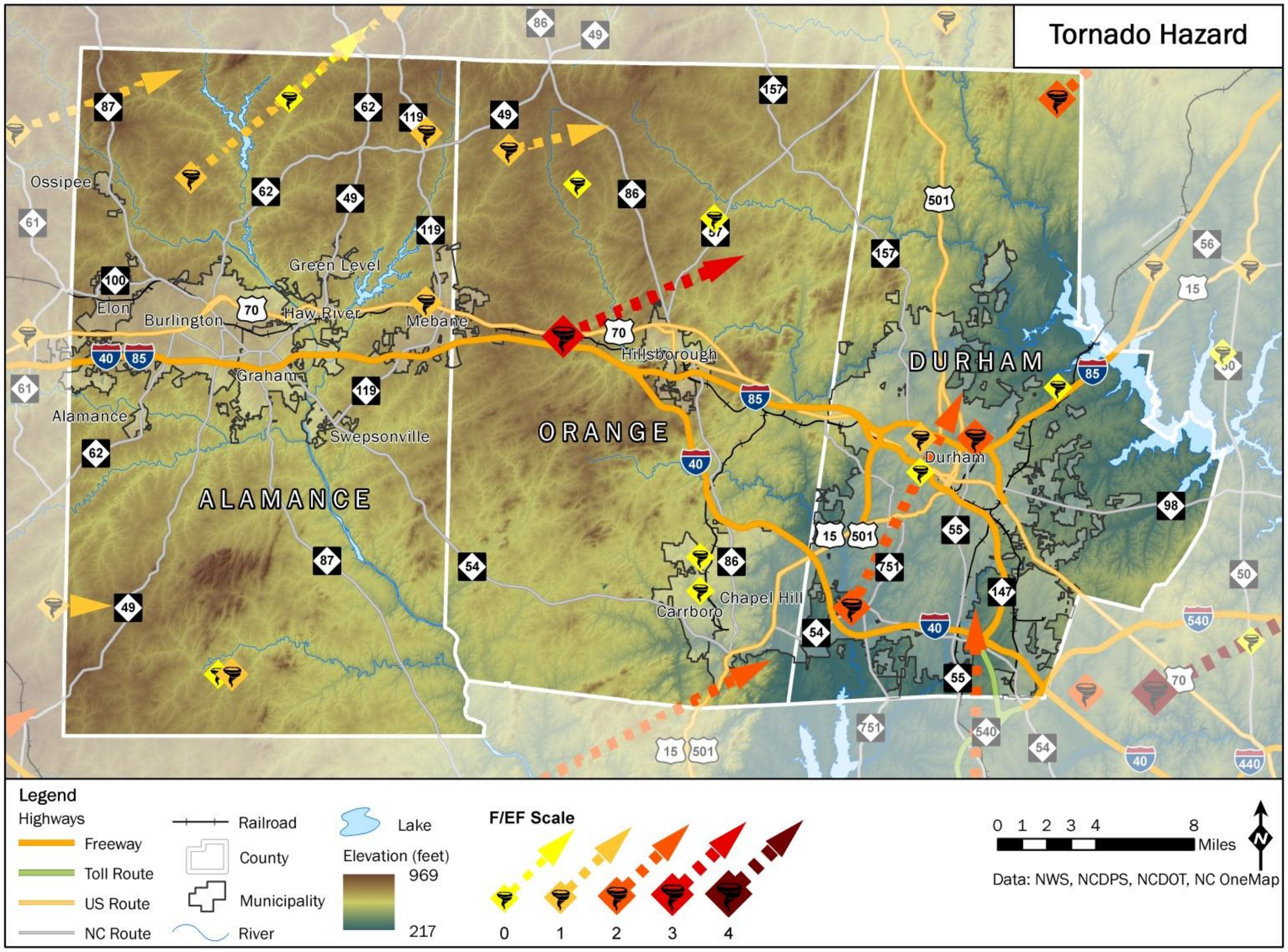
Probability of Future Occurrences

Future occurrences of potentially damaging tornadoes in the planning area are considered to be likely.

Tornado Hazard Vulnerability

All of the inventoried assets in the Eno-Haw Region are exposed to potential tornado activity. Any specific vulnerabilities of individual assets would depend greatly on individual design, building characteristics, and any existing mitigation measures currently in place. Such site-specific vulnerability determinations are outside the scope of this risk assessment but may be considered during future plan updates.

Figure 4.24: Historic Tornado Point Locations and Damage Paths in the Eno-Haw Region



4.5.2.3 Winter Weather

Winter Weather Hazard Description

In general, winter weather events may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation, all of which may create locally hazardous conditions regardless of the magnitude of the overall event. Blizzards, the most dangerous of all winter storms, combine heavy snowfall, low temperatures, and winds of at least 35 mph, reducing visibility to only a few yards. Ice storms occur when moisture falls and freezes immediately upon impact on trees, power lines, communication towers, structures, roads, and other hard surfaces. Ice storms can down trees, cause widespread power outages, damage property, and cause fatalities and injuries to human life.

Winter Weather Hazard Analysis

Nearly the entire continental United States is susceptible to severe winter weather events. Some winter storms may be large enough to affect several states, while others might affect limited, more localized areas. The degree of exposure typically depends on the normal expected severity of local winter weather. The Eno-Haw Region is accustomed to severe winter weather conditions, and frequently receives winter weather during the winter months. Given the atmospheric nature of the hazard, the entire Region has uniform exposure to a winter storm.

Location Within the Planning Area

Winter weather, including blizzards, frosts/freezes, heavy snow, and sleet are widespread atmospheric conditions that are not isolated to a specific geographic location. Therefore it is assumed that the entire planning area is exposed to this hazard. However, it is possible to map greatest one-day snowfall as an indicator of where severe conditions have been observed in the past in the Eno-Haw Region (**Figure 5.25**).

Extent (Magnitude and Severity)

There is currently no overall scale to rank the potential severity of severe winter weather events of this type but it is assumed that the magnitude and severity of future occurrences will be similar to that of historical occurrences.

Historical Occurrences

The following historical occurrences ranging from 1996 to the present have been identified based on the NCDC Storm Events database. NCDC presents winter weather hazards under multiple subcategories. **Table 4.24** shows occurrences of winter storms, winter weather, blizzards, frost/freezes, heavy snow, and sleet. Because winter weather affects a large geographic area, this information is processed by NCDC in forecast "zones," and therefore a municipal-level breakdown is not provided. Similarly, it is important to note that many of the events shown for one county are the same events that are counted for one of the other counties in the planning area. For these reasons, totals are not provided in the table for the Eno-Haw area as a whole as some double-counting would be inherent in the numbers. Also, only historical occurrences listed in the NCDC database are shown here and other smaller, unrecorded, or unreported events may have occurred within the planning area during this timeframe.

Figure 4.25: Greatest One-Day Snowfall in the Eno-Haw Region

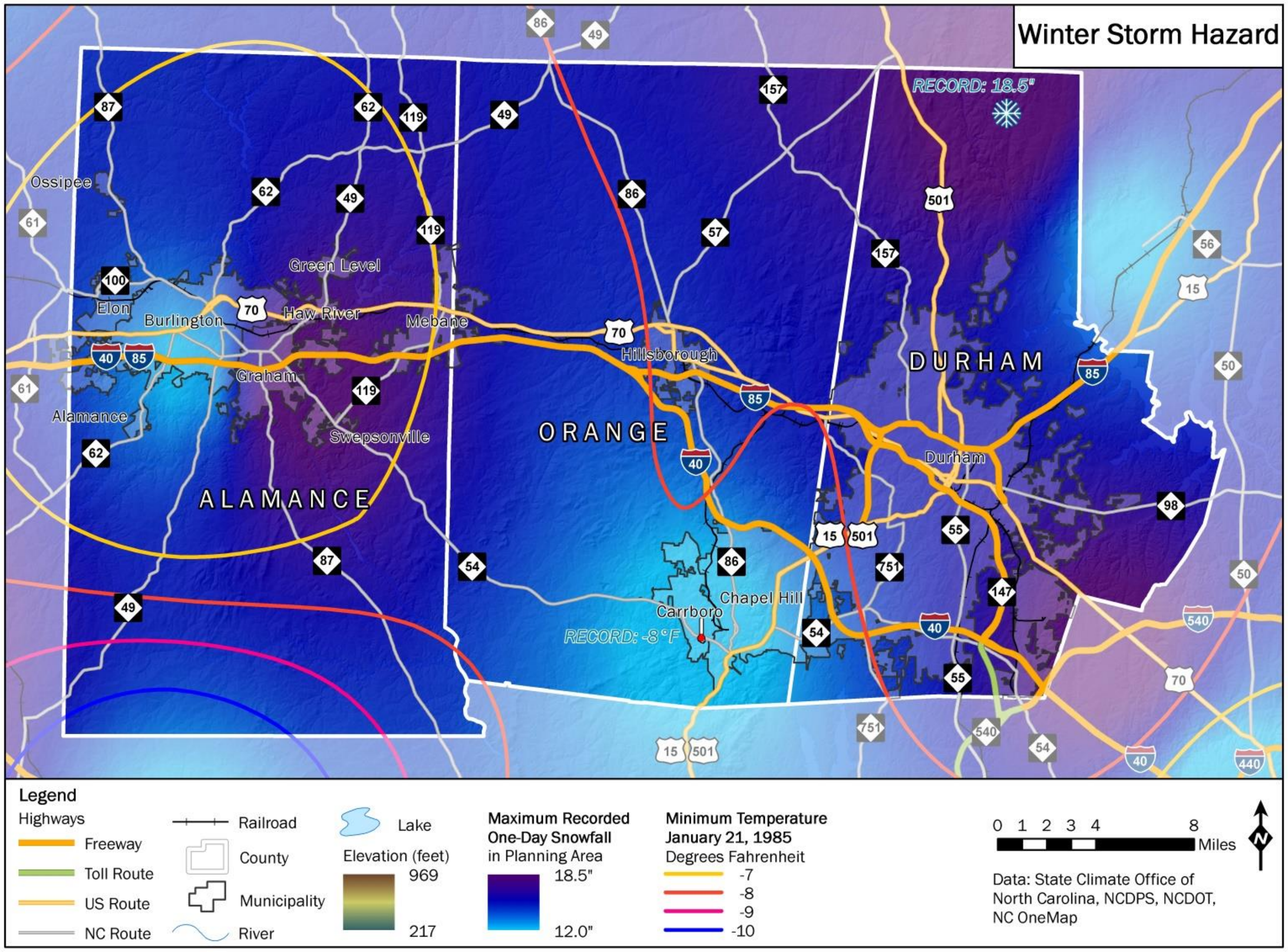


Table 4.24: Summary of Winter Weather Occurrences by Participating Jurisdiction (1950 through October 2014)

Jurisdiction	Number of Winter Storm Events	Number of Winter Weather Events	Number of Blizzard Events	Number of Frost/ Freeze Events	Number of Heavy Snow Events	Number of Sleet Events	Deaths	Injuries	Reported Property Damage	Reported Crop Damage
Alamance County	24	22	0	0	3	0	0	0	$20,000	$0
Orange County	23	20	0	0	3	0	0	0	$30,000	$0
Durham County	20	16	0	0	0	0	0	0	$30,000	$0

Source: National Climatic Data Center Storm Events Database

In summary, a total of at least 24 separate winter storm events, 22 separate winter weather events, 0 frost/freeze events, 3 heavy snow events, and 0 sleet events have affected the planning area since 1996, causing an estimated $80,000 in property damages. Values are not available to calculate potential crop damages (most likely that would have been due to freezes). No deaths or injuries from winter weather have been reported.

Probability of Future Occurrences

It is assumed that the probably of future occurrences of winter weather events in the Eno-Haw Region is highly likely and is anticipated to be similar in nature to known historical occurrences.

Winter Weather Hazard Vulnerability

All of the inventoried assets in the Eno-Haw Region are exposed to potential winter weather. Any specific vulnerabilities of individual assets would depend greatly on individual design, building characteristics (such as a flat roof), and any existing mitigation measures currently in place. Such site-specific vulnerability determinations are outside the scope of this risk assessment but may be considered during future plan updates.

4.5.2.4 Hurricane and Tropical Storm

Hurricane/Tropical Storm Hazard Description

Hurricanes and tropical storms are classified as cyclones and are 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 that causes inland flooding, and tornadoes. While mentioned here, each of these individual forces are more thoroughly addressed as separate hazards within this risk assessment (e.g., flood and tornado).

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 this basin is 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 mph, 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 mph the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Scale (**Table 4.25**), which rates hurricane intensity in categories on a scale of 1 to 5, with category 5 being the most intense.

Table 4.25: Saffir-Simpson Scale for Hurricanes

Category	Maximum Sustained Wind Speed (MPH)	Minimum Surface Pressure (Millibars)	Storm Surge (Feet)
1	74–95	Greater than 980	3–5
2	96–110	979–965	6–8
3	111–130	964–945	9–12
4	131–155	944–920	13–18
5	155 +	Less than 920	19+

Source: National Oceanic and Atmospheric Administration

The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure and storm surge potential, 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% of total tropical cyclone landfalls, they account for over 70% of the damage in the United States. **Table 4.26** describes the damage that could be expected for each category of hurricane. Damage during hurricanes might also result from spawned tornadoes, storm surge, and inland flooding associated with heavy rainfall that usually accompanies these storms.

Table 4.26: Hurricane Damage Classification

Category	Damage Level	Description of Damages
1	Minimal	No real damage to buildings. 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 might 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 might 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 might 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 might be required.

Source: National Oceanic and Atmospheric Administration, Federal Emergency Management Agency

Hurricane/Tropical Storm Hazard Analysis

On average, North Carolina experiences a hurricane approximately once every two years. Substantial hurricane damage is typically most likely to be expected in the easternmost counties of the state; however, hurricane and tropical storm-force winds have significantly impacted areas far inland, including Alamance, Orange, and Durham counties. In fact, five such storms have passed within 75 miles of the planning area since 1851, the first of which being in 1893 (see **Figure 4.26** and **Table 4.27**). The total number of five includes two Category 2 hurricanes and three Category 1 hurricanes.

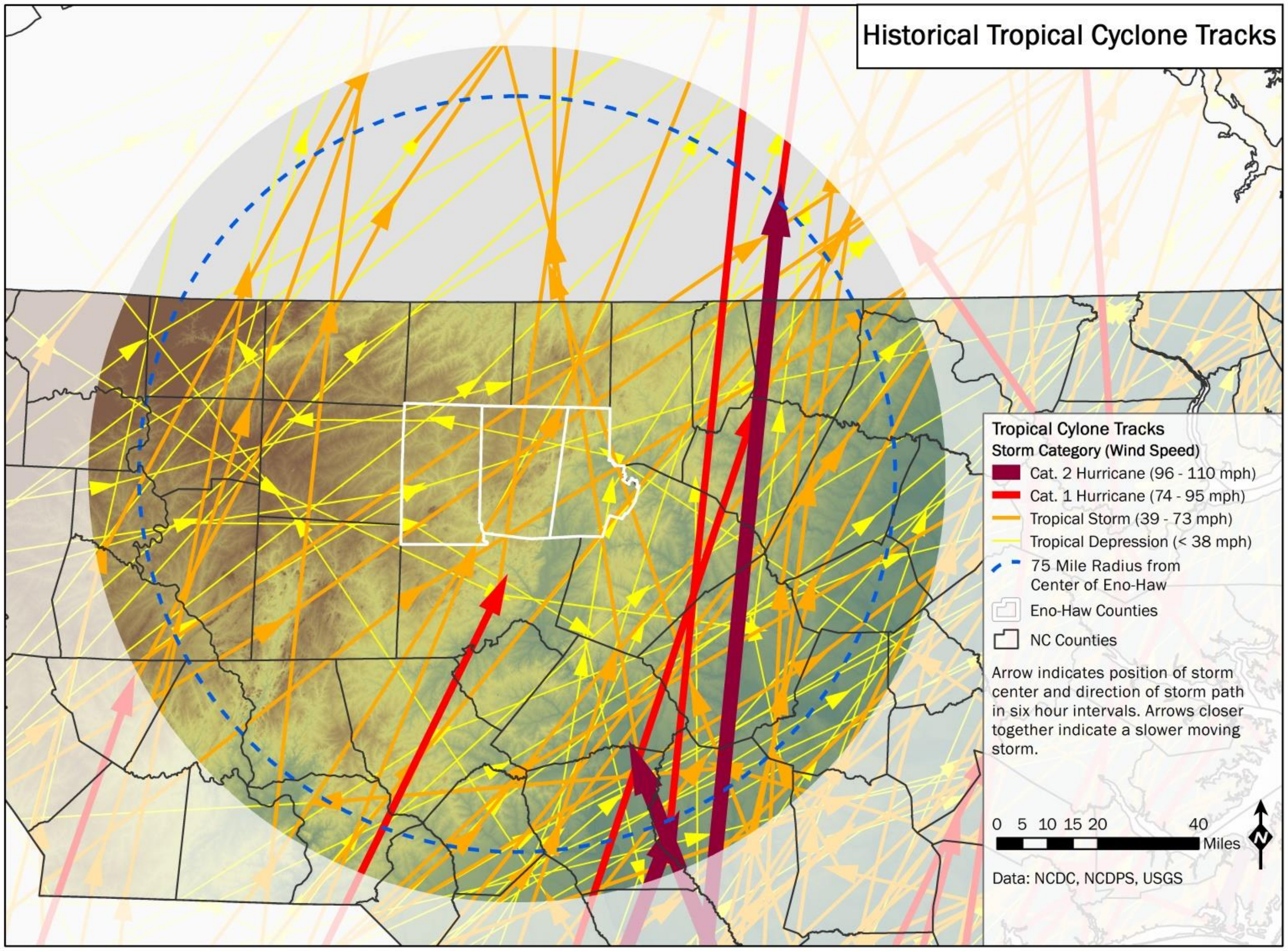
Location Within the Planning Area

Hurricanes and tropical storms are widespread atmospheric disturbances that are not isolated to a specific geographic location within the planning area. Therefore it is assumed that the entire planning area is exposed to this hazard.

Extent (Magnitude and Severity)

Hurricanes and tropical storms of any magnitude and severity are theoretically possible within the planning area, however major hurricanes (Category 3 and greater) are less likely to retain that classification as far inland as the Eno-Haw Region. Since the 1850s, the greatest magnitude hurricane to impact the planning area has been a Category 2 hurricane (see *Historical Occurrences* section below). A Category 2 hurricane typically results in moderate damage including some damage to roofing material, doors and windows; and considerable damage to vegetation, mobile homes, etc. A Category 1 hurricane typically results in minimal damages, including damage primarily to unanchored mobile homes, shrubbery, and trees.

Figure 4.26: Historical Hurricane and Tropical Storm Tracks in the Eno-Haw Region



Historical Occurrences

Table 4.27 lists the five hurricane and tropical storm paths that have crossed within a 75 statute mile radius of the mean center of the planning area from 1851 to 2011 (the data from the National Hurricane Center is only current through 2011). This table only shows events with hurricane force winds. As the previous figure illustrates, there have been multiple extratropical and subtropical events that have come within close proximity to the planning area, however the maximum wind speeds associated with these lesser events have had a much less substantial impact on the region. It does seem as though wind speeds have gotten somewhat progressively more severe over the past 160 years.

Table 4.27: Historical Occurrences of Hurricane Storm Paths Crossing within 75 Miles of the Planning Area

Name	Date	Magnitude	Maximum Recorded Wind Speed (mph)
Not Named	10/13/1893	Category 1	80
Not Named	9/29/1896	Category 1	85
Not Named	10/31/1899	Category 1	75
Hurricane Hazel	10/15/1954	Category 2	110
Hurricane Fran	9/6/1996	Category 2	100

Source: NOAA National Hurricane Center

Figure 4.42 is based on the mapped paths of the storm systems shown in Table 4.28. **Table 4.28** lists significant hurricane and tropical storm events recorded by NCDC since 1996. The events recorded in the table below may reflect storms that did not pass within 75 miles of the planning area but that were still significant to the planning area in some way.

Table 4.28: Historical Occurrences of Hurricanes and Tropical Storms (1996 through October 2014)

Date	Name	Deaths	Injuries	Reported Property Damage	Reported Crop Damage
ALAMANCE COUNTY					
7/12/1996	Hurricane Bertha	0	0	$0	$0
9/5/1996	Hurricane Fran	1	0	$0	$0
9/4/1999	Hurricane Dennis (Remnants)	0	0	$0	$3,000,000
9/15/1999	Hurricane Floyd	0	0	$3,000,000,000	$500,000
Subtotal Alamance		*1*	*0*	*$3,000,000,000*	*$3,500,000*
ORANGE COUNTY					
7/12/1996	Hurricane Bertha	0	0	$0	$0
9/5/1996	Hurricane Fran	0	0	$0	$0
9/4/1999	Hurricane Dennis (Remnants)	0	0	$0	$0
9/15/1999	Hurricane Floyd	0	0	$0	$0
Subtotal Orange		*0*	*0*	*$0*	*$0*
DURHAM COUNTY					
7/12/1996	Hurricane Bertha	0	0	$0	$0
9/5/1996	Hurricane Fran	1	0	$0	$0

Date	Name	Deaths	Injuries	Reported Property Damage	Reported Crop Damage
9/4/1999	Hurricane Dennis (Remnants)	0	0	$0	$0
9/15/1999	Hurricane Floyd	0	0	$0	$0
9/18/2003	Hurricane Isabel	0	0	$205,000	$0
Subtotal Orange		*1*	*0*	*$205,000*	*$0*
TOTAL ENO-HAW		**2**	**0**	**$3,000,205,000**	**$3,500,000**

Source: National Climatic Data Center

Probability of Future Occurrences

Future occurrences of hurricanes and tropical storms is considered to be likely.

Hurricane/Tropical Storm Hazard Vulnerability

All of the inventoried assets in the Eno-Haw Region are exposed to potential hurricane and tropical storm events. Any specific vulnerabilities of individual assets would depend greatly on individual design, building characteristics, and any existing mitigation measures currently in place. Such site-specific vulnerability determinations are outside the scope of this risk assessment but may be considered during future plan updates.

4.5.3 Geologic Hazards

Geologic hazards include landslides and earthquakes. As with the other hazard types discussed in this risk assessment, geologic hazards may occur as a result of or in combination with other hazards. For example, excessive rainfall can contribute to landslide occurrences, etc.

4.5.3.1 Landslide

Landslide Hazard Description

A landslide is the downward and outward movement of slope-forming soil, rock, and vegetation, which is driven by gravity. Landslides may be triggered by both natural and human-caused changes in the environment, including heavy rain, rapid snow melt, steepening of slopes due to construction or erosion, earthquakes, volcanic eruptions, and changes in groundwater levels. Landslides occur when the force of gravity pulling down the slope exceeds the strength of the earth materials that comprise to hold it in place.

There are several types of landslides: rock falls, rock topple, slides, slumps, and debris 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. Slumps are landslides that typically occur on smaller slopes when loosely consolidated materials or rock layers move a short distance down a slope, typically in a rotational fashion. Debris flows, sometimes referred to as mudslides, mudflows, lahars, or debris avalanches, are fast-moving rivers of rock, earth, and other debris saturated with water.

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events. Slopes are also more likely to fail if vegetative cover is low and/or soil water content is high. 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. Slopes greater than 10 degrees are more likely to slide, as are slopes where the height from the top of the slope to its toe is greater than 40 feet.

In the United States, it is estimated that landslides cause up to $2 billion in damages and from 25 to 50 deaths annually. Globally, landslides cause billions of dollars in damage and thousands of deaths and injuries each year.

Landslide Hazard Analysis

Location Within the Planning Area

Figure 4.27 shows information developed by the United States Geological Survey (USGS) which depicts areas of landslide incidence and susceptibility. This information suggests that there is some significant potential risk that is not supported by any historical data or detailed landslide hazard mapping presently available for the planning area. In addition, **Figure 4.28** shows slope and average annual precipitation data for the Eno-Haw Region.

Figure 4.27: Landslide Susceptibility and Incidence Data for the Eno-Haw Region

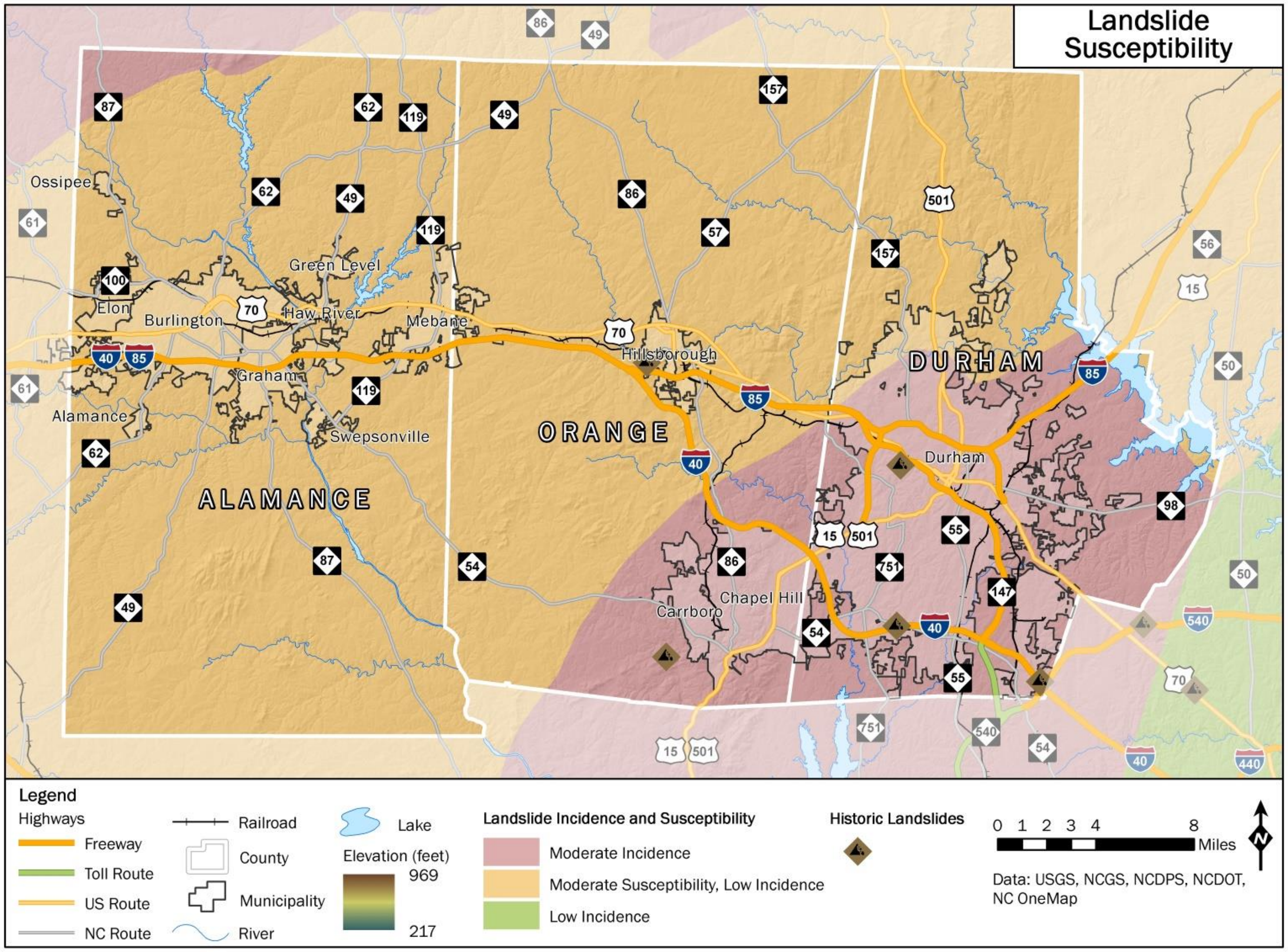
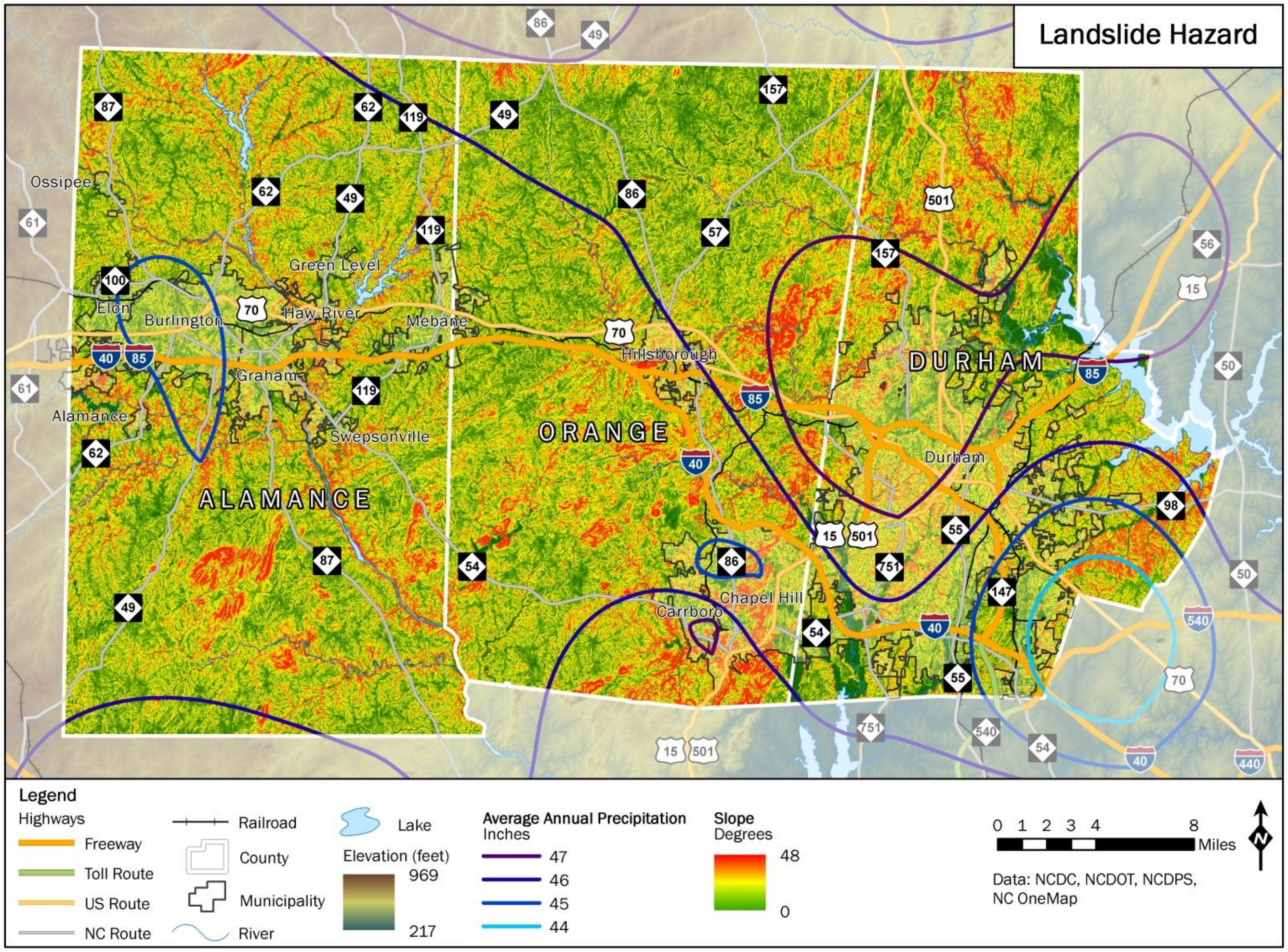


Figure 4.28: Slope and Average Annual Precipitation Data for the Eno-Haw Region



Extent (Magnitude and Severity)

The magnitude and severity of landslides can vary greatly depending on terrain and other highly localized factors. In addition, there is no overall severity rating scale for landslides that can be applied to the Eno-Haw Region.

Historical Occurrences

There are no records of historical occurrences of significant landslides in the planning area.

Landslide Hazard Vulnerability

Sufficient hazard information is not currently available with which to conduct a detailed vulnerability assessment. In addition, any specific vulnerabilities of individual assets would depend on individual design, building characteristics, and any existing mitigation measures currently in place. Such site-specific vulnerability determinations are outside the scope of this risk assessment but may be considered during future plan updates.

4.5.3.2 Earthquake

Earthquake Hazard Description

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of caverns. Earthquakes can affect hundreds of thousands of square miles, cause damage to property measured in the tens of billions of dollars, result in loss of life and injury to hundreds of thousands of persons; and disrupt the social and economic functioning of the affected area. Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site, and regional geology. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (mountain regions and along hillsides), and liquefaction, in which ground soil loses the ability to resist shear and flows much like quick sand. In the case of liquefaction, anything relying on the substrata for support can shift, tilt, rupture, or collapse.

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.

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 (**Table 4.29**). Each unit increase in magnitude on the Richter Scale corresponds to a 10-fold increase in wave amplitude, or a 32-fold increase in energy. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale based on direct and indirect measurements of seismic effects. A detailed description of the Modified Mercalli Intensity Scale of earthquake intensity and its correspondence to the Richter Scale is given in **Table 4.30**.

Table 4.29: Richter Scale

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

Source: Federal Emergency Management Agency.

Table 4.30: Modified Mercalli Intensity Scale for Earthquakes

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

Source: Federal Emergency Management Agency.

Earthquake Hazard Analysis

Approximately two-thirds of North Carolina is subject to earthquakes, with the western and southeast region most vulnerable to a very damaging earthquake. The state is affected by both the Charleston Fault in South Carolina and the New Madrid Fault in Tennessee. Both of these faults have generated earthquakes measuring greater than 8 on the Richter Scale during the last 200 years. In addition, there are several smaller fault lines throughout North Carolina.

Location Within the Planning Area

Figure 4.29 shows peak ground acceleration (PGA) and historic earthquake epicenters for the state of North Carolina and relevant surrounding areas. **Figures 4.30** through **4.32** show PGA at the county level for the three counties in the planning area.

Figure 4.29: Peak Ground Acceleration and Historic Epicenters Relevant to the Eno-Haw Region

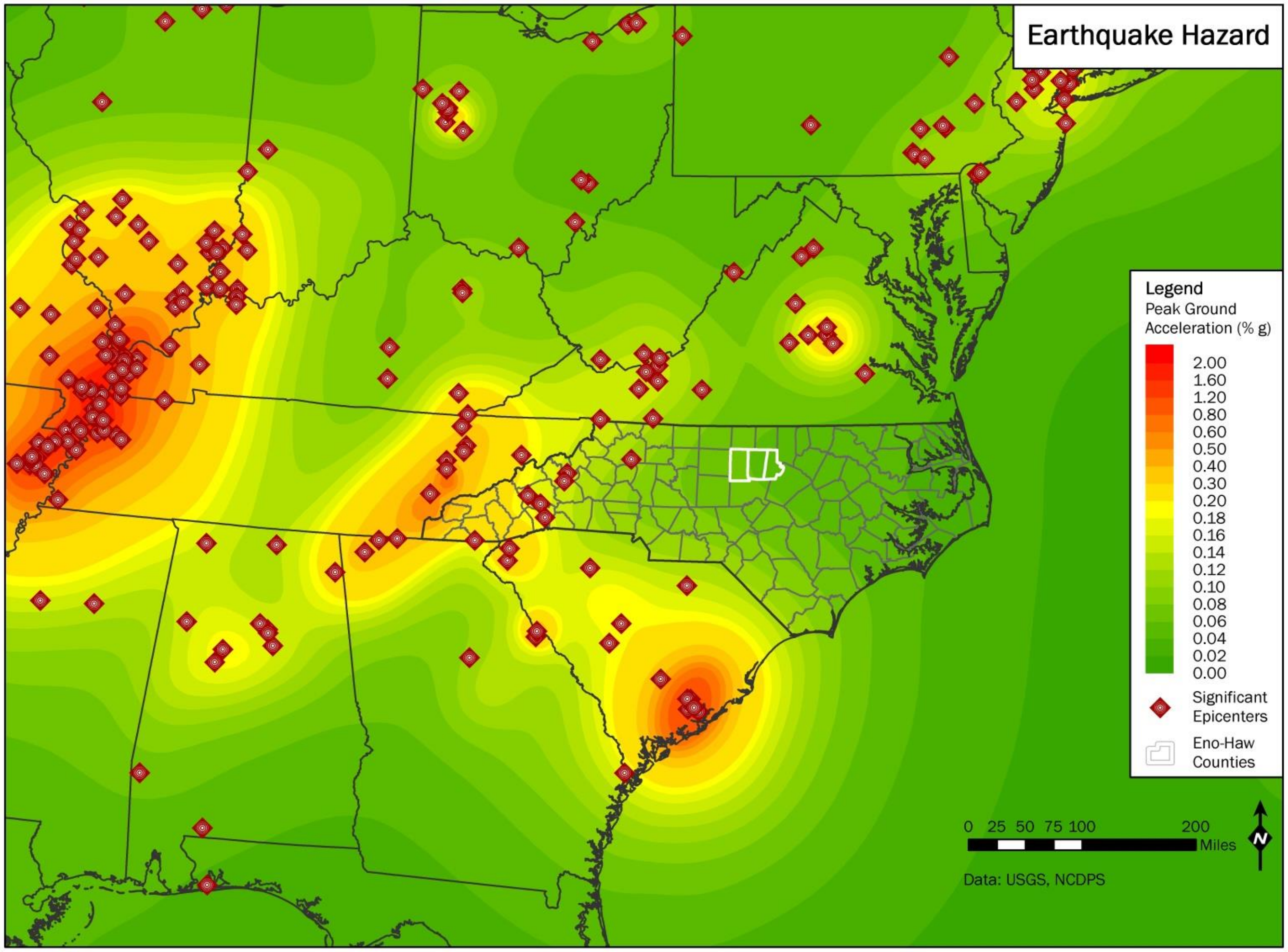


Figure 4.30: Peak Ground Acceleration for Alamance County

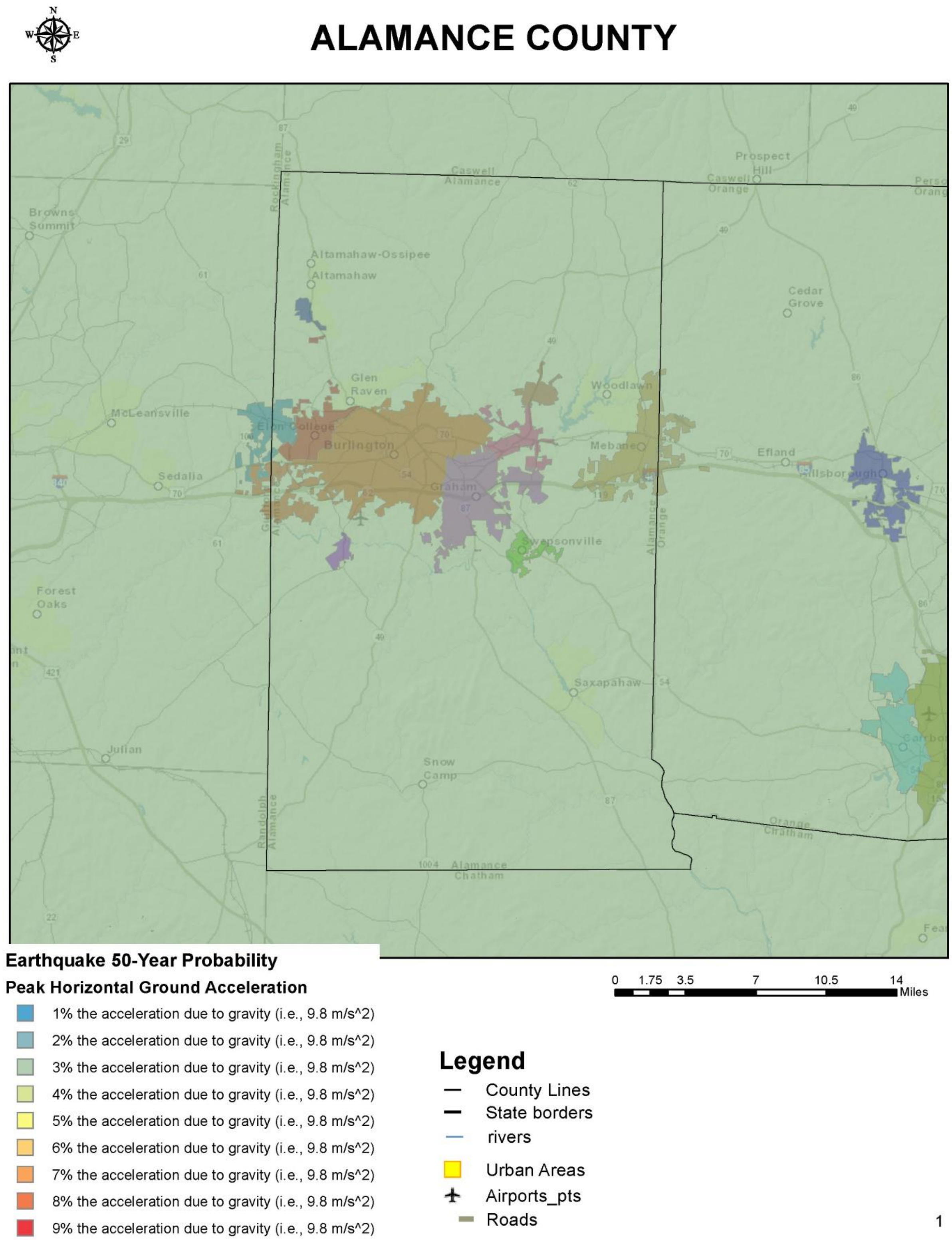


Figure 4.31: Peak Ground Acceleration for Orange County

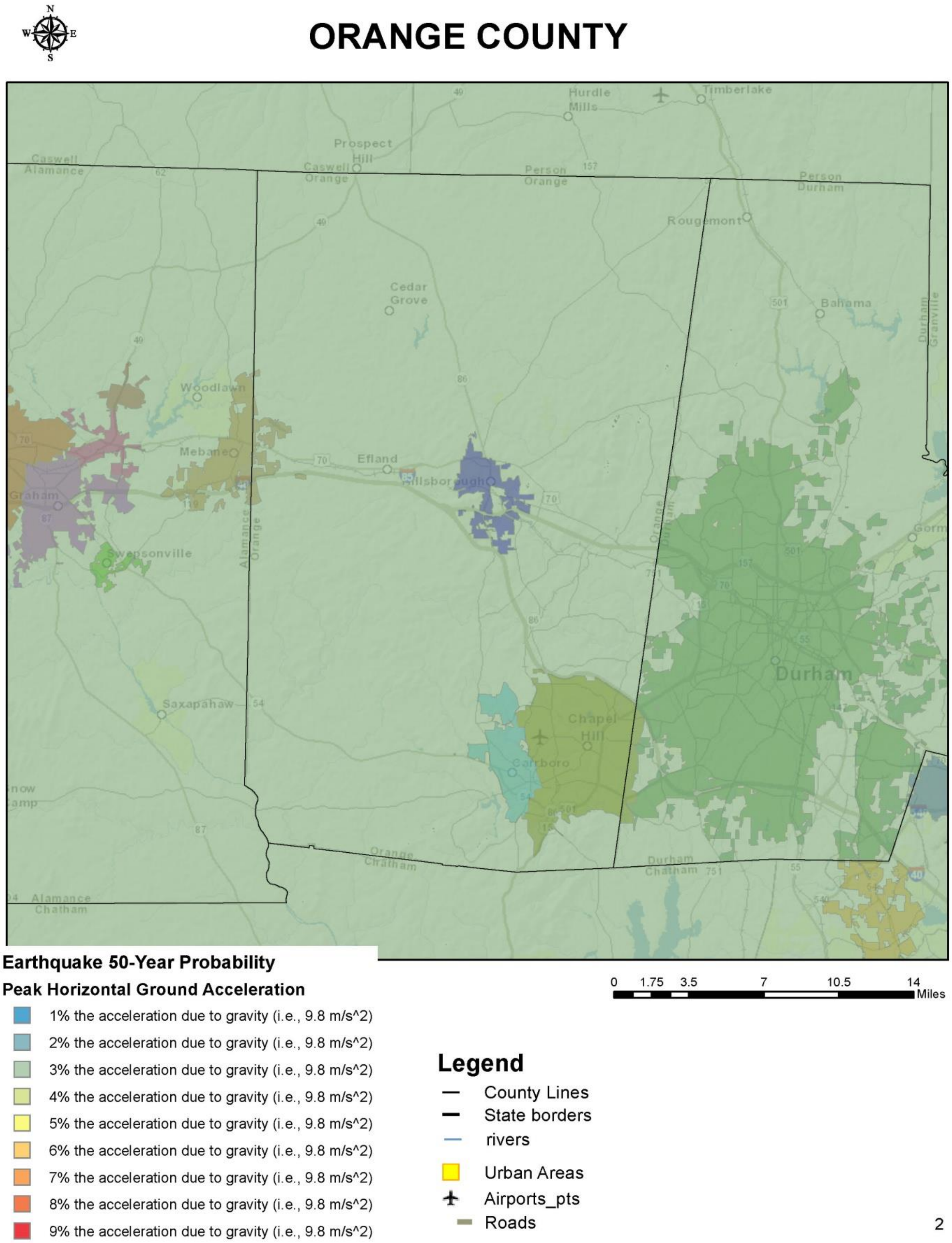
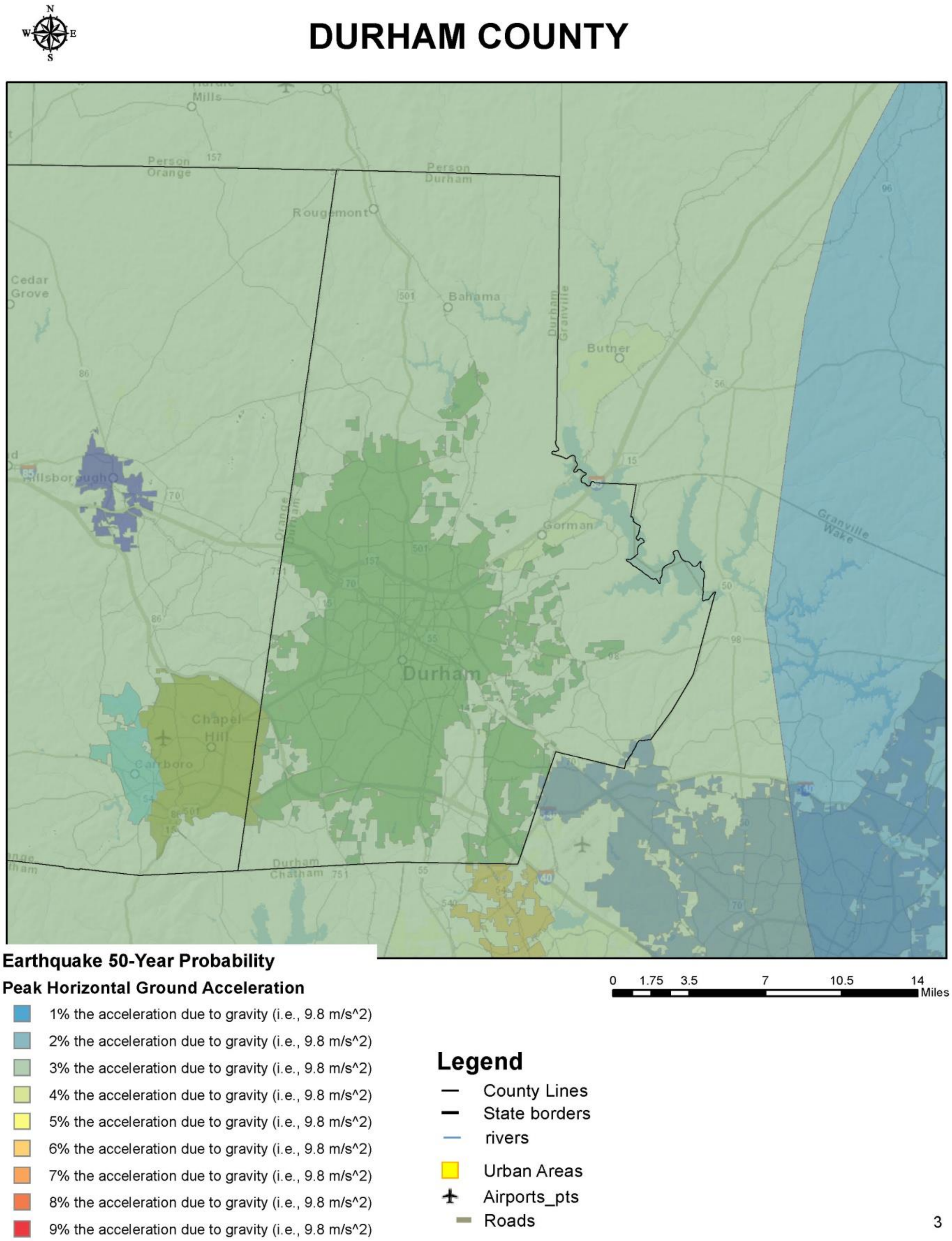


Figure 4.32: Peak Ground Acceleration for Durham County



Extent (Magnitude and Severity) and Historical Occurrences
According to USGS, there is a 0.30% chance of a major earthquake occurring within 50 kilometers of the City of Durham within the next 50 years. The largest earthquake within 30 miles of Durham was a 2.7 magnitude in 1978. There was another 2.7 magnitude earthquake that was felt 4.25 miles from Greensboro (in neighboring Guilford County) in 1993.

Probability of Future Occurrences
The probability of significant, damaging earthquake events affecting the Eno-Haw Region is considered to be unlikely. However, it is likely that future earthquakes resulting in light to moderate perceived shaking and damages ranging from none to very light may affect the Region to some degree.

Earthquake Hazard Vulnerability
Due to the relatively low probability of an earthquake occurrence producing significant damages in the participating jurisdictions, a detailed vulnerability assessment was not conducted for this hazard.

4.5.4 Other Hazards

The wildfire hazard does not fit into any of the hazard classifications described above (hydrologic, atmospheric, and geologic). Therefore, wildfire is presented here under the category of "Other Hazards."

4.5.4.1 Wildfire

Wildfire Hazard Description
A wildfire is any fire occurring in a wildland area (e.g., grassland, forest, brush land) except for fire under prescription. Wildfires are part of the natural management of forest ecosystems, but may also be caused by human factors. Nationally, over 80% of forest fires are started by negligent human behavior such as smoking in wooded areas or improperly extinguishing campfires. The second most common cause for wildfire is lightning.

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

Wildfire probability depends on local weather conditions, outdoor activities such as camping, debris burning, and construction, and the degree of public cooperation with fire prevention measures. Drought conditions and other natural hazards (tornadoes, hurricanes, etc.) increase the probability of wildfires by producing fuel in both urban and rural settings. Forest damage from hurricanes and tornadoes may also block interior access roads and fire breaks, pull down overhead power lines, or damage pavement and underground utilities.

Wildfires can cause significant damage to property and threatens the lives of people who are unable to evacuate wildfire-prone areas. Many individual homes and cabins, subdivisions, resorts, recreational areas, organizational camps, businesses, and industries are located within high wildfire hazard areas. Further, the increasing demand for outdoor recreation places more people in wildlands during holidays, weekends, and vacation periods. Unfortunately, wildland residents and visitors are rarely educated or prepared for wildfire events that can sweep through the brush and timber and destroy property within minutes.

Wildfires can result in severe economic losses. Businesses that depend on timber, such as paper mills and lumber companies, experience losses that are often passed along to consumers through higher prices, and sometimes jobs are lost. The high cost of responding to and recovering from wildfires can deplete state resources and increase insurance rates. The economic impact of wildfires can also be felt in the tourism industry if roads and tourist attractions are closed due to health and safety concerns, such as reduced air quality by means of wildfire smoke and ash.

Wildfire Hazard Analysis

The entire Eno-Haw Region is at risk to a wildfire occurrence. However, drought conditions may make a fire more likely in certain locations under certain conditions. Further, areas in the urban-wildland interface are particularly susceptible to fire hazards as populations inhabit formerly undeveloped areas.

Location Within the Planning Area

In an effort to identify specific potential wildfire hazard areas within the planning area, a GIS-based data layer called the Wildland Fire Susceptibility Index (WFSI) was obtained from the North Carolina Division of Forest Resources (NCDFR). The WFSI is a component layer derived from the Southern Wildfire Risk Assessment (SWRA), a multi-year project to assess and quantify wildfire risk for the 13 Southern states. The WFSI is a value between 0 and 1. It was developed consistent with the mathematical calculation process for determining the probability of an acre burning. 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 planning area have this value determined consistently, it allows for comparison and ordination of areas as to the likelihood of an acre burning.

Figures 4.33 through **4.45** illustrate the level of wildfire potential for the planning area based on the WFSI data provided by NCDFR. Areas with a WFSI value of 0.01–0.05 were considered to be at moderate risk to the wildfire hazard. Areas with a WFSI value greater than 0.05 were considered to be at high risk to the wildfire hazard. Areas with a WFSI value less than 0.01 were considered to not be at risk to the wildfire hazard.

Extent (Magnitude and Severity)

The average size of wildfires in the Eno-Haw Region is typically small.

Historical Occurrences

According to statistics provided by NCDFR, the 5-year average number of fires for the Eno-Haw region was 41.8. The 5-year average number of acres burned was 129.94. **Table 4.31** shows a breakdown of the number of fires and number of acres burned by county by year from 2009 through 2013.

Table 4.31: Historical Occurrences of Wildfire

County	2009	2010	2011	2012	2013
Alamance					
Number of Fires	5	3	10	3	2
Number of Acres Burned	11.4	1.7	46.0	4.5	1.2
Orange					
Number of Fires	18	31	35	13	16
Number of Acres Burned	46.6	32.6	47.5	31.5	43.6
Durham					
Number of Fires	18	24	12	8	11
Number of Acres Burned	25.0	62.0	62.8	196.0	37.3
TOTAL ENO-HAW					
Number of Fires	**41**	**58**	**57**	**24**	**29**
Number of Acres	**83.0**	**96.3**	**156.3**	**232.0**	**82.1**

Source: North Carolina Division of Forest Resources.

Probability of Future Occurrences

It is assumed that wildfire occurrences of these types and magnitudes will continue to be likely in the planning area.

Figure 4.33: Wildfire Hazard Areas in the Village of Alamance

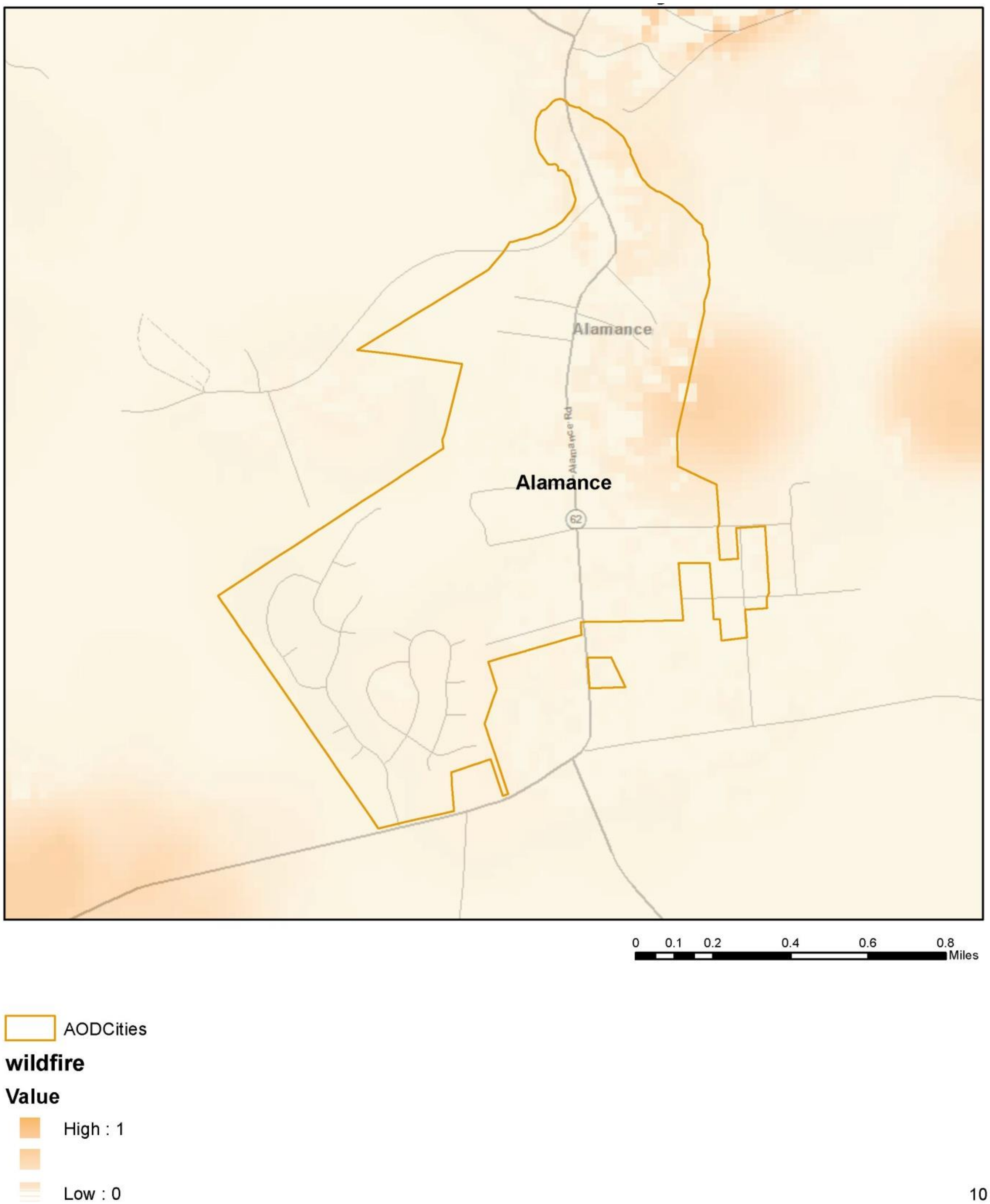


Figure 4.34: Wildfire Hazard Areas in the City of Burlington

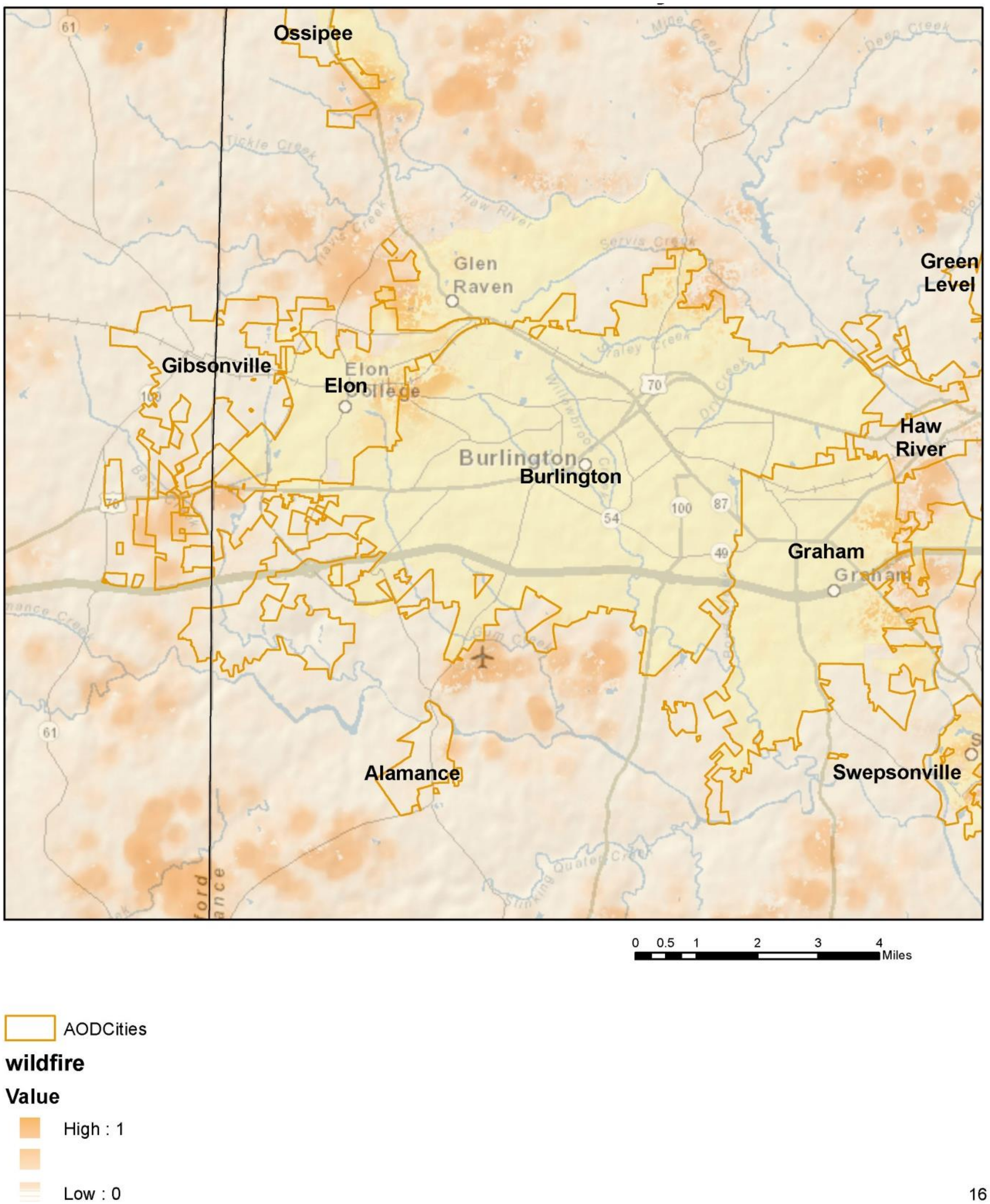


Figure 4.35: Wildfire Hazard Areas in the Town of Elon

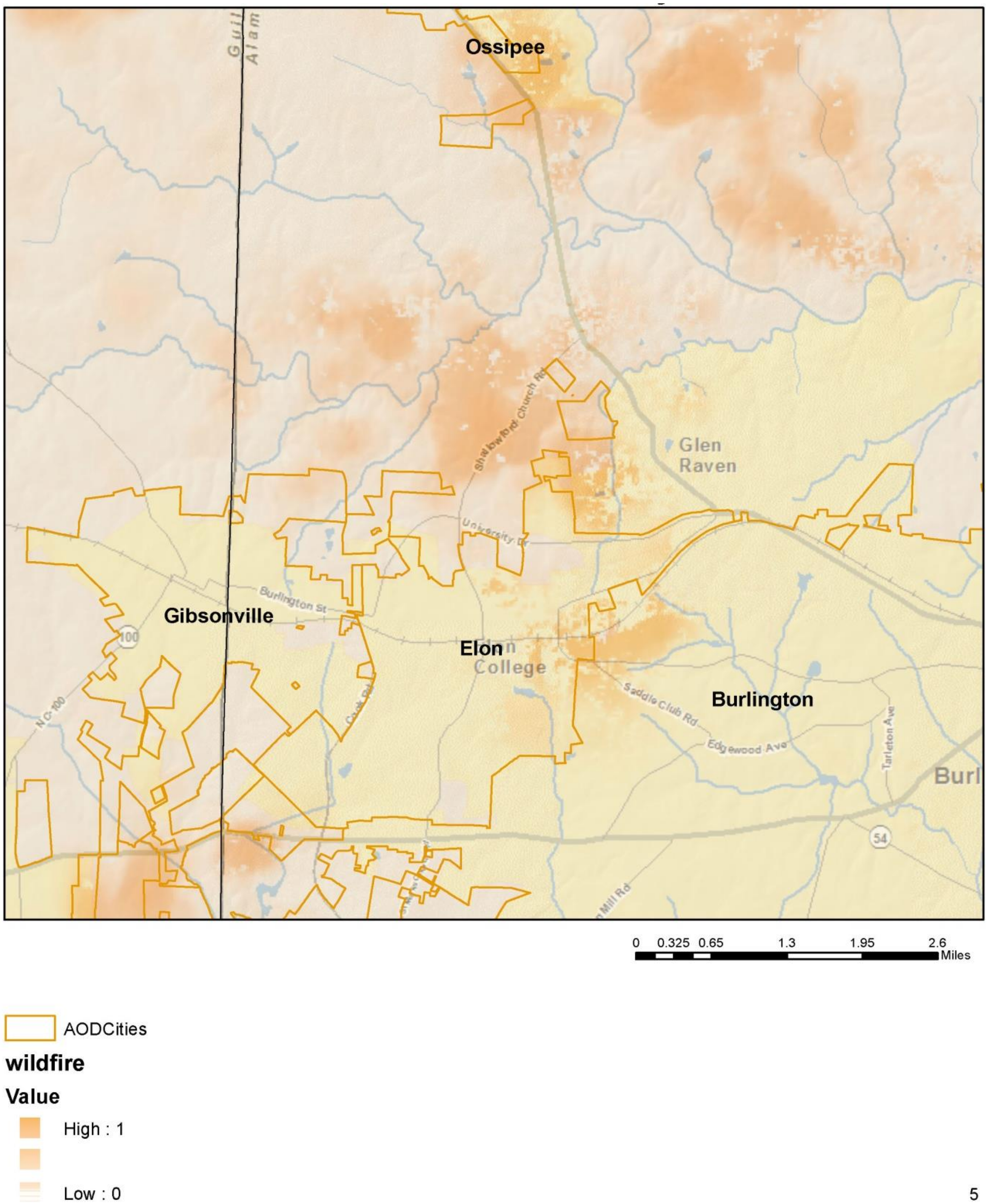


Figure 4.36: Wildfire Hazard Areas in the City of Graham

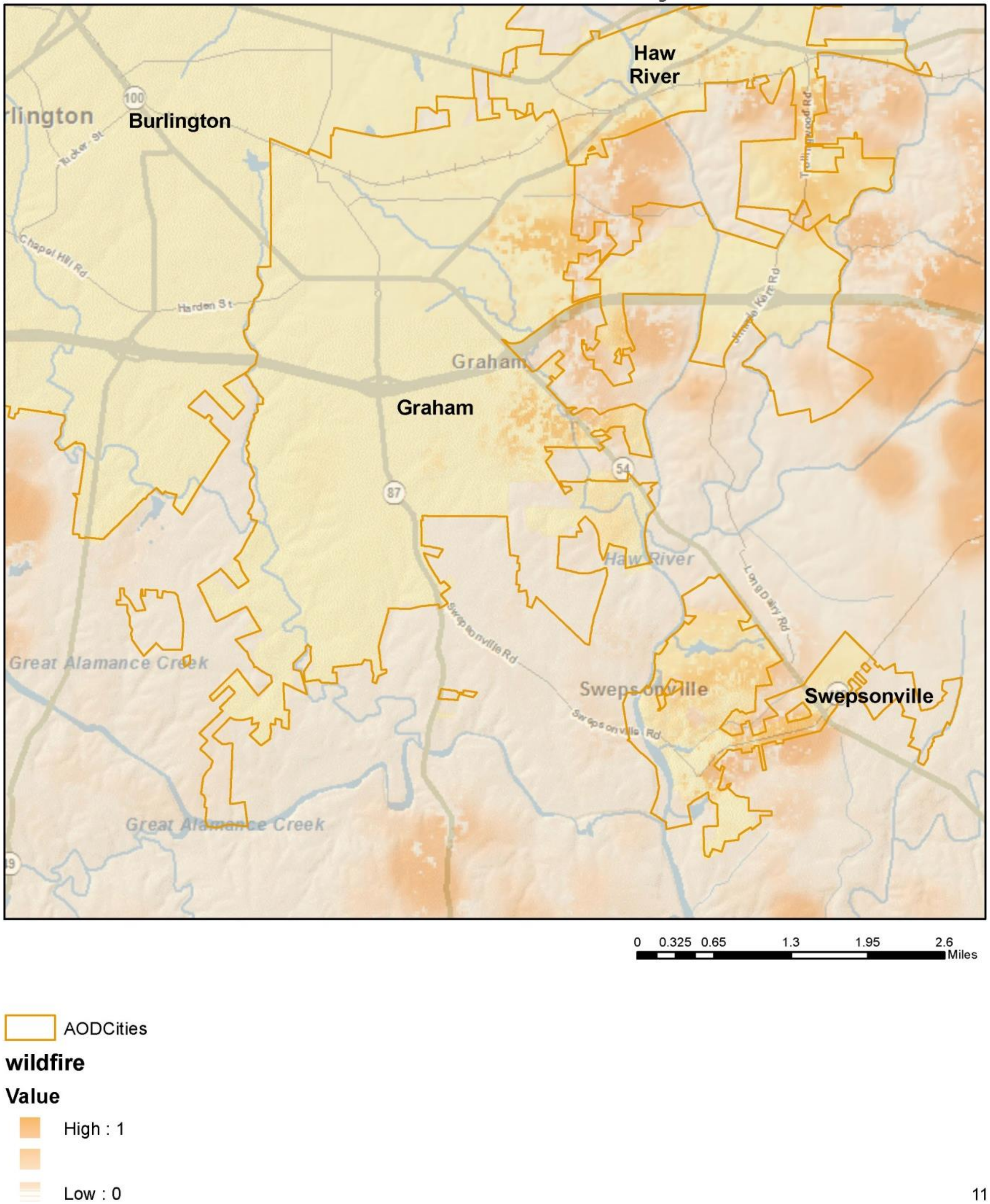


Figure 4.37: Wildfire Hazard Areas in the Town of Green Level

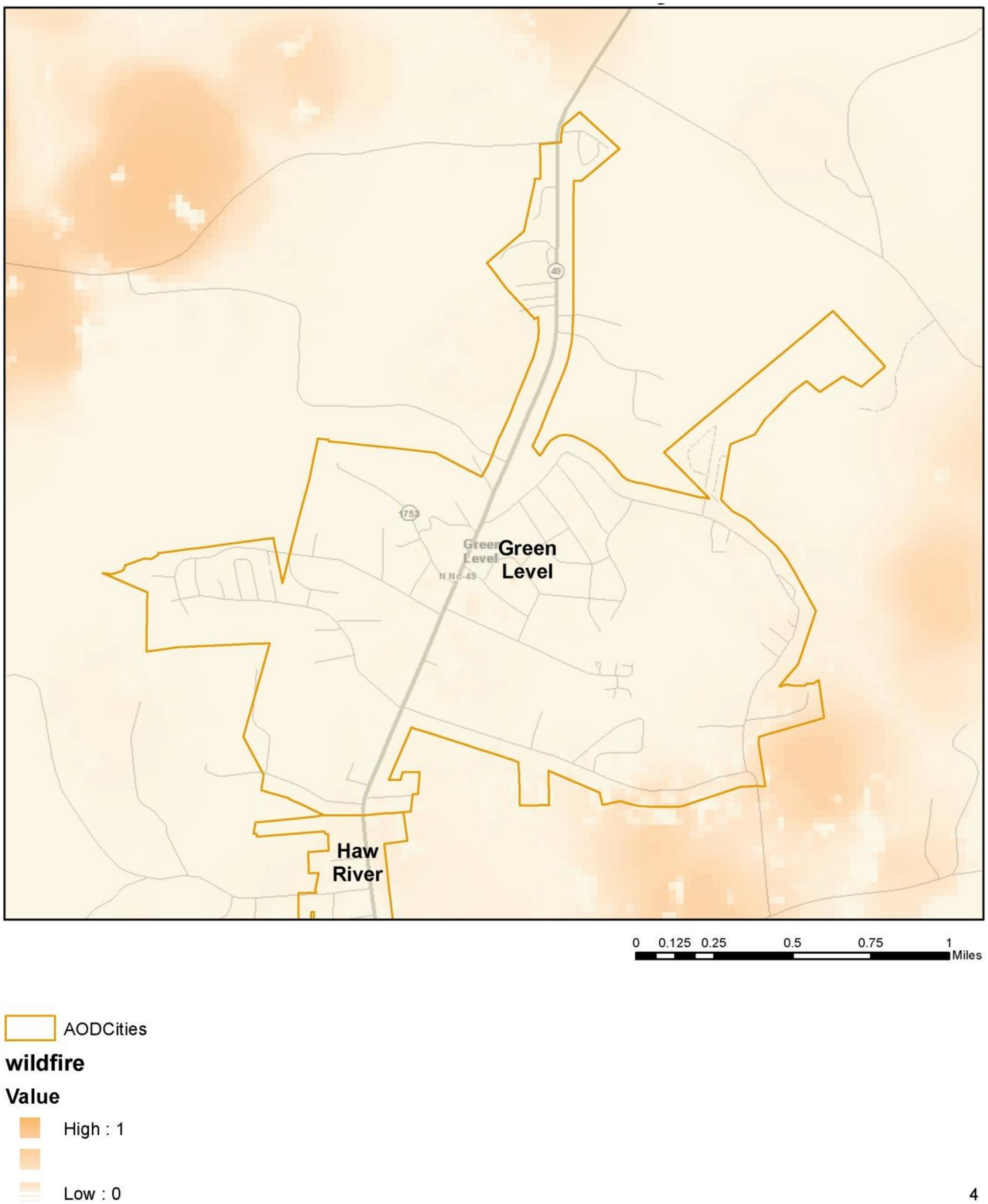


Figure 4.38: Wildfire Hazard Areas in the Town of Haw River

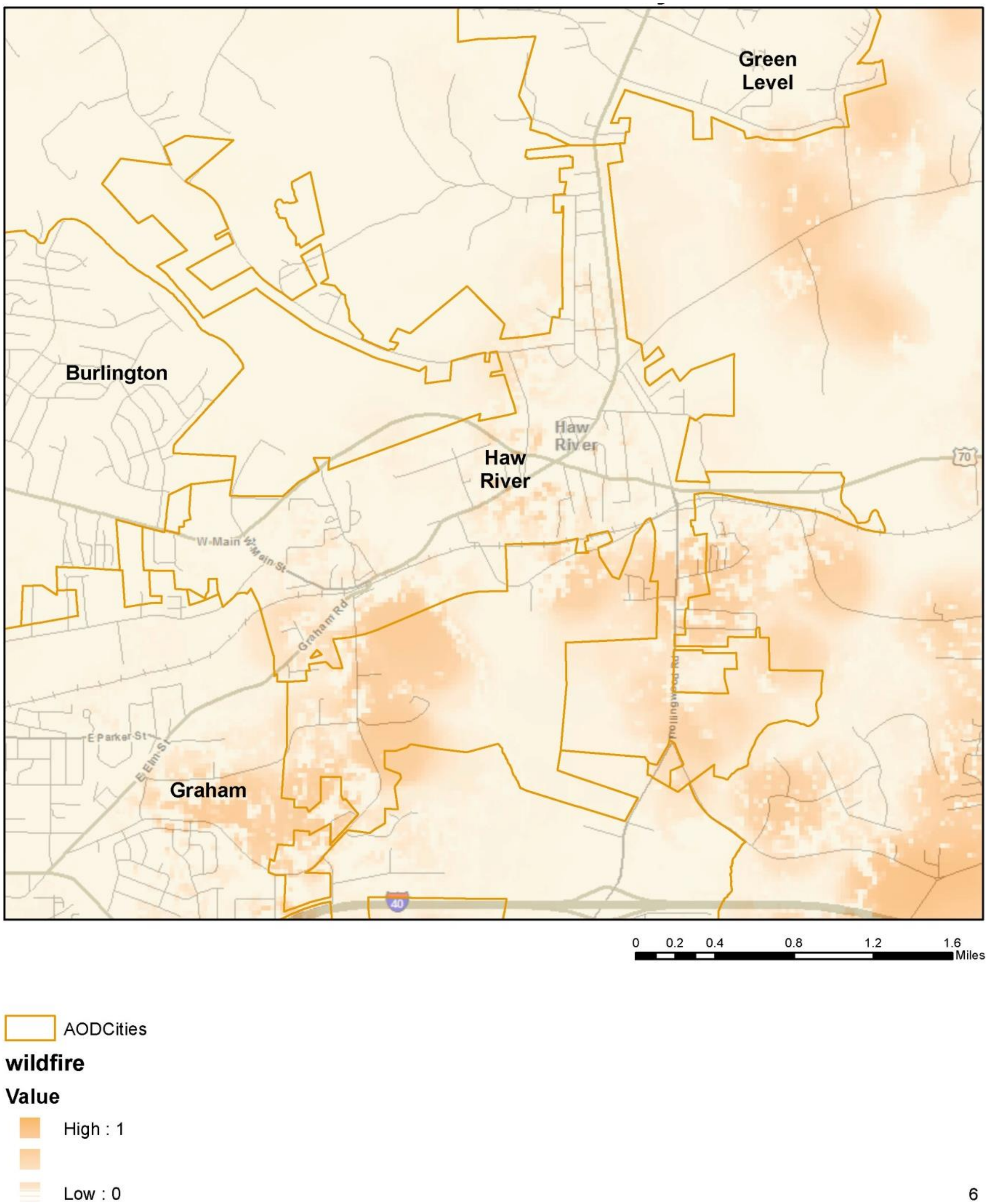


Figure 4.39: Wildfire Hazard Areas in the City of Mebane

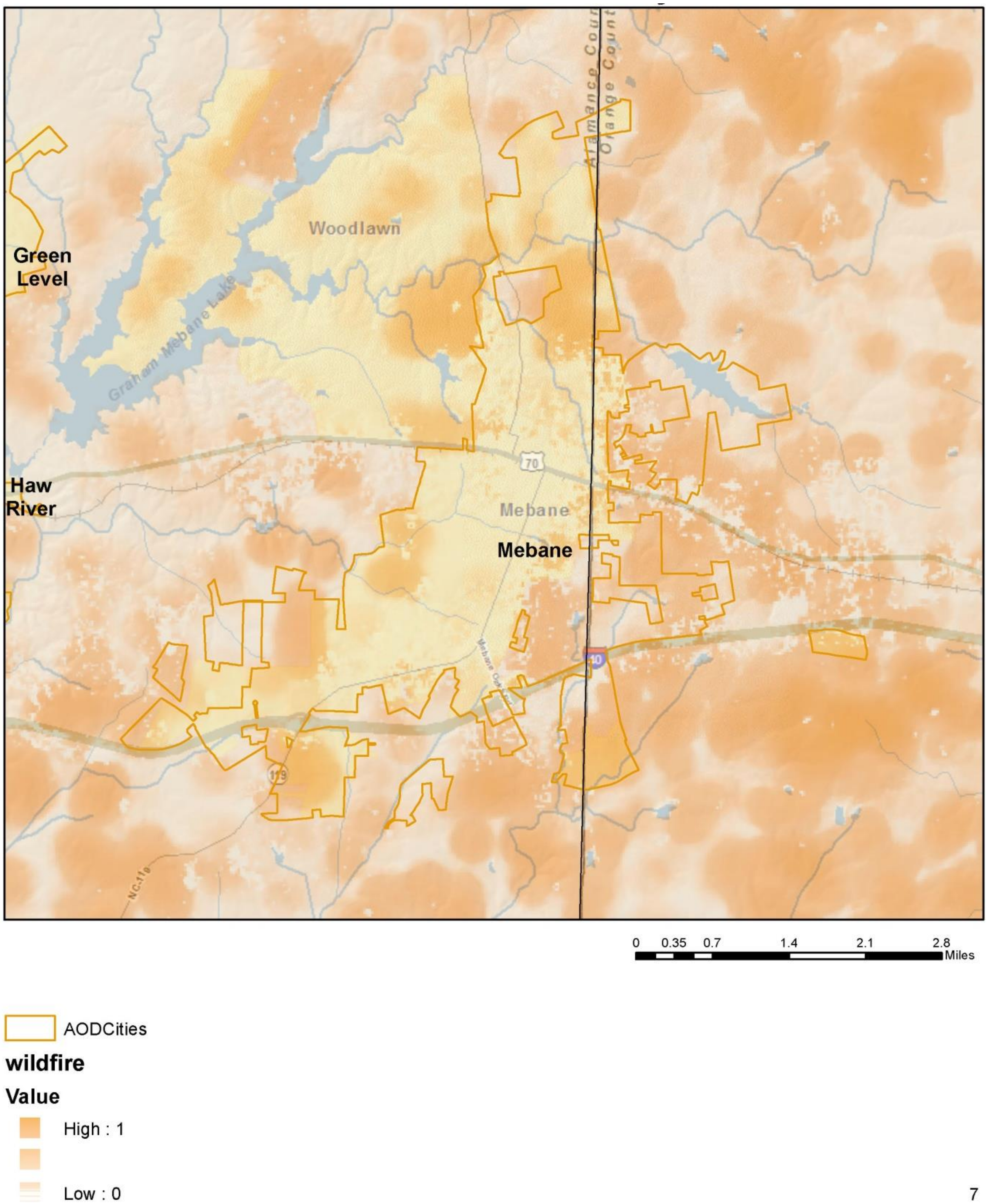


Figure 4.40: Wildfire Hazard Areas in the Town of Ossipee

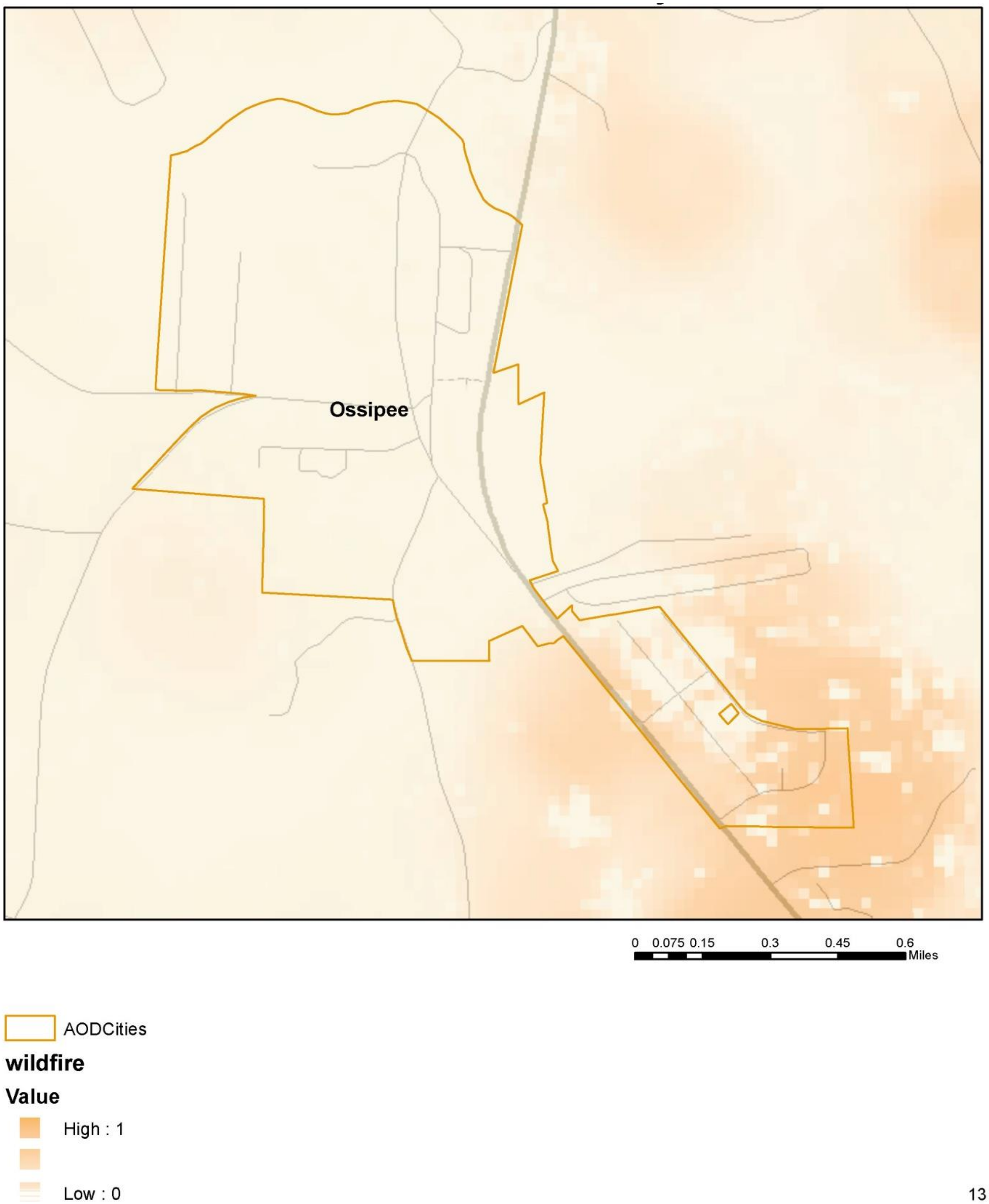


Figure 4.41: Wildfire Hazard Areas in the Town of Swepsonville

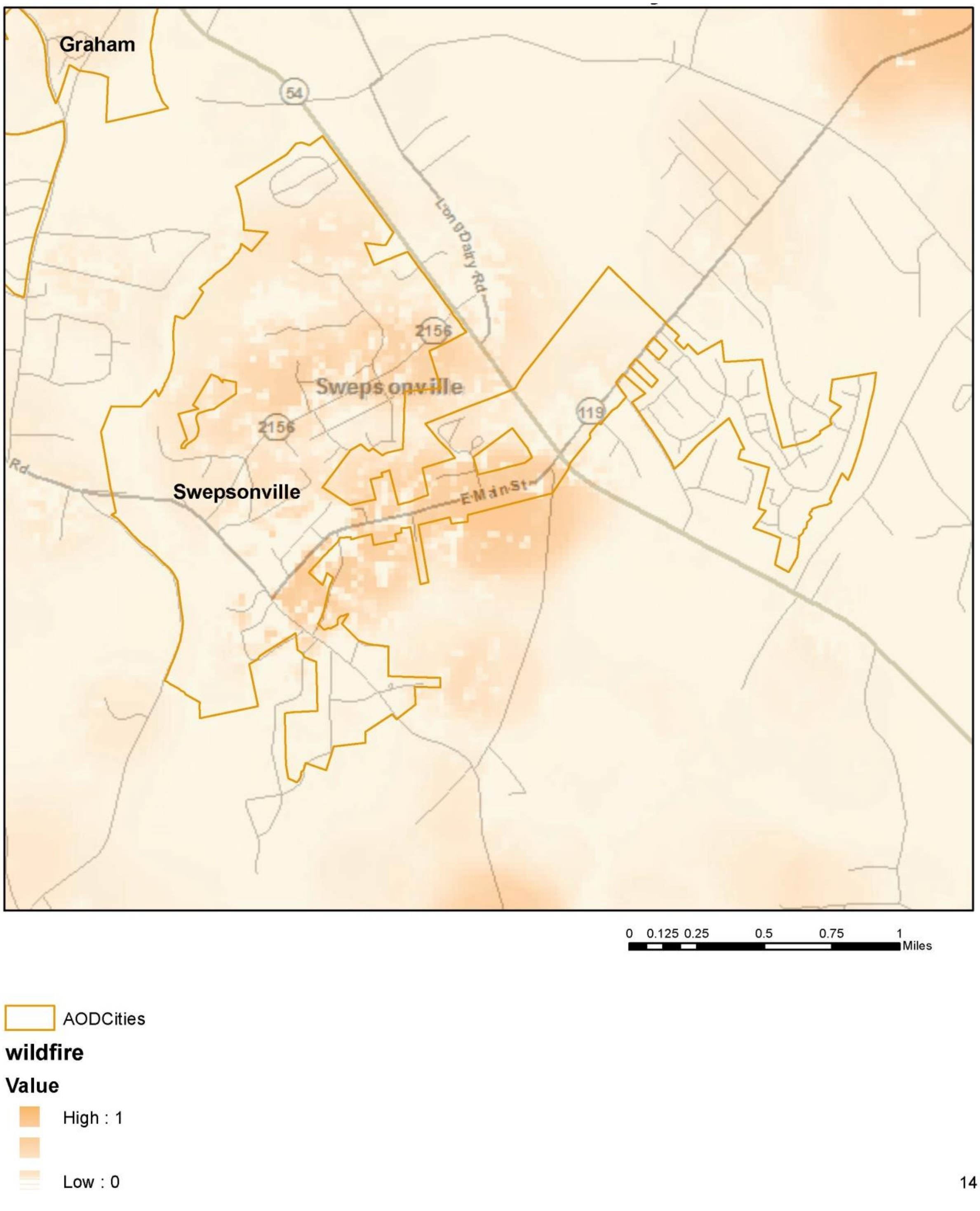


Figure 4.42: Wildfire Hazard Areas in the City of Durham

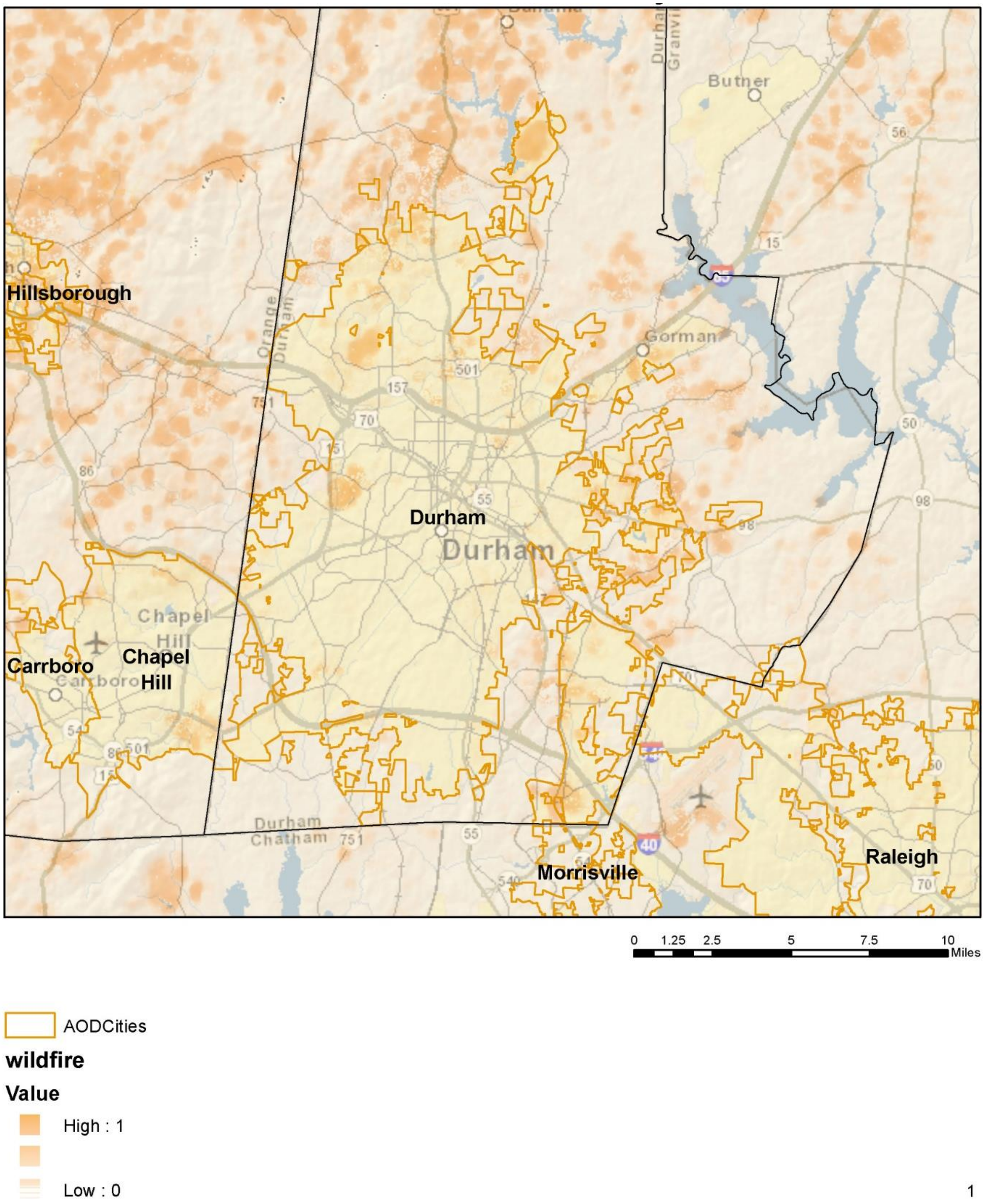


Figure 4.43: Wildfire Hazard Areas in the Town of Carrboro

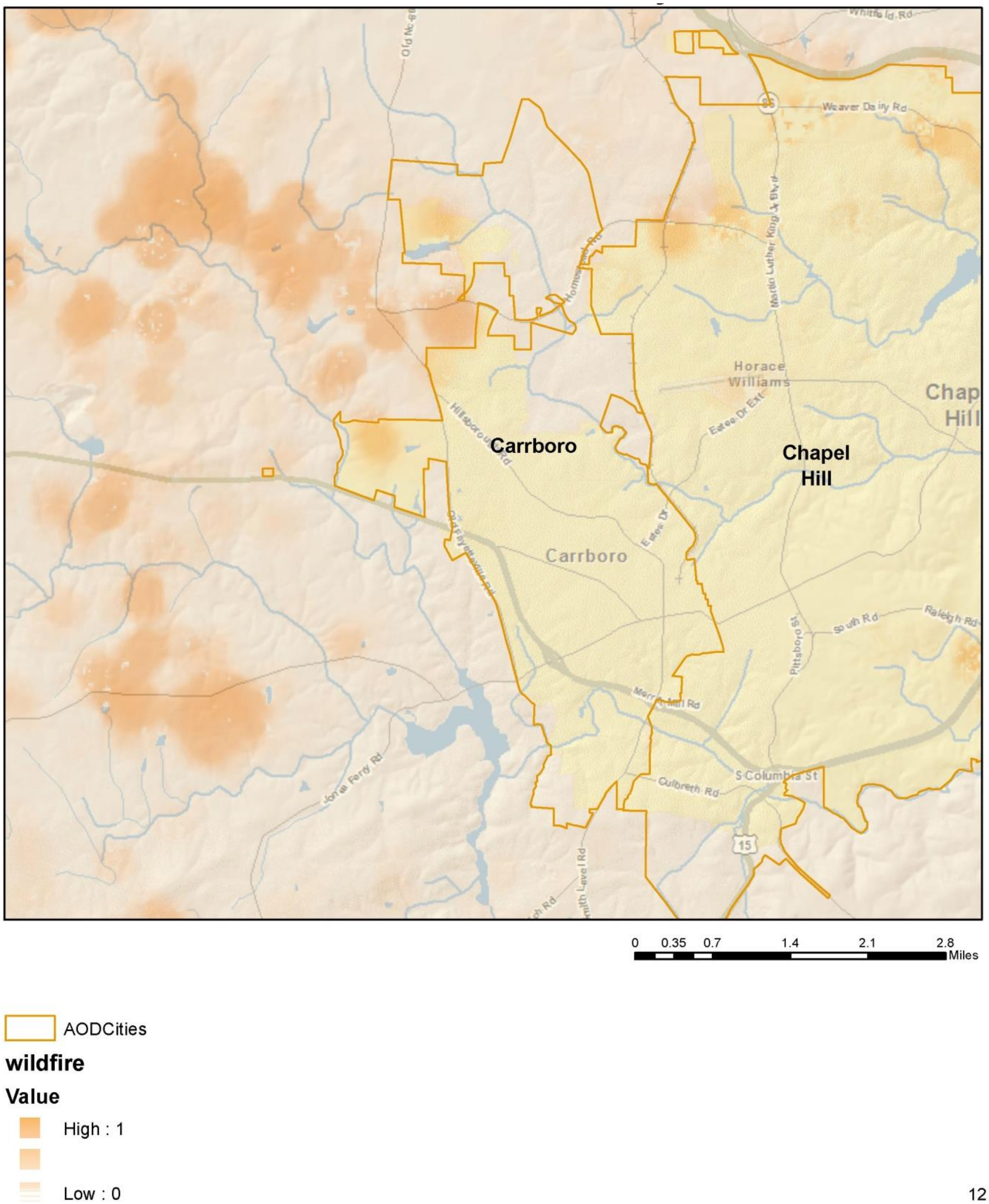


Figure 4.44: Wildfire Hazard Areas in the Town of Chapel Hill

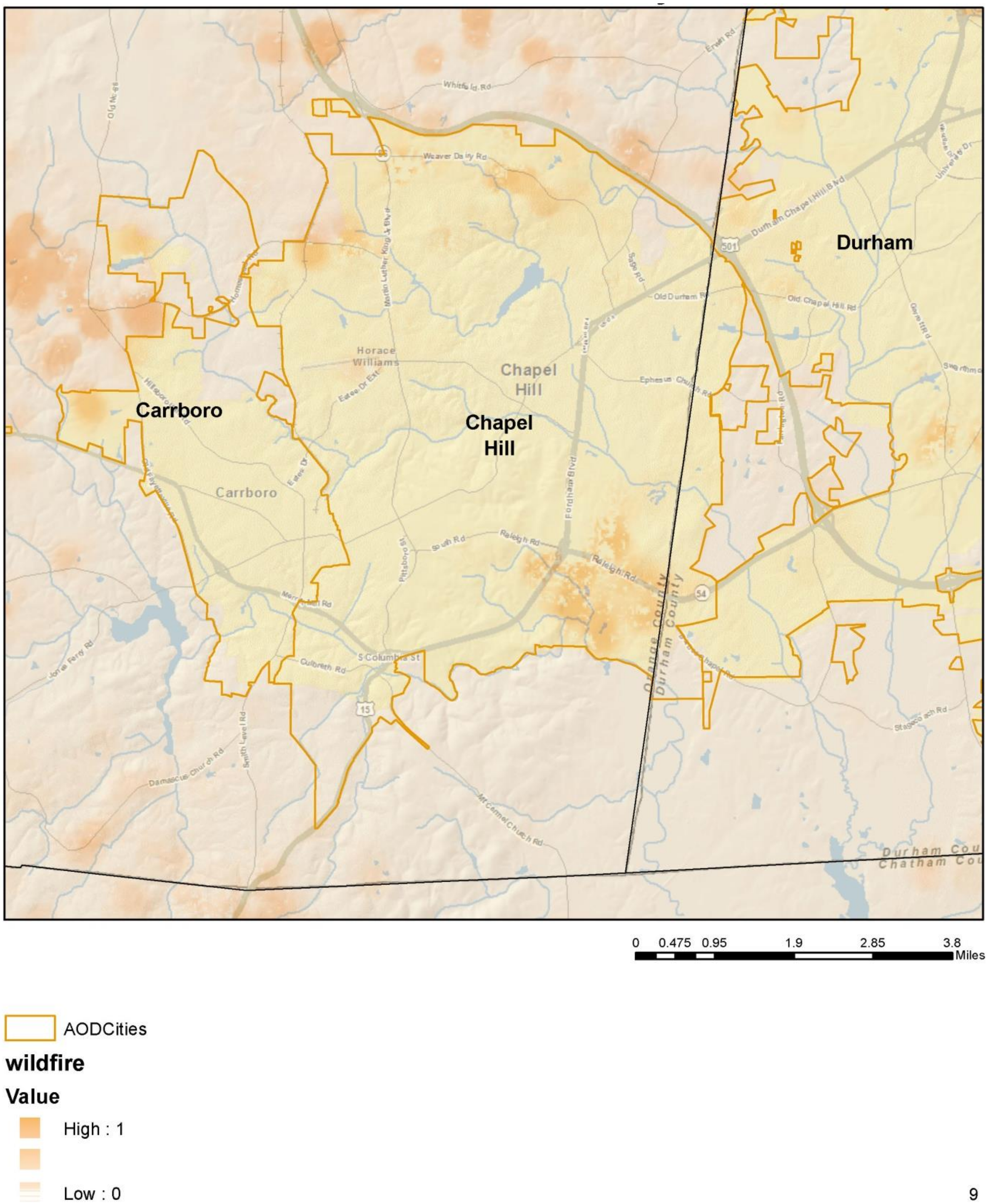
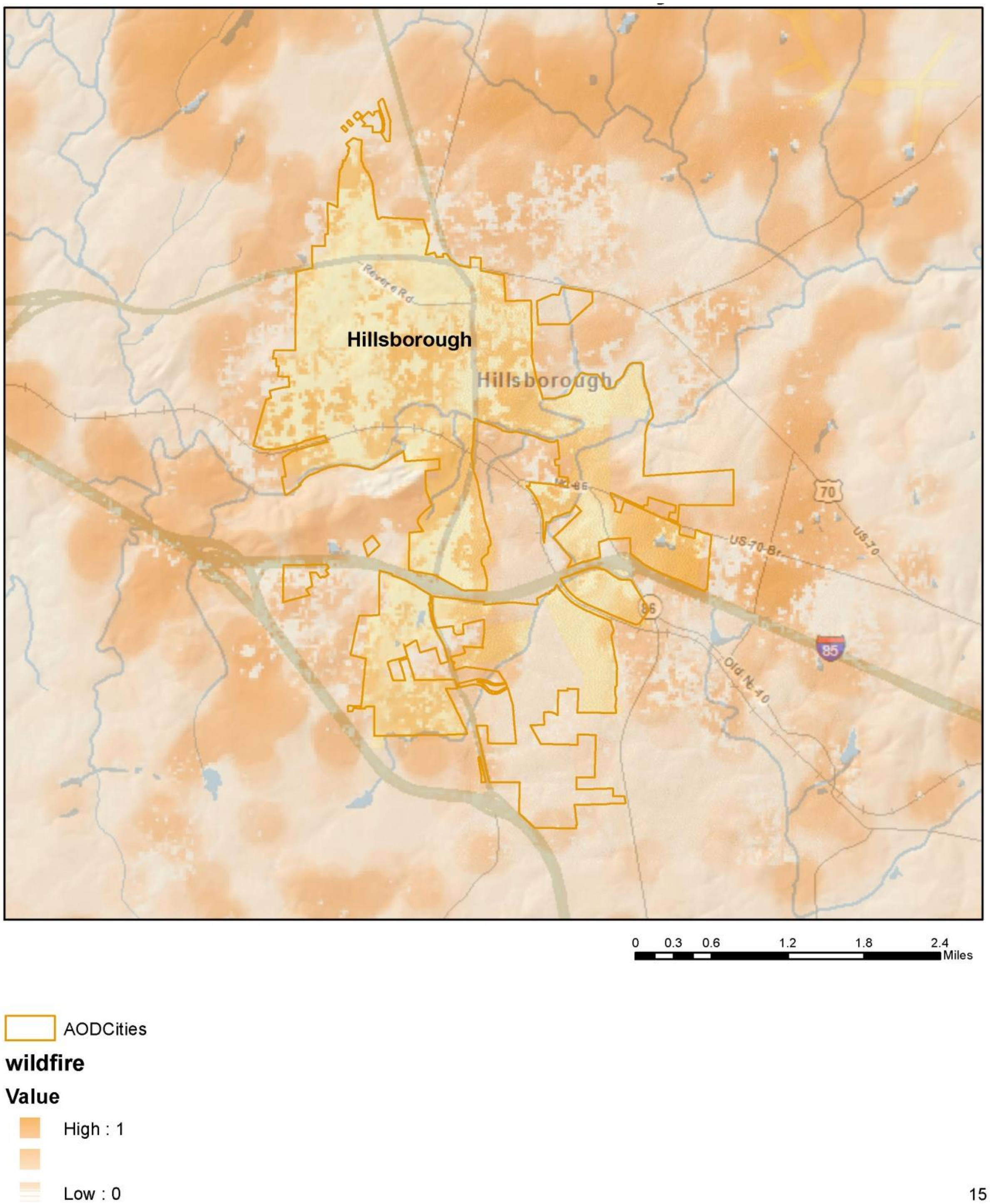


Figure 4.45: Wildfire Hazard Areas in the Town of Hillsborough



Wildfire Hazard Vulnerability

The following tables provide counts and values by jurisdiction relevant to wildfire hazard vulnerability in the Eno-Haw Region.

Table 4.32: Exposure to Wildfire High Hazard Areas

Jurisdiction	Number of Developed Parcels At Risk		Number of Undeveloped Parcels At Risk		Number of Buildings At Risk		Value of Buildings At Risk	Population At Risk		Elderly Population At Risk		Children At Risk	
	Num	Per	Num	Per	Num	Per		Num	Per	Num	Per	Num	Per
Alamance County (Unincorporated)	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**$0**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
Alamance	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Burlington	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Elon	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Graham	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Green Level	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Haw River	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Mebane	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Ossipee	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Swepsonville	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Subtotal Alamance	*0*	*0.0%*	*0*	*0.0%*	*0*	*0.0%*	*$0*	*0*	*0.0%*	*0*	*0.0%*	*0*	*0.0%*
Orange County (Unincorporated)	**26**	**0.1%**	**184**	**0.7%**	**130**	**0.4%**	**$14,515,795**	**274**	**0.5%**	**30**	**0.5%**	**13**	**0.5%**
Carrboro	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Chapel Hill	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Hillsborough	0	0.0%	0	0.0%	0	0.3%	$0	0	0.0%	0	0.0%	0	0.0%
Subtotal Orange	*26*	*0.1%*	*184*	*0.4%*	*130*	*0.0%*	*$14,515,795*	*274*	*0.2%*	*30*	*0.2%*	*13*	*0.2%*
Durham County (Unincorporated)	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**$0**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
Durham	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Subtotal Durham	*0*	*0.0%*	*0*	*0.0%*	*0*	*0.0%*	*$0*	*0*	*0.0%*	*0*	*0.0%*	*0*	*0.0%*
TOTAL ENO-HAW	**26**	**0.01%**	**184**	**0.1%**	**130**	**0.1**	**$14,515,795**	**274**	**0.0%**	**30**	**0.0%**	**13**	**0.0%**

Table 4.33: Exposure to Wildfire Moderate Hazard Areas

Jurisdiction	Number of Developed Parcels At Risk		Number of Undeveloped Parcels At Risk		Number of Buildings At Risk		Value of Buildings At Risk	Population At Risk		Elderly Population At Risk		Children At Risk	
	Num	Per	Num	Per	Num	Per		Num	Per	Num	Per	Num	Per
Alamance County (Unincorporated)	**714**	**2.2%**	**215**	**0.7%**	**925**	**2.2%**	**$119,973,287**	**1,727**	**2.9%**	**271**	**3.2%**	**100**	**3.0%**
Alamance	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Burlington	1	0.0%	12	0.1%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Elon	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Graham	6	0.1%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Green Level	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Haw River	13	1.2%	0	0.0%	8	0.5%	$4,075,072	12	0.5%	2	0.6%	1	0.4%
Mebane	171	3.4%	230	4.5%	144	3.6%	$106,171,352	301	2.6%	33	2.5%	23	2.7%
Ossipee	5	1.8%	3	1.1%	3	0.8%	$402,012	0	0.0%	0	0.0%	0	0.0%
Swepsonville	0	0.0%	2	0.3%	5	0.8%	$636,251	12	1.1%	2	1.0%	1	1.4%
Subtotal Alamance	*910*	*1.3%*	*262*	*0.7%*	*1,085*	*1.3%*	*$231,257,974*	*2,053*	*1.4%*	*308*	*1.4%*	*125*	*1.3%*
Orange County (Unincorporated)	**2,100**	**7.4%**	**851**	**3.0%**	**2,363**	**8.2%**	**$225,430,321**	**4,155**	**8.2%**	**449**	**7.7%**	**199**	**6.8%**
Carrboro	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Chapel Hill	0	0.0%	0	0.0%	0	0.0%	$0	0	0.0%	0	0.0%	0	0.0%
Hillsborough	227	7.9%	59	2.1%	136	4.8%	$36,998,046	234	3.8%	29	3.8%	17	3.8%
Subtotal Orange	*2,327*	*4.7%*	*910*	*1.8%*	*2,499*	*4.9%*	*$262,428,367*	*4,389*	*3.3%*	*478*	*3.7%*	*216*	*3.1%*
Durham County (Unincorporated)	**709**	**3.2%**	**176**	**0.8%**	**862**	**3.5%**	**$165,903,998**	**1,267**	**3.2%**	**134**	**2.2%**	**91**	**4.1%**
Durham	267	0.3%	33	0.0%	229	0.3%	$127,761,218	489	0.2%	43	0.2%	38	0.2%
Subtotal Durham	*976*	*1.0%*	*209*	*0.2%*	*1,091*	*1.0%*	*$293,665,216*	*1,756*	*0.7%*	*177*	*0.7%*	*129*	*0.7%*
TOTAL ENO-HAW	**4,213**	**1.9%**	**1,581**	**0.7%**	**4,675**	**2.0%**	**$787,351,557**	**8,198**	**1.5%**	**963**	**1.6%**	**470**	**1.3%**

4.6 Conclusions on Hazard Risk

Based on consensus of the Hazard Mitigation Planning Team, primarily at the third HMPT meeting, in addition to the results presented in this *Risk Assessment*, the hazards addressed in this plan have been ranked according to the following prioritized list:

High Risk Hazards
- Flood
- Winter Weather
- Hurricane and Tropical Storm

Moderate Risk Hazards
- Drought/Extreme Heat
- Thunderstorm, Lightning, and Hail
- Dam/Levee Failure
- Tornado

Low Risk Hazards
- Wildfire
- Earthquake
- Landslide

The HMPT has agreed to focus on the high and moderate risk hazards identified above for purposes of mitigation strategy development. The list above is also consistent with Annualized Loss Estimates (ALEs) calculated for the planning area which point to four of the same hazards, although in a slightly different order:

- Hurricane and Tropical Storm
- Flood
- Tornado
- Thunderstorm, Lightning, and Hail

In addition to the results presented throughout this *Risk Assessment*, the annualized losses presented in **Table 4.34** and summarized above further help substantiate the priority ranking stated here in these conclusions on hazard risk.

Table 4.34: Annualized Loss Estimates (ALEs) by Hazard by Jurisdiction

Jurisdiction	Flood	Dam/Levee Failure	Drought/ Extreme Heat	Thunderstorm, Lightning, and Hail	Tornado	Winter Weather	Hurricane and Tropical Storm	Landslide	Earthquake	Wildfire
Alamance County	**$26,316**	**NA**	**Neg**	**$7,585**	**$15,846**	**Neg**	**$158,078,947**	**NA**	**NA**	**NA**
Alamance	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Burlington	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Elon	Neg	NA	NA	$5,123	NA	NA	NA	NA	NA	NA
Graham	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Green Level	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Haw River	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Mebane	$73,684	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Ossipee	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Swepsonville	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Subtotal Alamance	*$100,000*	*NA*	*Neg*	*$12,708*	*$15,846*	*Neg*	*$158,078,947*	*NA*	*NA*	*NA*
Orange County	**$8,421**	**NA**	**Neg**	**Neg**	**Neg**	**Neg**	**Neg**	**NA**	**NA**	**NA**
Carrboro	Neg	NA	NA	Neg	Neg	NA	NA	NA	NA	NA
Chapel Hill	$552,632	NA	NA	$37,931	NA	NA	NA	NA	NA	NA
Hillsborough	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Subtotal Orange	*$561,053*	*NA*	*Neg*	*$37,931*	*Neg*	*Neg*	*Neg*	*NA*	*NA*	*NA*
Durham County	**$8,421**	**NA**	**Neg**	**$6,892**	**$436,538**	**Neg**	**$10,789**	**NA**	**NA**	**NA**
Durham	Neg	NA	NA	Neg	NA	NA	NA	NA	NA	NA
Subtotal Durham	*$8,421*	*NA*	*Neg*	*$6,892*	*$436,538*	*Neg*	*$10,789*	*NA*	*NA*	*NA*
Total Eno-Haw	**$669,474**	**NA**	**Neg**	**$57,531**	**$452,384**	**Neg**	**$158,089,736**	**NA**	**NA**	**NA**

"Neg" = "Negligible" which indicates that historical losses were less than $5,000.
"NA" = "Not Applicable" which indicates that an ALE is only applicable at the county level or that historical losses were unavailable.

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