Annex J
Town of Wake Forest

This annex includes jurisdiction-specific information for the Town of Wake Forest. It consists of the following five subsections:

- J.1 Town of Wake Forest Community Profile
- J.2 Town of Wake Forest Risk Assessment
- J.3 Town of Wake Forest Vulnerability Assessment
- J.4 Town of Wake Forest Capability Assessment
- J.5 Town of Wake Forest Mitigation Strategy

J.1 TOWN OF WAKE FOREST COMMUNITY PROFILE

J.1.1 Geography and the Environment

Wake Forest is town located in Wake County in the state of North Carolina. It was incorporated in 1880 and was originally named for the college that was opened in the 19th century. Although the college later moved to Winston-Salem, the town remains one of the fastest growing suburbs in the country.

Overall, Wake County is known as one of three counties that comprise the Research Triangle metropolitan region, so named for the Research Triangle Park (RTP) which encompasses the three major metropolitan areas of Chapel-Hill, Durham, and Raleigh. Each of these metropolitan areas is home to a major research university (UNC-Chapel Hill, Duke, and NC State University, respectively) and RTP draws on these universities for its workforce. The Research Triangle Park is a hub of high-tech and biotech research and is a defining feature of the economy in Wake County.

Summer temperatures generally venture into the 90s for highs and cool off to the 70s at night. Winter temperatures in can drop to below freezing but generally highs are in the 50s. Rainfall is most common in the summer months but occurs consistently throughout the year.

J.1.2 Population and Demographics

According to the 2010 Census, Wake Forest has a population of 30,117 people. The jurisdiction has seen exceptional growth between 2000 and 2010, and the population density is almost 2,200 people per square mile. Population counts from the US Census Bureau for 1990, 2000, and 2010 are presented in **Table J.1**.

TABLE J.1: POPULATION COUNTS FOR WAKE FOREST

Jurisdiction	1990 Census Population	2000 Census Population	2010 Census Population	% Change 2000-2010
WAKE FOREST	5,769	12,588	30,117	139.25%

Source: US Census Bureau

The racial characteristics of the jurisdiction are presented in **Table J.2**. Whites make up the majority of the population in the jurisdiction, accounting for nearly 80 percent of the population.

TABLE J.2: DEMOGRAPHICS OF WAKE FOREST

Jurisdiction	White Persons, Percent (2010)	Black Persons, Percent (2010)	American Indian or Alaska Native, Percent (2010)	Other Race, Percent (2010)	Persons of Hispanic Origin, Percent (2010)*
WAKE FOREST	77.3%	15.3%	0.4%	7.0%	5.1%

*Hispanics may be of any race, so also are included in applicable race categories
Source: US Census Bureau

J.1.3 Housing

According to the 2010 US Census, there are 11,370 housing units in Wake Forest, the majority of which are single family homes or mobile homes. Housing information for the jurisdiction is presented in **Table J.3**.

TABLE J.3: HOUSING CHARACTERISTICS

Jurisdiction	Housing Units (2000)	Housing Units (2010)	Seasonal Units, Percent (2010)	Median Home Value (2006-2010)
WAKE FOREST	5,091	11,370	7.5%	$255,500

Source: US Census Bureau

J.1.4 Infrastructure

Transportation

There are several major roadways that residents of Wake Forest utilize. The most prominent is Interstate 40 which runs through the county on an east-west track. It has two spurs, one of which is I-540/NC-540 which is a partly completed loop that connects the jurisdiction to many of the other municipalities. In addition to the Interstate, there are many major highways that residents of the municipality utilize. Federal highways of note are US-1, US-64, US-264, US-70, and US-401, while state highways in the include NC-39, NC-42, NC-50, NC-54, NC-55, NC-96, NC-98, and NC-231.

In terms of other transportation services, Raleigh-Durham International Airport (RDU) is one of the largest airports in the state and serves more than 35 international and domestic locations and over 9 million passengers a year. Wake County is also home to two Amtrak railway facilities, located in Raleigh and Cary. The Triangle Transit authority operates a bus system that connects Raleigh, Durham, and Chapel-Hill and there are also several intra-county bus lines that provide service between Wake County municipalities.

Utilities

Electrical power in the jurisdiction is provided by two entities and Duke Energy and Wake Electric Membership Corporation with Duke Energy providing service to a majority of the service. Water and sewer service is provided by two main entities as well: The City of Raleigh Public Utilities and Western Wake Partners. Natural gas is provided by PSNC Energy.

Community Facilities

There are a number of buildings and community facilities located throughout Wake Forest. According to the data collected for the vulnerability assessment (Section 6.4.1), there are 4 fire stations, 4 police stations, and 8 public schools located within the county. There is one medical care facility located in the municipality

Citizens also have access to several parks, including three state parks: Falls Lake State Recreation Area, William B. Umstead State Park, and Jordan Lake State Recreation Area. There are also a number of county and municipal parks located throughout the county, including the American Tobacco Trail which is a rails to trails project that is open to a wide variety of non-motorized uses.

J.1.5 Land Use

Much of Wake County is developed and relatively urbanized. However, there are some areas that are more sparsely developed, sometimes due to the conservation of land as parks. There are many incorporated municipalities located throughout the study area, and these areas are where the region's population is generally concentrated. The incorporated areas are also where many businesses, commercial uses, and institutional uses are located. Land uses in the balance of the jurisdiction consist of a variety of types of residential, commercial, industrial, government, and recreational uses. Local land use and associated regulations are further discussed in *Section 7: Capability Assessment.*

J.1.6 Employment and Industry

According to the North Carolina Employment Security Commission, in 2012 (the last full year with data available), Wake County had an average annual employment of 453,415 workers. The Retail Trade industry employed 11.4% of the County's workforce followed by Health Care and Social Assistance (10.5%); Professional and Technical Services (9.3%); and Accommodation and Food Services (9.2%). In 2012, the projected median household income was $60,412 compared to $42,941 for the state of North Carolina in 2011 (2012 numbers were not available).

J.2 TOWN OF WAKE FOREST RISK ASSESSMENT

This subsection includes hazard profiles for each of the significant hazards identified in Section 4: *Hazard Identification* as they pertain to Wake Forest. Each hazard profile includes a description of the hazard's location and extent, notable historical occurrences, and the probability of future occurrences. Additional information can be found in Section 5: *Hazard Profiles*.

J.2.1 Drought

Location and Spatial Extent

Drought typically covers a large area and cannot be confined to any geographic or political boundaries. According to the Palmer Drought Severity Index, Wake Forest has a relatively low risk for drought hazard. However, local areas may experience much more severe and/or frequent drought events than what is represented on the Palmer Drought Severity Index map. Furthermore, it is assumed that the county would be uniformly exposed to drought, making the spatial extent potentially widespread. It is also notable that drought conditions typically do not cause significant damage to the built environment.

Historical Occurrences

According to the North Carolina Drought Monitor, Wake Forest has had drought occurrences all of the last fourteen years (2000-2013). **Table J.4** shows the most severe drought classification for each year, according to North Carolina Drought Monitor classifications.

TABLE J.4: HISTORICAL DROUGHT OCCURRENCES IN WAKE FOREST

Abnormally Dry **Moderate Drought** **Severe Drought** **Extreme Drought** **Exceptional Drought**

	Wake Forest
2000	MODERATE
2001	SEVERE
2002	**EXCEPTIONAL**
2003	ABNORMAL
2004	ABNORMAL
2005	SEVERE
2006	SEVERE
2007	**EXCEPTIONAL**
2008	**EXCEPTIONAL**
2009	MODERATE
2010	SEVERE
2011	SEVERE
2012	MODERATE
2013	MODERATE

Source: North Carolina Drought Monitor

Probability of Future Occurrences

Based on historical occurrence information, it is assumed that Wake Forest has a probability level of likely (10-100 percent annual probability) for future drought events. This hazard may vary slightly by location but each area has an equal probability of experiencing a drought. However, historical information also indicates that there is a much lower probability for extreme, long-lasting drought conditions.

J.2.2 Extreme Heat

Location and Spatial Extent

Excessive heat typically impacts a large area and cannot be confined to any geographic or political boundaries. All of Wake Forest is susceptible to extreme heat conditions.

Historical Occurrences

Data from the National Climatic Data Center was used to determine historical extreme heat and heat wave events in Wake Forest. There were two events reported:

July 22, 1998 – *Excessive Heat* - Excessive heat plagued central North Carolina during July 22 through July 23. Maximum temperatures reached the 98 to 103 degree range combined with dew points in the 78 to 80 degree range with little wind to give heat index values of around 110 degrees.

August 22, 2007 – *Heat* - An athlete from Enloe High School running track collapsed from heat exhaustion and was sent to the hospital in critical condition. The student remained in the hospital in critical condition for several days.

In addition, information from the State Climate Office of North Carolina was reviewed to obtain historical temperature records in the region. Temperature information has been reported since 1898. The recorded maximum for Wake County was 107 degrees Fahrenheit in Raleigh at North Carolina State University in 2011.

The State Climate Office also reports average maximum temperatures in various locations in the county. The most centralized location is in Raleigh at North Carolina State University. **Table J.5** shows the average maximum temperatures from 1971 to 2000 at the North Carolina State University observation station which can be used as a general comparison for the region.

Table J.5: Average Maximum Temperature in Raleigh, Wake County

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Avg. Max (°F)	48.8	53.0	61.2	70.6	77.5	84.4	87.9	85.9	80.0	69.8	61.3	52.1

Source: State Climate Office of North Carolina

Probability of Future Occurrences

Based on historical occurrence information, it is assumed that all of Wake County has a probability level of likely (10 to 100 percent annual probability) for future extreme heat events to impact the region.

J.2.3 Hailstorm

Location and Spatial Extent

Hailstorms frequently accompany thunderstorms, so their locations and spatial extents coincide. It is assumed that Wake Forest is uniformly exposed to severe thunderstorms; therefore, all areas are equally exposed to hail which may be produced by such storms.

Historical Occurrences

According to the National Climatic Data Center, 8 recorded hailstorm events have affected Wake Forest since 1993.[1] **Table J.6** is a summary of the hail events in Wake Forest. **Table J.7** provides detailed information about each event that occurred. In all, hail occurrences resulted in $0 (2013 dollars) in property damages. Hail ranged in diameter from 0.75 inches to 1.75 inches. It should be noted that hail is notorious for causing substantial damage to cars, roofs, and other areas of the built environment that may not be reported to the National Climatic Data Center. Therefore, it is likely that damages are greater than the reported value.

Table J.6: Summary of Hail Occurrences in Wake Forest

Location	Number of Occurrences	Property Damage (2013)
Wake Forest	8	$0

[1] These hail events are only inclusive of those reported by the National Climatic Data Center (NCDC). It is likely that additional hail events have affected Wake Forest. In addition to NCDC, the North Carolina Department of Insurance office was contacted for information. As additional local data becomes available, this hazard profile will be amended.

Location	Number of Occurrences	Property Damage (2013)

Source: National Climatic Data Center

TABLE J.7: HISTORICAL HAIL OCCURRENCES IN WAKE FOREST

	Date	Magnitude	Deaths/Injuries	Property Damage*
Wake Forest				
WAKE FOREST	5/27/1996	0.75 in.	0/0	$0
WAKE FOREST	4/21/1997	0.75 in.	0/0	$0
WAKE FOREST	6/3/1998	1.25 in.	0/0	$0
WAKE FOREST	6/1/2002	0.75 in.	0/0	$0
WAKE FOREST	4/22/2006	1.75 in.	0/0	$0
WAKE FOREST	4/22/2006	1.75 in.	0/0	$0
WAKE FOREST	4/15/2007	0.88 in.	0/0	$0
WAKE FOREST	6/9/2007	0.88 in.	0/0	$0

*Property damage is reported in 2013 dollars; All damage may not have been reported.
Source: National Climatic Data Center

Probability of Future Occurrences

Based on historical occurrence information, it is assumed that the probability of future hail occurrences is likely (10 – 100 percent annual probability). Since hail is an atmospheric hazard (coinciding with thunderstorms), it is assumed that Wake Forest has equal exposure to this hazard. It can be expected that future hail events will continue to cause minor damage to property and vehicles throughout the county.

J.2.4 Hurricane and Tropical Storm

Location and Spatial Extent

Hurricanes and tropical storms threaten the entire Atlantic and Gulf seaboard of the United States. While coastal areas are most directly exposed to the brunt of landfalling storms, their impact is often felt hundreds of miles inland and they can affect Wake Forest. The entire jurisdiction is equally susceptible to hurricane and tropical storms.

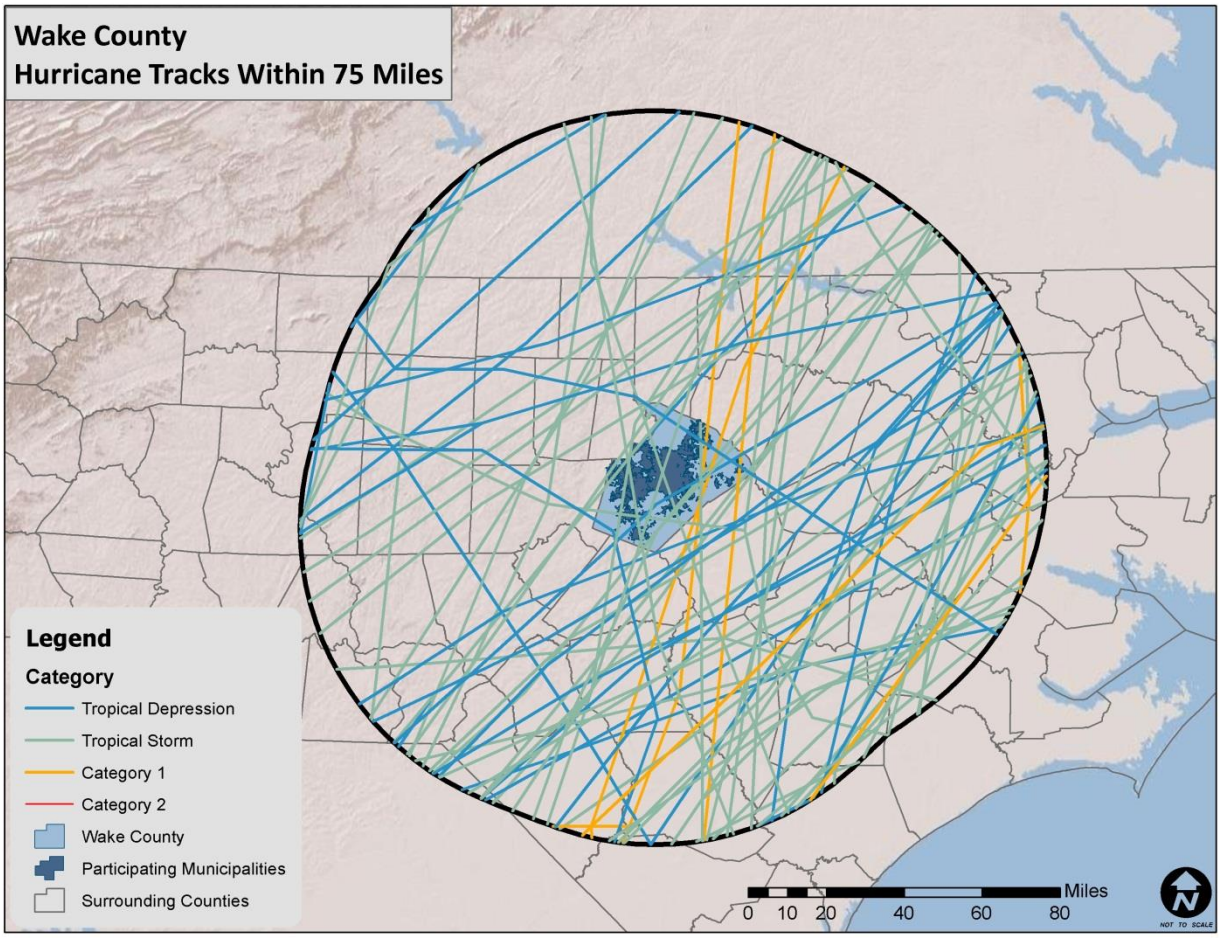
Historical Occurrences

According to the National Hurricane Center's historical storm track records, 87 hurricane or tropical storm tracks have passed within 75 miles of Wake County since 1850.[2] This includes eight hurricanes, fifty-five tropical storms, and twenty-four tropical depressions.

Of the recorded storm events, twenty-one storms have traversed directly through Wake County as shown in **Figure J.1**. **Table J.8** provides for each event the date of occurrence, name (if applicable), maximum wind speed (as recorded within 75 miles of Wake County) and Category of the storm based on the Saffir-Simpson Scale.

[2] These storm track statistics do not include extra-tropical storms. Though these related hazard events are less severe in intensity, they may cause significant local impact in terms of rainfall and high winds.

FIGURE J.1: HISTORICAL HURRICANE STORM TRACKS WITHIN 75 MILES OF WAKE COUNTY



Source: National Oceanic and Atmospheric Administration; National Hurricane Center

TABLE J.8: HISTORICAL STORM TRACKS WITHIN 75 MILES OF WAKE COUNTY (1850–2013)

Date of Occurrence	Storm Name	Maximum Wind Speed (miles per hour)	Storm Category
1851	NOT NAMED	35	Tropical Storm
1853	NOT NAMED	62	Tropical Storm
1854	NOT NAMED	57	Tropical Storm
1859	NOT NAMED	53	Tropical Storm
1859	NOT NAMED	35	Tropical Storm
1867	NOT NAMED	35	Tropical Storm
1873	XXXX873144	44	Tropical Storm
1873	NOT NAMED	44	Tropical Storm
1876	NOT NAMED	62	Tropical Storm
1877	NOT NAMED	48	Tropical Storm
1878	NOT NAMED	44	Tropical Storm
1878	NOT NAMED	79	Category 1
1882	NOT NAMED	53	Tropical Storm

Date of Occurrence	Storm Name	Maximum Wind Speed (miles per hour)	Storm Category
1883	NOT NAMED	44	Tropical Storm
1885	NOT NAMED	35	Tropical Storm
1886	NOT NAMED	31	Tropical Depression
1886	NOT NAMED	35	Tropical Storm
1886	NOT NAMED	53	Tropical Storm
1887	NOT NAMED	31	Tropical Depression
1888	NOT NAMED	31	Tropical Depression
1889	NOT NAMED	35	Tropical Storm
1891	NOT NAMED	35	Tropical Storm
1893	NOT NAMED	44	Tropical Storm
1893	NOT NAMED	70	Category 1
1893	NOT NAMED	31	Tropical Depression
1896	NOT NAMED	62	Tropical Storm
1899	NOT NAMED	66	Category 1
1902	NOT NAMED	35	Tropical Storm
1902	NOT NAMED	31	Tropical Depression
1904	NOT NAMED	48	Tropical Storm
1907	NOT NAMED	53	Tropical Storm
1911	NOT NAMED	22	Tropical Depression
1912	NOT NAMED	53	Tropical Storm
1913	NOT NAMED	57	Tropical Storm
1913	NOT NAMED	66	Category 1
1915	NOT NAMED	35	Tropical Storm
1916	NOT NAMED	31	Tropical Depression
1916	NOT NAMED	31	Tropical Depression
1920	NOT NAMED	31	Tropical Depression
1924	NOT NAMED	53	Tropical Storm
1927	NOT NAMED	44	Tropical Storm
1928	NOT NAMED	35	Tropical Storm
1928	NOT NAMED	40	Tropical Storm
1929	NOT NAMED	35	Tropical Storm
1935	NOT NAMED	53	Tropical Storm
1940	NOT NAMED	62	Tropical Storm
1944	NOT NAMED	48	Tropical Storm
1944	NOT NAMED	31	Tropical Depression
1945	NOT NAMED	35	Tropical Storm
1946	NOT NAMED	22	Tropical Depression
1947	NOT NAMED	22	Tropical Depression
1954	HAZEL	70	Category 1
1955	DIANE	53	Tropical Storm
1956	IVY	35	Tropical Storm
1959	CINDY	26	Tropical Depression

Date of Occurrence	Storm Name	Maximum Wind Speed (miles per hour)	Storm Category
1960	BRENDA	44	Tropical Storm
1961	UNNAMED	44	Tropical Storm
1964	CLEO	26	Tropical Depression
1965	UNNAMED	26	Tropical Depression
1968	CELESTE	31	Tropical Depression
1970	ALMA	22	Tropical Depression
1971	UNNAMED	40	Tropical Storm
1971	HEIDI	40	Tropical Storm
1972	AGNES	35	Tropical Storm
1976	SUBTROP:SUBTROP 3	35	Tropical Storm
1979	DAVID	35	Tropical Storm
1984	DIANA	40	Tropical Storm
1985	ONE-C	31	Tropical Depression
1985	BOB	26	Tropical Depression
1987	UNNAMED	53	Tropical Storm
1996	JOSEPHINE	44	Tropical Storm
1996	BERTHA	57	Tropical Storm
1996	FRAN	57	Tropical Storm
1997	DANNY	31	Tropical Depression
1998	EARL	66	Category 1
1999	DENNIS	31	Tropical Depression
1999	FLOYD*	66	Category 1
2000	GORDON	35	Tropical Storm
2000	HELENE	35	Tropical Storm
2003	NOT NAMED	57	Tropical Storm
2004	CHARLEY	79	Category 1
2004	GASTON	35	Tropical Storm
2004	JEANNE	31	Tropical Depression
2006	ALBERTO	35	Tropical Storm
2008	OMAR	26	Tropical Depression
2008	SIXTEEN	26	Tropical Depression
2008	HANNA	40	Tropical Storm

Source: National Hurricane Center

The National Climatic Data Center reported seven events associated with a hurricane or tropical storm in Wake Forest between 1950 and 2013. These storms are listed in **Table J.9** and are generally representative of storms with the greatest impact on the county over the time period.

TABLE J.9: HISTORICAL HURRICANE/TROPICAL STORM OCCURRENCES IN WAKE COUNTY

Date of Occurrence	Storm Name	Deaths/Injuries	Property Damage*
7/12/1996	Hurricane Bertha	0/0	$0
9/5/1996	Hurricane Fran	7/2	$0
8/27/1998	Hurricane Bonnie	0/0	$0

Date of Occurrence	Storm Name	Deaths/Injuries	Property Damage*
9/4/1999	Hurricane Dennis	0/0	$0
9/15/1999	Hurricane Floyd	0/0	$179,765,471
9/18/2003	Hurricane Isabel	1/0	$776,235
9/1/2006	Tropical Storm Ernesto	0/0	$0

*Property damage is reported in 2013 dollars; All damage may not have been reported.

Federal records also indicate that three disaster declarations were made in 1996 (Hurricane Fran), 1999 (Hurricane Floyd), and 2003 (Hurricane Isabel) for the county.[3]

Flooding and high winds are both hazards of concern with hurricane and tropical storm events in Wake County as evidenced by the difference in impacts caused by Hurricanes Fran and Floyd. Whereas Floyd's effects were primarily due to flooding, Fran's high winds caused damage throughout the county in conjunction with flooding impacts. Some anecdotal information is available for the major storms that have impacted the area as found below:

Tropical Storm Fran – September 5-6, 1996
After being saturated with rain just a few weeks earlier by Hurricane Bertha, Wake County was impacted by the one of the most devastating storms to ever make landfall along the Atlantic Coast. Fran dropped more than 10 inches of rain in many areas and had sustained winds of around 115 miles per hour as it hit the coast and began its path along the I-40 corridor towards Wake County. In the end, over 900 million dollars in damages to residential and commercial property and at least 1 death were reported in Wake County alone. Damages to infrastructure and agriculture added to the overall toll and more than 1.7 million people in the state were left without power.

Hurricane Floyd – September 16-17, 1999
Much like Hurricane Fran, Hurricane Floyd hit the North Carolina coast just 10 days after Tropical Storm Dennis dropped more than 10 inches of rain in many areas of the state. As a result, the ground was heavily saturated when Floyd dumped an additional 15 to 20 inches in some areas. Although much of the heavy damage from the storm was found further east, Wake County suffered significant damage from the storm. Across the state more than 6 billion dollars in property damage was recorded and agricultural impacts were extremely high.

Probability of Future Occurrences

Given the inland location of the jurisdiction, it is less likely to be affected by a hurricane or tropical storm system than counties closer to the coast. However, given its location in the eastern part of the state, hurricanes and tropical storms still remain a real threat to Wake Forest. Based on historical evidence, the probability level of future occurrence is likely (annual probability between 10 and 100 percent). Given the regional nature of the hazard, all areas are equally exposed to this hazard. When the jurisdiction is impacted, the damage could be catastrophic, threatening lives and property throughout the planning area.

[3] A complete listing of historical disaster declarations can be found in Section 4: *Hazard Identification*.

J.2.5 Lightning

Location and Spatial Extent

Lightning occurs randomly, therefore it is impossible to predict where and with what frequency it will strike. It is assumed that all of Wake Forest is uniformly exposed to lightning.

Historical Occurrences

According to the National Climatic Data Center, there has been one recorded lightning event in Wake Forest since 1950, as listed in summary **Table J.10** and detailed in **Table J.11**.[4] However, it is certain that more lightning events have in fact impacted the jurisdiction. Many of the reported events are those that caused damage, and it should be expected that damages are likely much higher for this hazard than what is reported.

TABLE J.10: SUMMARY OF LIGHTNING OCCURRENCES IN WAKE FOREST

Location	Number of Occurrences	Deaths/Injuries	Property Damage (2013)
Wake Forest	1	0/0	$55,838

Source: National Climatic Data Center

TABLE J.11: HISTORICAL LIGHTNING OCCURRENCES IN WAKE FOREST

	Date	Deaths/Injuries	Property Damage*	Details
Wake Forest				
WAKE FOREST	1/16/1998	0/0	$55,838	Lightning struck a brick house on Seawell Drive in Wake Forest about 20 miles northeast of Raleigh during the early afternoon. The lightning bolt hit the chimney of the new two story house, and the current ran throughout the house's wiring and into one of the bedrooms. Most of the damage was to the roof and in the bedroom. Flying debris and brick knocked holes in the walls, and bricks from the chimney were found 105 feet away in a neighbor's yard.

*Property damage is reported in 2013 dollars; All damage may not have been reported.
Source: National Climatic Data Center

[4] These lightning events are only inclusive of those reported by the National Climatic Data Center (NCDC). It is certain that additional lightning events have occurred in Wake Forest. The State Fire Marshall's office was also contacted for additional information but none could be provided. As additional local data becomes available, this hazard profile will be amended.

Probability of Future Occurrences

Although there were not a high number of historical lightning events reported in Wake Forest via NCDC data, it is a regular occurrence accompanied by thunderstorms. In fact, lightning events will assuredly happen on an annual basis, though not all events will cause damage. According to Vaisala's U.S. National Lightning Detection Network (NLDN®), Wake Forest is located in an area of the country that experienced an average of 4 to 5 lightning flashes per square kilometer per year between 1997 and 2010. Therefore, the probability of future events is highly likely (100 percent annual probability). It can be expected that future lightning events will continue to threaten life and cause minor property damages throughout the jurisdiction.

J.2.6 Severe Thunderstorm/High Wind

Location and Spatial Extent

A wind event is an atmospheric hazard, and thus has no geographic boundaries. It is typically a widespread event that can occur in all regions of the United States. However, thunderstorms are most common in the central and southern states because atmospheric conditions in those regions are favorable for generating these powerful storms. Also, Wake Forest typically experiences several straight-line wind events each year. These wind events can and have caused significant damage. It is assumed that Wake Forest has uniform exposure to an event and the spatial extent of an impact could be large.

Historical Occurrences

Severe storms were at least partially responsible for three disaster declarations in Wake County in 1988, 1998, and 2011.[5] According to NCDC, there have been 5 reported thunderstorm/high wind events since 1994 for high wind and since 1950 for thunderstorms.[6] These events caused $0 (2013 dollars) in damages. **Table J.12** summarizes this information. **Table J.13** presents detailed high wind and thunderstorm wind event reports including date, magnitude, and associated damages for each event.[7]

TABLE J. 12: SUMMARY OF THUNDERSTORM/HIGH WIND OCCURRENCES IN WAKE FOREST

Location	Number of Occurrences	Deaths/Injuries	Property Damage (2013 dollars)
Wake Forest	5	0/0	$0

Source: National Climatic Data Center

TABLE J.13: HISTORICAL THUNDERSTORM/HIGH WIND OCCURRENCES IN WAKE FOREST

	Date	Type	Magnitude	Deaths/ Injuries	Property Damage*
Wake Forest					
WAKE FOREST	1/19/1996	TSTM WIND	0 kts.	0/0	$0
WAKE	3/5/1997	TSTM WIND	50 kts.	0/0	$0

[5] A complete listing of historical disaster declarations can be found in Section 4: *Hazard Profiles*.

[6] These thunderstorm events are only inclusive of those reported by the National Climatic Data Center (NCDC). It is certain that additional thunderstorm events have occurred in Wake Forest. As additional local data becomes available, this hazard profile will be amended.

[7] The dollar amount of damages provided by NCDC is divided by the number of affected counties to reflect a damage estimate for the county.

	Date	Type	Magnitude	Deaths/ Injuries	Property Damage*
FOREST/ZEBULON					
WAKE FOREST	8/14/1999	TSTM WIND	0 kts.	0/0	$0
WAKE FOREST	6/11/2004	TSTM WIND	50 kts.	0/0	$0
WAKE FOREST	7/1/2012	THUNDERSTORM WIND	50 kts.	0/0	$0

*Property damage is reported in 2013 dollars; All damage may not have been reported.
Source: National Climatic Data Center

Probability of Future Occurrences

Given the high number of previous events, it is certain that wind events, including straight-line wind and thunderstorm wind, will occur in the future. This results in a probability level of highly likely (100 percent annual probability) for future wind events for the entire jurisdiction.

J.2.7 Tornado

Location and Spatial Extent

Tornadoes occur throughout the state of North Carolina, and thus in Wake Forest. Tornadoes typically impact a relatively small area, but damage may be extensive. Event locations are completely random and it is not possible to predict specific areas that are more susceptible to tornado strikes over time. Therefore, it is assumed that Wake Forest is uniformly exposed to this hazard.

Historical Occurrences

Tornadoes are becoming a more and more common occurrence in central and eastern North Carolina as demonstrated by a recent outbreak of tornadoes in the spring of 2011. According to the National Climatic Data Center, there have been no recorded tornado events in Wake Forest since 1956 (**Table J.14**), resulting in $0 (2013 dollars) in property damages.[8] Detailed information on these events can be found in **Table J.15**. Although no events were reported, an F5 event is possible. It is important to note that only tornadoes that have been reported are factored into this risk assessment. It is likely that a high number of occurrences have gone unreported over the past 50 years.

TABLE J.14: SUMMARY OF TORNADO OCCURRENCES IN WAKE FOREST

Location	Number of Occurrences	Deaths/Injuries	Property Damage (2013)
Wake Forest	0	0/0	$0

Source: National Climatic Data Center

TABLE J.15: HISTORICAL TORNADO IMPACTS IN WAKE FOREST

	Date	Magnitude	Deaths/ Injuries	Property Damage*	Details
Wake Forest					
None reported					

[8] These tornado events are only inclusive of those reported by the National Climatic Data Center (NCDC). It is likely that additional tornadoes have occurred in Wake Forest. As additional local data becomes available, this hazard profile will be amended.

	Date	Magnitude	Deaths/ Injuries	Property Damage*	Details

*Property Damage is reported in 2013 dollars.
Source: NCDC

2011 Tornadoes- April 16, 2011
In 2011, the county and all of its jurisdictions were impacted by one of the worst tornado-related events in the county's recorded history. A squall line descended the Blue Ridge by the late morning hours, and rapidly intensified |as it moved east into the central Piedmont of North Carolina, with four long live tornadic supercells evolving from the linear convective segment. These tornadic supercells went on to produce 9 tornadoes in the Raleigh CWA, including 2 EF3s, and 4 EF2s. The tornadoes left 6 dead with approximately 275 injuries.

Probability of Future Occurrences
According to historical information, tornado events are not an annual occurrence for the jurisdiction. However, tornadoes are a somewhat common occurrence in the county as it is located in an area of relatively flat topography in the southeastern United States. While the majority of the reported tornado events are small in terms of size, intensity, and duration, they do pose a significant threat should Wake Forest experience a direct tornado strike. The probability of future tornado occurrences affecting Wake Forest is likely (10-100 percent annual probability).

J.2.8 Winter Storm and Freeze

Location and Spatial Extent
Nearly the entire continental United States is susceptible to winter storm and freeze events. Some ice and winter storms may be large enough to affect several states, while others might affect limited, localized areas. The degree of exposure typically depends on the normal expected severity of local winter weather. Wake Forest is accustomed to smaller scale severe winter weather conditions and often receives severe winter weather during the winter months. Given the atmospheric nature of the hazard, the entire jurisdiction has uniform exposure to a winter storm.

Historical Occurrences
Severe winter weather has resulted in six disaster declarations in Wake Forest. This includes ice storms in 1968 and 2002, snow storms in 1977, 1993, and 1996, and a severe winter storm in 2000. [9] According to the National Climatic Data Center, there have been no recorded winter storm events in Wake Forest since 1993 (**Table J.16**).[10] These events resulted in $0 (2013 dollars) in damages. However, there have been 28 recorded countywide events and most severe winter weather events are only recorded at the county level.

TABLE J.16: SUMMARY OF WINTER STORM EVENTS IN WAKE FOREST

Location	Number of Occurrences	Deaths/Injuries	Property Damage (2013)
Wake Forest	0	0/0	$0

Source: National Climatic Data Center

[9] A complete listing of historical disaster declarations can be found in Section 4: *Hazard Profiles*.
[10] These ice and winter storm events are only inclusive of those reported by the National Climatic Data Center (NCDC). It is certain that additional winter storm conditions have affected Wake Forest.

There have been several severe winter weather events in Wake Forest. The text below describes one of the major events and associated impacts on the county. Similar impacted can be expected with severe winter weather.

1996 Winter Storm
This storm left two feet of snow and several thousand citizens without power for up to nine days. Although shelters were opened, some roads were impassible for up to four days. This event caused considerable disruption to business, industry, schools, and government services.

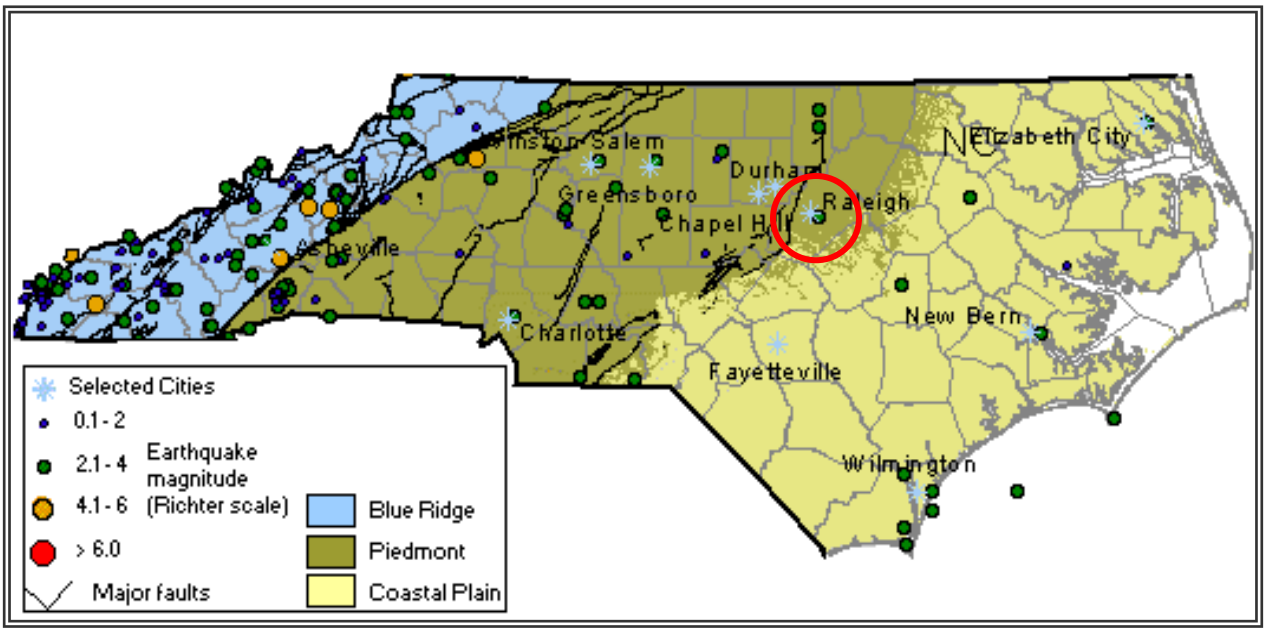
Winter storms throughout the planning area have several negative externalities including hypothermia, cost of snow and debris cleanup, business and government service interruption, traffic accidents, and power outages. Furthermore, citizens may resort to using inappropriate heating devices that could to fire or an accumulation of toxic fumes.

Probability of Future Occurrences
Winter storm events will remain a somewhat regular occurrence in Wake Forest due to location and latitude. According to historical information, Wake County experiences an average of 1-2 winter storm events each year. Therefore, the annual probability is likely (10-100 percent).

J.2.9 Earthquake

Location and Spatial Extent
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 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. **Figure J.2** is a map showing geological and seismic information for North Carolina.

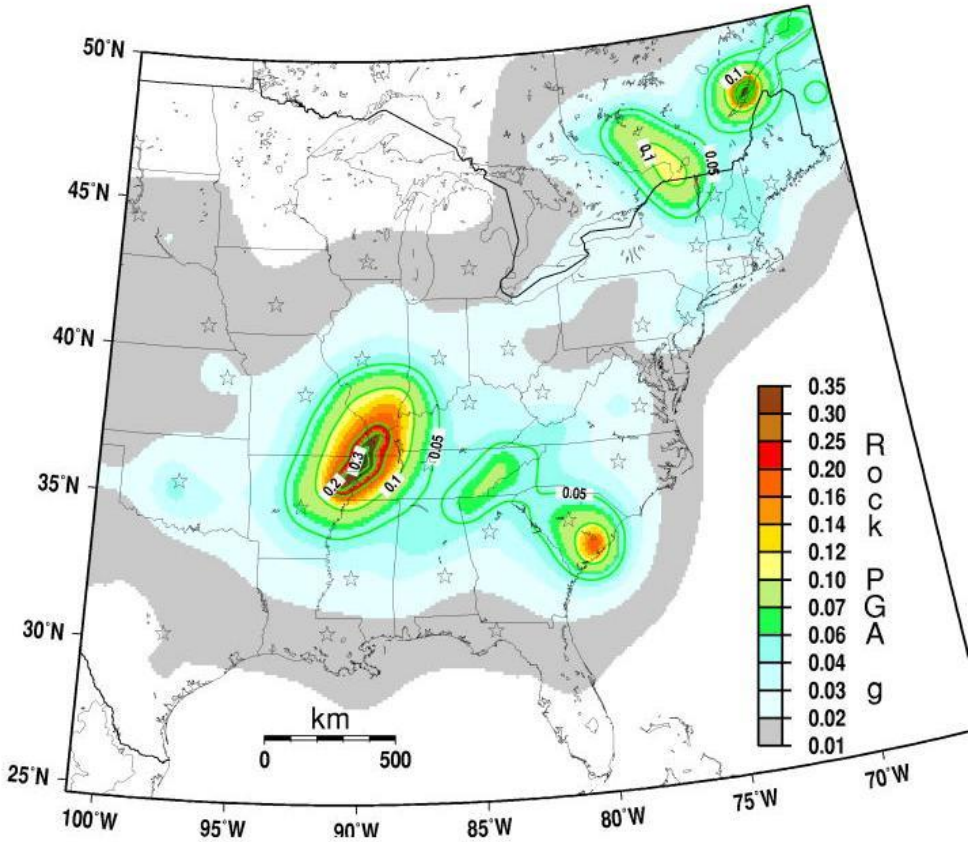
FIGURE J.2: GEOLOGICAL AND SEISMIC INFORMATION FOR NORTH CAROLINA



Source: North Carolina Geological Survey

Figure J.3 shows the intensity level associated with Wake Forest, based on the national USGS map of peak acceleration with 10 percent probability of exceedance in 50 years. It is the probability that ground motion will reach a certain level during an earthquake. The data show peak horizontal ground acceleration (the fastest measured change in speed, for a particle at ground level that is moving horizontally due to an earthquake) with a 10 percent probability of exceedance in 50 years. The map was compiled by the U.S. Geological Survey (USGS) Geologic Hazards Team, which conducts global investigations of earthquake, geomagnetic, and landslide hazards. According to this map, Wake Forest lies within an approximate zone of level "2" to "3" ground acceleration. This indicates that the county exists within an area of moderate seismic risk.

FIGURE J.3: PEAK ACCELERATION WITH 10 PERCENT PROBABILITY OF EXCEEDANCE IN 50 YEARS



Source: USGS, 2008

Historical Occurrences

Although no earthquakes are known to have occurred directly in Wake Forest since 1874, several have occurred in the county and affected the municipality. The strongest of these measured a VIII on the Modified Mercalli Intensity (MMI) scale. **Table J.17** provides a summary of earthquake events reported by the National Geophysical Data Center between 1638 and 1985. **Table J.18** presents a detailed occurrence of each event including the date, distance for the epicenter, and Modified Mercalli Intensity (if known).[11]

TABLE J.17: SUMMARY OF SEISMIC ACTIVITY IN WAKE FOREST

Location	Number of Occurrences	Greatest MMI Reported	Richter Scale Equivalent
Wake Forest	--	--	--

Source: National Geophysical Data Center

[11] Due to reporting mechanisms, not all earthquakes events were recorded during this time. Furthermore, some are missing data, such as the epicenter location, due to a lack of widely used technology. In these instances, a value of "unknown" is reported.

TABLE J.18: SIGNIFICANT SEISMIC EVENTS IN WAKE FOREST (1638 -1985)

Location	Date	Epicentral Distance (km)	Magnitude	MMI (magnitude)
Wake Forest				
None reported				

Source: National Geophysical Data Center

In addition to those earthquakes specifically affecting Wake Forest, a list of earthquakes that have caused damage throughout North Carolina is presented below in **Table J.19.**

TABLE J.19: EARTHQUAKES WHICH HAVE CAUSED DAMAGE IN NORTH CAROLINA

Date	Location	Richter Scale (Magnitude)	MMI (Intensity)	MMI in North Carolina
12/16/1811 - 1	NE Arkansas	8.5	XI	VI
12/16/1811 - 2	NE Arkansas	8.0	X	VI
12/18/1811 - 3	NE Arkansas	8.0	X	VI
01/23/1812	New Madrid, MO	8.4	XI	VI
02/071812	New Madrid, MO	8.7	XII	VI
04/29/1852	Wytheville, VA	5.0	VI	VI
08/31/1861	Wilkesboro, NC	5.1	VII	VII
12/23/1875	Central Virginia	5.0	VII	VI
08/31/1886	Charleston, SC	7.3	X	VII
05/31/1897	Giles County, VA	5.8	VIII	VI
01/01/1913	Union County, SC	4.8	VII	VI
02/21/1916*	Asheville, NC	5.5	VII	VII
07/08/1926	Mitchell County, NC	5.2	VII	VII
11/03/1928*	Newport, TN	4.5	VI	VI
05/13/1957	McDowell County, NC	4.1	VI	VI
07/02/1957*	Buncombe County, NC	3.7	VI	VI
11/24/1957*	Jackson County, NC	4.0	VI	VI
10/27/1959 **	Chesterfield, SC	4.0	VI	VI
07/13/1971	Newry, SC	3.8	VI	VI
11/30/1973*	Alcoa, TN	4.6	VI	VI
11/13/1976	Southwest Virginia	4.1	VI	VI
05/05/1981	Henderson County, NC	3.5	VI	VI

*This event is accounted for in the Wake Forest occurrences.
** Conflicting reports on this event, intensity in North Carolina could have been either V or VI
Source: This information compiled by Dr. Kenneth B. Taylor and provided by Tiawana Ramsey of NCEM. Information was compiled from the National Earthquake Center, Earthquakes of the US by Carl von Hake (1983), and a compilation of newspaper reports in the Eastern Tennessee Seismic Zone compiled by Arch Johnston, CERI, Memphis State University (1983).

Probability of Future Occurrences

The probability of significant, damaging earthquake events affecting Wake Forest is unlikely. However, it is possible that future earthquakes resulting in light to moderate perceived shaking and damages ranging from none to very light will affect the county. The annual probability level for the county is estimated between 1 and 10 percent (possible).

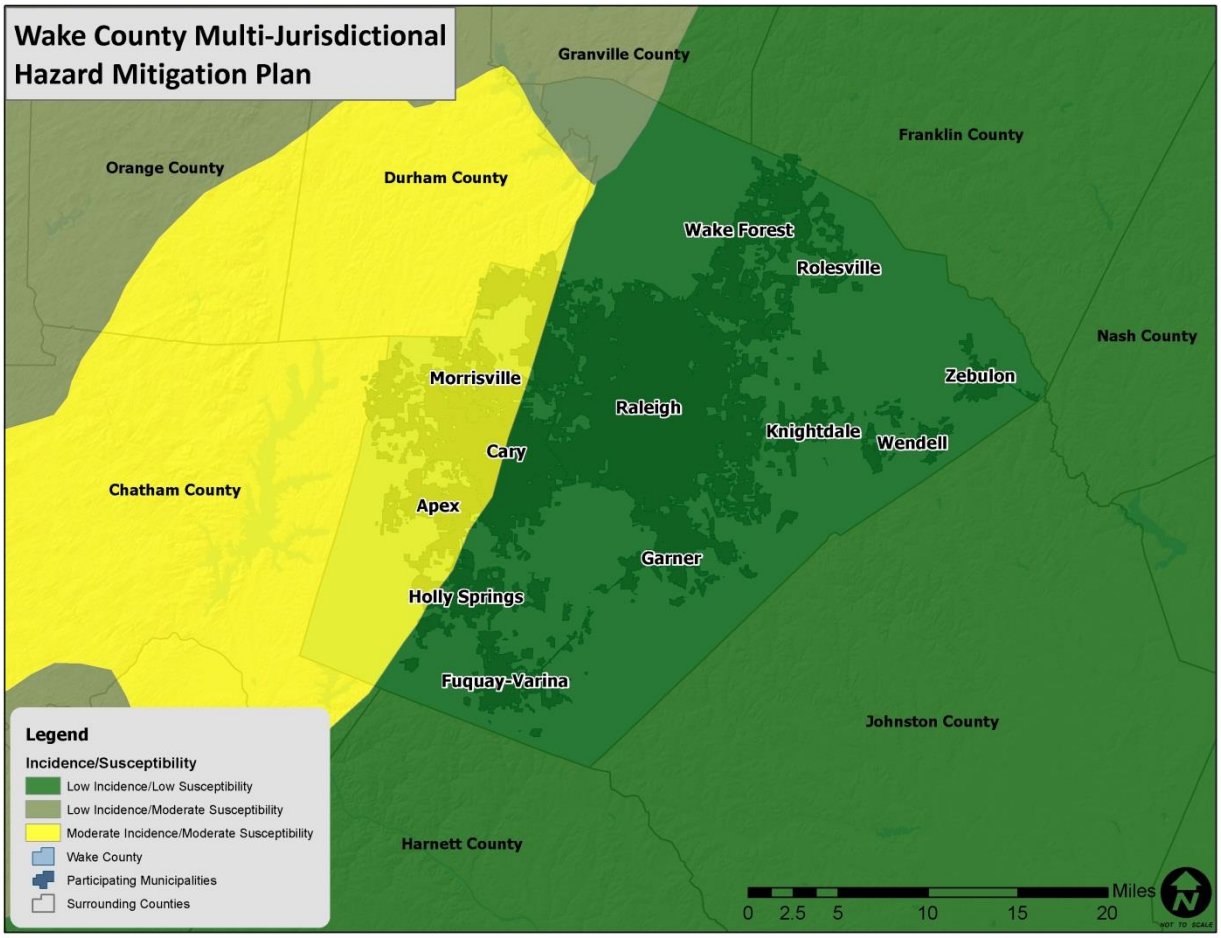
J.2.10 Landslide

Location and Spatial Extent

Landslides occur along steep slopes when the pull of gravity can no longer be resisted (often due to heavy rain). Human development can also exacerbate risk by building on previously undevelopable steep slopes and constructing roads by cutting through hills or mountains. Landslides are possible throughout Wake Forest, although the overall risk is relatively low.

According to **Figure J.4** below, the majority of the county has low landslide activity. However there is a small area along the western border of the county that has a moderate incidence and moderate susceptibility. In all other areas (including all of Wake Forest), there is low susceptibility.

FIGURE J.4: LANDSLIDE SUSCEPTIBILITY AND INCIDENCE MAP OF WAKE COUNTY



Source: USGS

Historical Occurrences

Steeper topography in some areas of Wake Forest make the planning area susceptible to landslides. Most landslides are caused by heavy rainfall in the area. Building on steep slopes that was not previously possible also contributes to risk. **Table J.20** presents a summary of the landslide occurrence

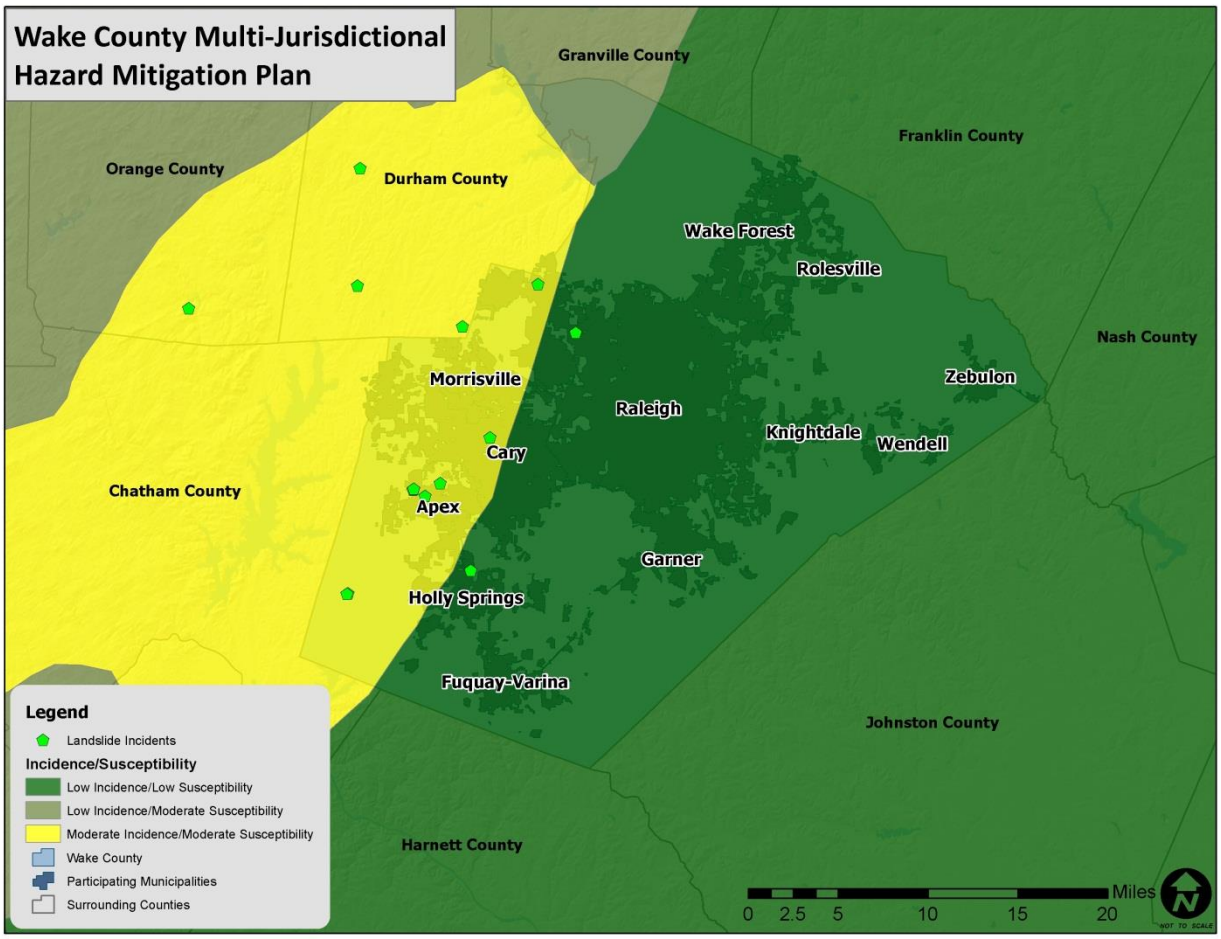
events as provided by the North Carolina Geological Survey[12]. The georeferenced locations of the landslide events presented in the aforementioned tables are presented in **Figure J.5**. Some incidence mapping has also been completed throughout the western portion of North Carolina though none has been done in this area of the state. Therefore, it should be noted that more incidents than what is reported may have occurred in Wake Forest.

TABLE J.20: SUMMARY OF LANDSLIDE ACTIVITY IN WAKE FOREST

Location	Number of Occurrences
Wake Forest	0

Source: North Carolina Geological Survey

FIGURE J.5: LOCATION OF PREVIOUS LANDSLIDE OCCURRENCES IN WAKE COUNTY



Source: North Carolina Geological Survey

Probability of Future Occurrences

Based on historical information and the USGS susceptibility index, the probability of future landslide events is possible (1 to 10 percent probability). Local conditions may become more favorable for

[12] It should be noted that the North Carolina Geological Survey (NCGS) emphasized the dataset provided was incomplete. Therefore, there may be additional historical landslide occurrences. Furthermore, dates were not included for every event. The earliest date reported was 1940. No damage information was provided by NCGS.

landslides due to heavy rain, for example. This would increase the likelihood of occurrence. It should also be noted that some areas in Wake Forest have greater risk than others given factors such as steepness on slope and modification of slopes.

J.2.11 Dam and Levee Failure

Location and Spatial Extent

The North Carolina Division of Land Resources provides information on dams, including a hazard potential classification. There are three hazard classifications—high, intermediate, and low—that correspond to qualitative descriptions and quantitative guidelines. **Table J.21** explains these classifications.

TABLE J.21: NORTH CAROLINA DAM HAZARD CLASSIFICATIONS

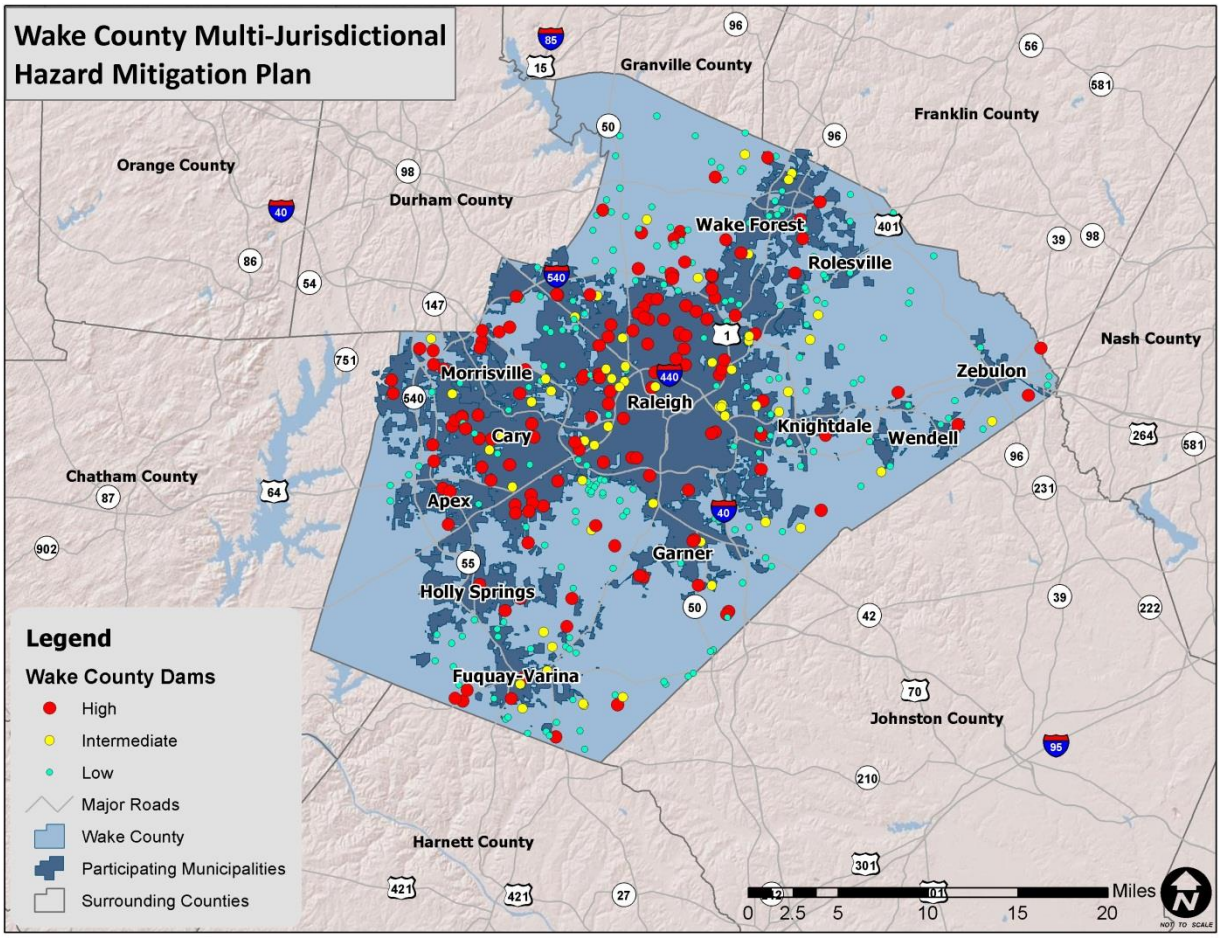
Hazard Classification	Description	Quantitative Guidelines
Low	Interruption of road service, low volume roads	Less than 25 vehicles per day
	Economic damage	Less than $30,000
Intermediate	Damage to highways, Interruption of service	25 to less than 250 vehicles per day
	Economic damage	$30,000 to less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

Source: North Carolina Division of Land Resources

According to the North Carolina Division of Land Management there are 11 dams in Wake Forest.[13] **Figure J.6** shows the dam location and the corresponding hazard ranking for each. Of these dams, three are classified as high hazard potential. These high hazard dams are listed in **Table J.22**.

[13] The February 8, 2012 list of high hazard dams obtained from the North Carolina Division of Energy, Mineral, and Land Resources (http://portal.ncdenr.org/web/lr/dams) was reviewed and amended by local officials to the best of their knowledge.

FIGURE J.6: WAKE COUNTY DAM LOCATION AND HAZARD RANKING



Source: North Carolina Division of Land Resources, 2012

TABLE J.22: WAKE FOREST HIGH HAZARD DAMS

Dam Name	Hazard Potential	Surface Area (acres)	Max Capacity (Ac-ft)	Owner Type
Wake Forest				
Wake Forest Water Supply Dam	High	50	945	Local Gov
Lewis Dam	High	10	80	Private
St. Andrews Plantation Dam	High	3	23	Private

Source: North Carolina Division of Land Resources, 2012

It should also be noted that the North Carolina dam classification regulations were recently updated. As a result of the change, more dams are generally classified as high hazard.

Historical Occurrences

No dam breaches were reported in Wake Forest. However, several breach scenarios in the jurisdiction could cause substantial damage.

Probability of Future Occurrences

Given the current dam inventory and historic data, a dam breach is unlikely (less than 1 percent annual probability) in the future. However, as has been demonstrated in the past, regular monitoring is necessary to prevent these events.

J.2.12 Erosion

Location and Spatial Extent

Erosion in Wake Forest is typically caused by flash flooding events. Unlike coastal areas, where the soil is mainly composed of fine grained particles such as sand, Wake Forest soils have greater organic matter content. Furthermore, vegetation also helps to prevent erosion in the area. Erosion occurs in Wake Forest, particularly along the banks of rivers and streams, but it is not an extreme threat. No areas of concern were reported by the planning committee.

Historical Occurrences

Several sources were vetted to identify areas of erosion in Wake Forest. This includes searching local newspapers, interviewing local officials, and reviewing the previous hazard mitigation plan. Little information could be found and erosion was not addressed in the previous Wake Forest hazard mitigation plan.

Probability of Future Occurrences

Erosion remains a natural, dynamic, and continuous process for Wake Forest, and it will continue to occur. The annual probability level assigned for erosion is possible (between 1 and 10 percent annually).

J.2.13 Flood

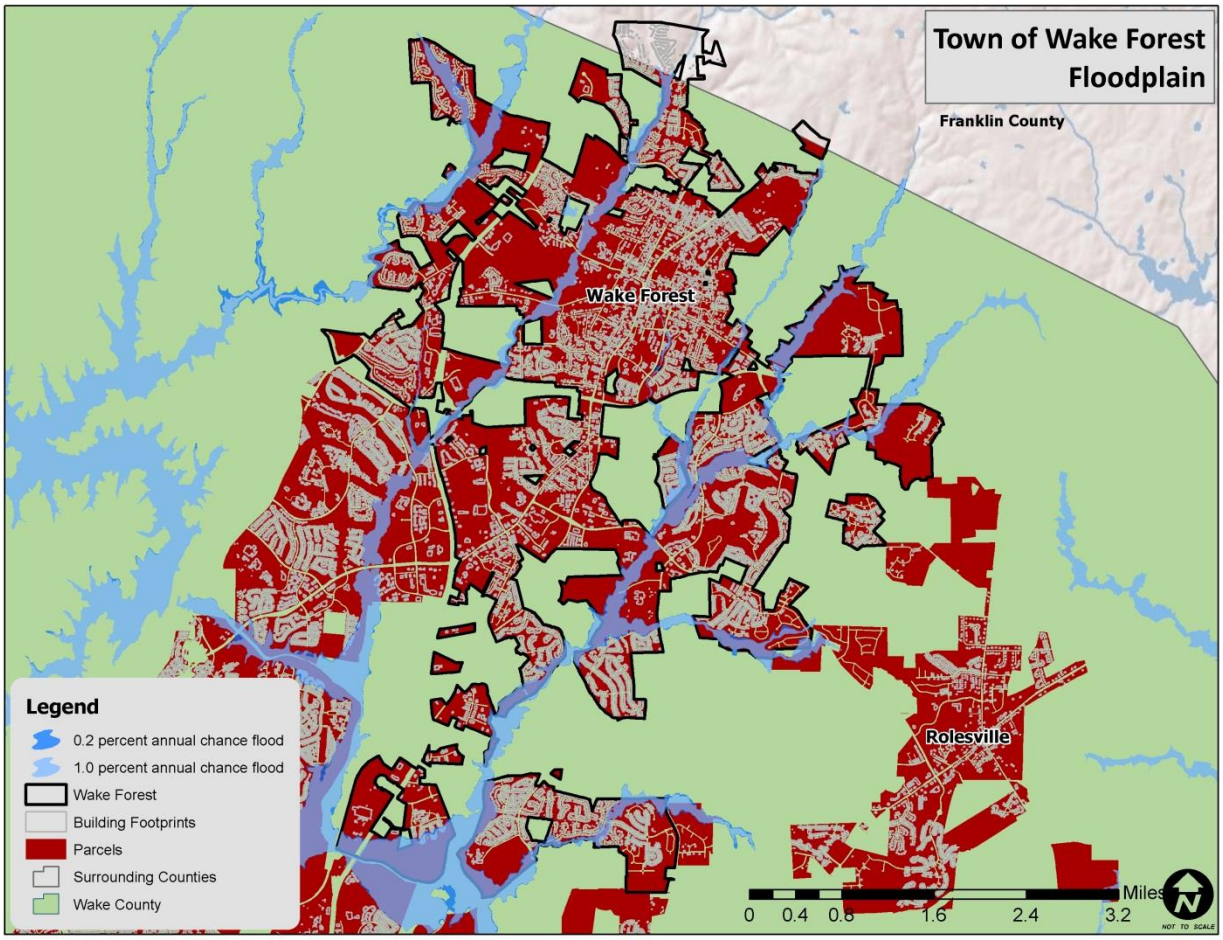
Location and Spatial Extent

There are areas in Wake Forest that are susceptible to flood events. Special flood hazard areas in the jurisdiction were mapped using Geographic Information System (GIS) and FEMA Digital Flood Insurance Rate Maps (DFIRM).[14] This includes Zone A (1-percent annual chance floodplain), Zone AE (1-percent annual chance floodplain with elevation), Zone X500 (0.2-percent annual chance floodplain). According to GIS analysis, of the 14 square miles that make up Wake Forest, there are 1.56 square miles of land in zones A and AE (1-percent annual chance floodplain/100-year floodplain).

These flood zone values account for 11.1 percent of the total land area in Wake Forest. It is important to note that while FEMA digital flood data is recognized as best available data for planning purposes, it does not always reflect the most accurate and up-to-date flood risk. Flooding and flood-related losses often do occur outside of delineated special flood hazard areas. **Figure J.7** illustrates the location and extent of currently mapped special flood hazard areas for Wake Forest based on best available FEMA Digital Flood Insurance Rate Map (DFIRM) data.

[14] The county-level DFIRM data used for Wake Forest were updated in 2010.

FIGURE J.7: SPECIAL FLOOD HAZARD AREAS IN WAKE FOREST



Source: Federal Emergency Management Agency

Historical Occurrences

Information from the National Climatic Data Center was used to ascertain historical flood events. The National Climatic Data Center reported a total of 3 events in Wake Forest since 1993.[15] A summary of these events is presented in **Table J.23**. These events accounted for over $0 (2013 dollars) in property damage in the county.[16] Specific information on flood events, including date, type of flooding, and deaths and injuries, can be found in **Table J.24**.

TABLE J.23: SUMMARY OF FLOOD OCCURRENCES IN WAKE FOREST

Location	Number of Occurrences	Deaths/Injuries	Property Damage (2013)
Wake Forest	3	0/0	$0

Source: National Climatic Data Center

[15] These events are only inclusive of those reported by NCDC. It is likely that additional occurrences have occurred and have gone unreported.
[16] The total damage amount was averaged over the number of affected counties when multiple counties were involved in the flood event.

TABLE J.24: HISTORICAL FLOOD EVENTS IN WAKE FOREST

	Date	Type	Deaths/ Injuries	Property Damage*
Wake Forest				
WAKE FOREST	8/26/1999	FLASH FLOOD	0/0	$0
WAKE FOREST	9/10/2001	FLASH FLOOD	0/0	$0
WAKE FOREST	12/2/2009	FLASH FLOOD	0/0	$0

Source: National Climatic Data Center

Historical Summary of Insured Flood Losses

According to FEMA flood insurance policy records as of December 2013, there have been 0 flood losses reported in Wake Forest through the National Flood Insurance Program (NFIP) since 1978. A summary of these figures for the jurisdiction is provided in **Table J.25**. It should be emphasized that these numbers include only those losses to structures that were insured through the NFIP policies, and for losses in which claims were sought and received. It is likely that additional instances of flood loss in Wake Forest were either uninsured, denied claims payment, or not reported.

TABLE J.25: SUMMARY OF INSURED FLOOD LOSSES IN WAKE FOREST

Location	Flood Losses	Claims Payments
Wake Forest	0	$0

Source: FEMA, NFIP

Repetitive Loss Properties

FEMA defines a repetitive loss property as any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period, since 1978. A repetitive loss property may or may not be currently insured by the NFIP. Currently there are over 140,000 repetitive loss properties nationwide.

As of July 2013, there are 0 non-mitigated repetitive loss properties located in Wake Forest, which accounted for 0 losses and $0 in claims payments under the NFIP. Without mitigation, repetitive loss properties will likely continue to experience flood losses. **Table J.26** presents detailed information on repetitive loss properties and NFIP claims and policies for Wake Forest.

TABLE J.26: SUMMARY OF REPETITIVE LOSS PROPERTIES IN WAKE FOREST

Location	Number of Properties	Types of Properties	Number of Losses	Building Payments	Content Payments	Total Payments	Average Payment
Wake Forest	0	-	0	$0	$0	$0	$0

Source: National Flood Insurance Program

Probability of Future Occurrences

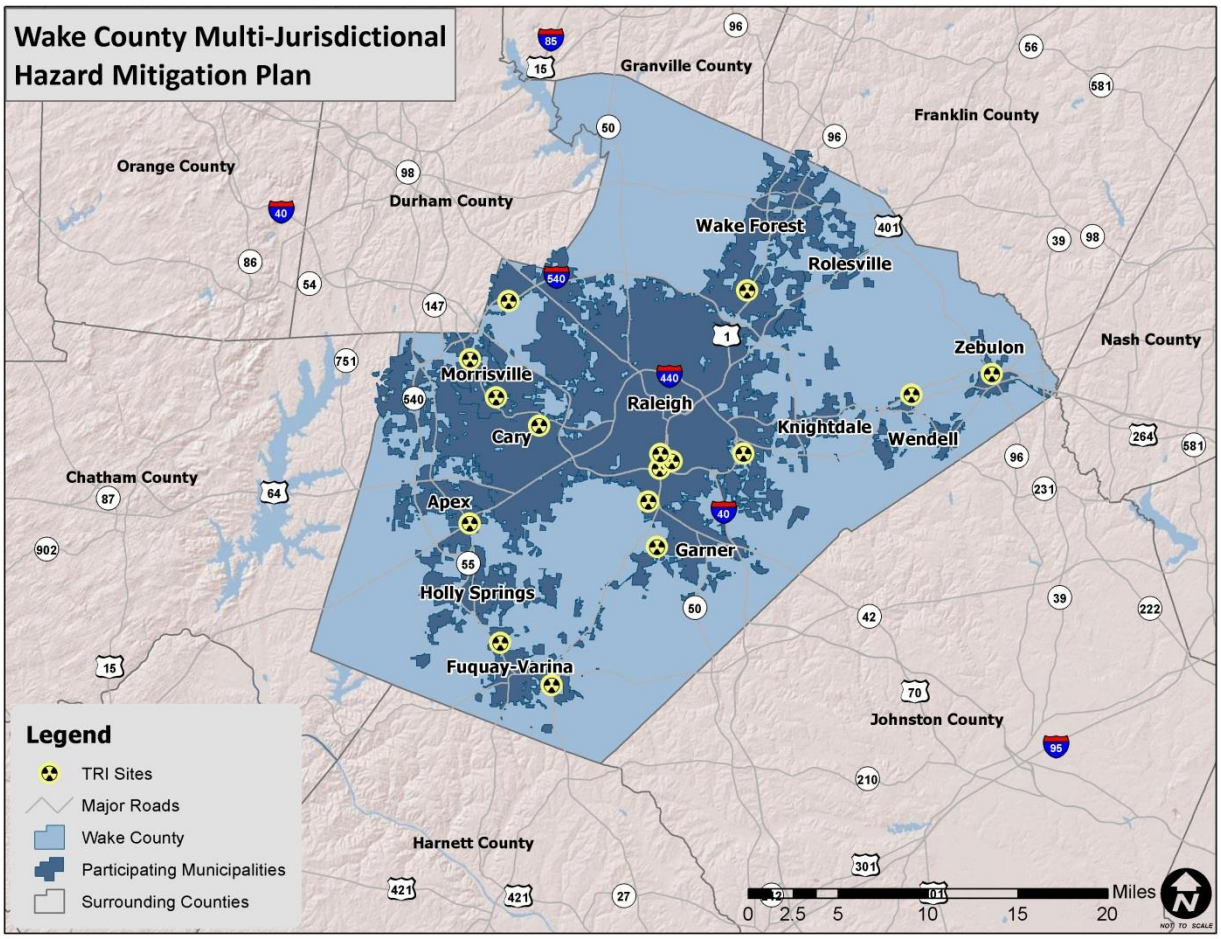
Flood events will remain a threat in areas prone to flooding in Wake Forest, and the probability of future occurrences will remain likely (between 10 and 100 percent annual probability) The probability of future flood events based on magnitude and according to best available data is illustrated in the figures above**,** which indicates those areas susceptible to the 1-percent annual chance flood (100-year floodplain) and the 0.2-percent annual chance flood (500-year floodplain).

J.2.14 Hazardous Materials Incidents

Location and Spatial Extent

As a result of the 1986 Emergency Planning and Community Right to Know Act (EPCRA), the Environmental Protection Agency provides public information on hazardous materials. One facet of this program is to collect information from industrial facilities on the releases and transfers of certain toxic agents. This information is then reported in the Toxic Release Inventory (TRI). TRI sites indicate where such activity is occurring. Wake Forest has no TRI sites as shown in **Figure J.8.**

FIGURE J.8: TOXIC RELEASE INVENTORY (TRI) SITES IN WAKE COUNTY



Source: EPA

In addition to "fixed" hazardous materials locations, hazardous materials may also impact the jurisdiction via roadways and rail. All roads that permit hazardous material transport are considered potentially at risk to an incident.

Historical Occurrences

The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) lists historical occurrences throughout the nation. A "serious incident" is a hazardous materials incident that involves:

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

However, prior to 2002, a hazardous materials "serious incident" was defined as follows:

- a fatality or major injury due to a hazardous material,
- closure of a major transportation artery or facility or evacuation of six or more person due to the presence of hazardous material, or
- a vehicle accident or derailment resulting in the release of a hazardous material.

Table J.27 presents detailed information on historic HAZMAT incidents reported in Wake Forest.

TABLE J.27: SUMMARY OF HAZMAT INCIDENTS IN WAKE FOREST

Report Number	Date	City	Mode	Serious Incident?	Fatalities/ Injuries	Damages ($)	Quantity Released
Wake Forest							
None reported							

Source: USDOT PHMSA

Probability of Future Occurrences

Although there are no toxic release inventory sites in Wake Forest, there are several roadways and rails that transport hazardous materials, so it is possible that a hazardous material incident may occur in the jurisdiction (between 1 percent and 10 percent annual probability). Local officials are mindful of this possibility and take precautions to prevent such an event from occurring. Furthermore, there are detailed plans in place to respond to an occurrence.

J.2.15 Wildfire

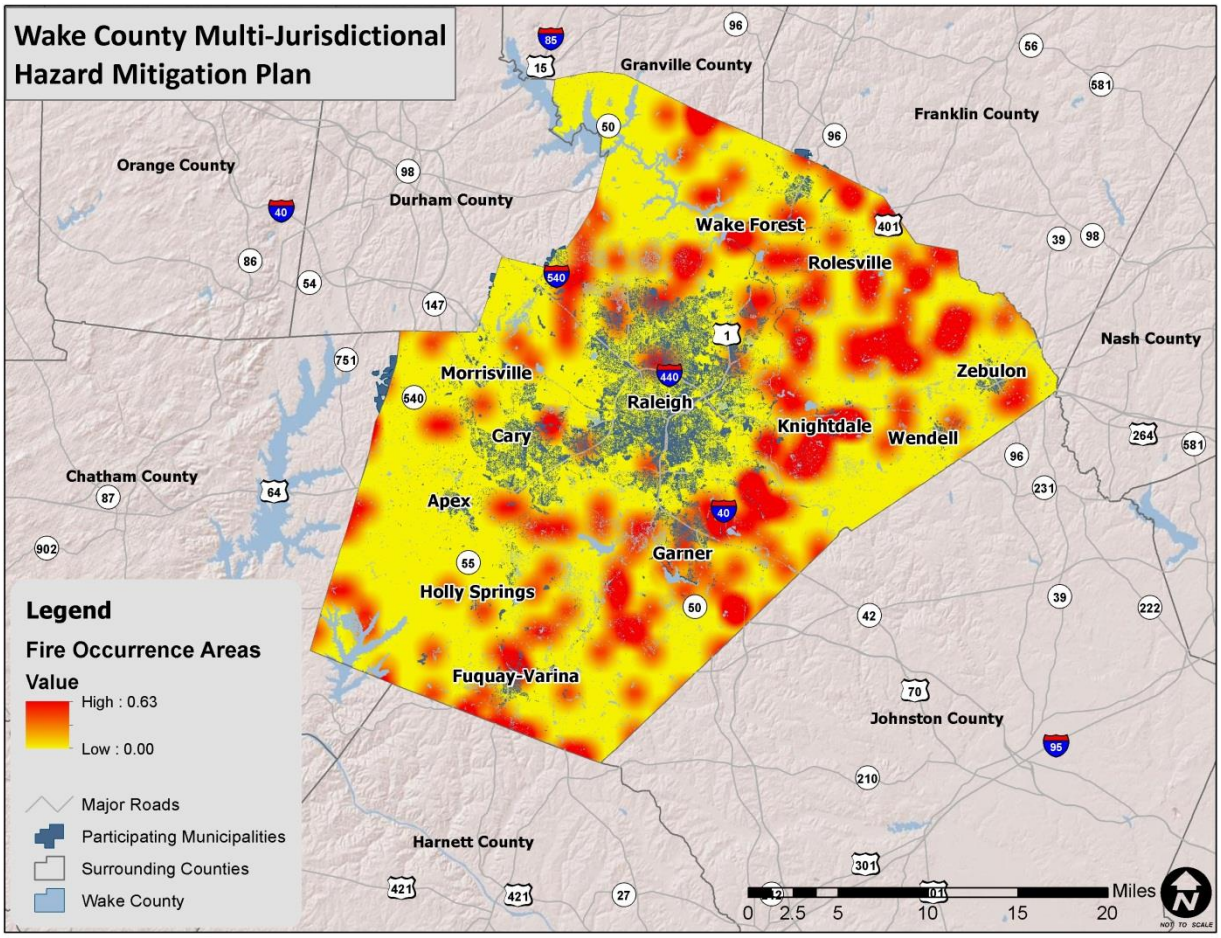
Location and Spatial Extent

The entire jurisdiction is at some risk to a wildfire occurrence. However, several factors such as drought conditions or high levels of fuel on the forest floor, may make a wildfire more likely. Furthermore, areas in the urban-wildland interface are particularly susceptible to fire hazard as populations abut formerly undeveloped areas.

Historical Occurrences

Figure J.9 shows the Fire Occurrence Areas (FOA) in Wake Forest based on data from the Southern Wildfire Risk Assessment. This data is based on historical fire ignitions and is reported as the number of fires that occur per 1,000 acres each year. Therefore, even areas classified as at relatively high risk within the county are a relatively low risk compared to other areas of the state.

FIGURE J.9: HISTORIC WILDFIRE EVENTS IN WAKE FOREST



Source: Southern Wildfire Risk Assessment

Based on data from the North Carolina Division of Forest Resources from 2003 to 2012, Wake County experiences an average of 16 wildfires annually which burn an average of 98 acres per year. The data indicates that most of these fires are small, averaging six acres per fire. **Table J.28** lists the number of reported wildfire occurrences in the county between the years 2003 and 2012.

TABLE J.28: HISTORICAL WILDFIRE OCCURRENCES IN WAKE FOREST

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Wake County										
Number of Fires	8	13	18	23	28	12	2	21	17	13
Number of Acres	52.3	28.7	65.0	167.4	120.9	74.6	17.3	130.2	225.0	101.0

Source: North Carolina Division of Forest Resources

Probability of Future Occurrences

Wildfire events will be an ongoing occurrence in Wake Forest. The likelihood of wildfires increases during drought cycles and abnormally dry conditions. Fires are likely to stay small in size but could increase due local climate and ground conditions. Dry, windy conditions with an accumulation of forest

floor fuel (potentially due to ice storms or lack of fire) could create conditions for a large fire that spreads quickly. It should also be noted that some areas do vary somewhat in risk. For example, highly developed areas are less susceptible unless they are located near the urban-wildland boundary. The risk will also vary due to assets. Areas in the urban-wildland interface will have much more property at risk, resulting in increased vulnerability and need to mitigate compared to rural, mainly forested areas. The probability assigned to Wake Forest for future wildfire events is possible (a 1 and 10 percent annual probability).

J.2.16 Nuclear Accident

Location and Spatial Extent

The entire county is at risk to a nuclear incident. However, areas in the southwest part of the region are more susceptible due to their proximity to the Shearon Harris Nuclear Station.

Historical Occurrences

Although there have been no major nuclear events at the Shearon Harris Nuclear Station, there is some possibility that one could occur as there have been incidents in the past in the United States at other facilities and at facilities around the world. In May of 2013, there was an unplanned shutdown of the plant which resulted from the discovery of a ¼ inch crack in the Reactor Pressure Vessel Head.

Shearon Harris has declared 2 "Alerts" and 28 "Notice of Unusual Events" since 1986, which are shown in **Table J.29**. There have also been 338 additional incidents reported to the NRC since 1986, but they did not necessitate an emergency declaration and therefore were not included in this analysis.

Table J.29: SHEARON HARRIS EMERGENCY DECLARATION HISTORY

Emergency Declaration	Date	Description
Alert	08/12/1988	Loss of greater than 50% of main control board (MCB) alarms due to electrical problems; normal power supply to annunciator panel failed and did not transfer to its backup inverter.
Alert	10/09/1988	Fire on "B" Main Electrical Transformer; release of flammable gas in the Protected Area.
Unusual Event	11/28/1986	Loss of ERFIS computer system to display Safety Parameter Display System (SPDS) (55 lapsed minutes).
Unusual Event	11/29/1986	Loss of ERFIS computer system to display SPDS (58 lapsed minutes).
Unusual Event	11/30/1986	Loss of ERFIS computer system to display SPDS (48 lapsed minutes).
Unusual Event	12/03/1986	Loss of ERFIS computer system to display SPDS (27 lapsed minutes).
Unusual Event	12/11/1986	Safety Injection (an Emergency Core Cooling System) actuated while testing electronic circuitry.
Unusual Event	01/27/1987	Loss of ERFIS computer system to display SPDS (23 lapsed minutes).
Unusual Event	07/11/1987	Loss of ERFIS computer system to display SPDS (22 lapsed minutes).
Unusual Event	07/24/1987	Loss of ERFIS computer system to display SPDS (32 lapsed minutes).
Unusual Event	07/25/1987	Loss of ERFIS computer system to display SPDS (28 lapsed minute).
Unusual Event	02/04/1988	Fire within the Protected Area greater than 10 minutes; smoke observed coming from the motor for the reactor auxiliary building supply fan.
Unusual Event	10/06/1988	RCS leakage in excess of Tech Specs (unidentified leakage > 1.0 gpm).
Unusual Event	10/20/1988	RCS leakage in excess of Tech Specs; pressure operated relief valve opened and admitted RCS inventory to the pressurized relief tank (PRT).
Unusual Event	11/17/1988	Loss of ERFIS computer system to display SPDS for > 60 minutes.
Unusual Event	12/01/1988	Reactor coolant system (RCS) leakage in excess of Tech Specs (unidentified leakage > 1.0 gpm).

Emergency Declaration	Date	Description
Unusual Event	12/16/1988	High level alarm on radiological effluent release monitor the (Treated Laundry and Hot Shower high level alarm was set just above background).
Unusual Event	03/13/1989	Loss of ERFIS computer system to display SPDS for > 60 minutes.
Unusual Event	01/24/1991	Plant shutdown required by Technical Specifications. Excessive leakage of a containment penetration; leakage discovered during surveillance testing.
Unusual Event	02/15/1991	Loss of ERFIS computer system to display SPDS for > 4 hours.
Unusual Event	03/05/1991	Plant shutdown required by Technical Specifications (testing of "A" Reactor Coolant Pump (RCP) electrical protection function).
Unusual Event	04/14/1992	Loss of ERFIS computer system to display SPDS for > 4 hours.
Unusual Event	02/06/1993	Loss of ERFIS computer system to display SPDS for > 4 hours.
Unusual Event	02/17/1994	Loss of ERFIS computer system to display SPDS for > 4 hours.
Unusual Event	07/22/1994	Loss of both emergency diesel generators - "B" diesel generator was being worked on; in accordance with test procedures, "A" diesel generator is required to be tested within 24 hours following having redundant diesel out-of-service; did not pass test.
Unusual Event	11/05/1995	Unplanned emergency core cooling system (ECCS) discharge to the reactor vessel; reactor trip and safety injection (SI) occurred during the performance of testing.
Unusual Event	12/14/1995	Train derailment on site - while removing empty cask car from the Protected Area, the rail cars were moved onto the Engine Spur to allow passage of the CSX engine on adjacent Plant Spur; cask car shifted; 4 wheels of the car left the rails.
Unusual Event	01/22/1997	Security Event - while working Work Request and Authorization (WR&A), I&C Tech investigation found cut wire in a Turbine Building radiation monitor. Later determined to not be vandalism (i.e., not a security threat).
Unusual Event	04/02/2000	Loss of Emergency Response Facility Information System (ERFIS) computer system to display Safety Parameter Display System (SPDS) for more than 4 hours.
Unusual Event	08/23/2011	Seismic activity at the site due to a magnitude 5.8 earthquake near Mineral, VA.

The PULSTAR Nuclear Research Reactor has one reported "Notice of Unusual Events" since 1986, which is shown in **Table J.30**. This event occurred on August 23, 2011, and was due to seismic activity from the magnitude 5.8 earthquake near Mineral, Virginia. There were two additional known events in which an emergency declaration was not made and assistance was not required from the City of Raleigh or Wake County. One event occurred on July 2, 2011, and resulted in a shutdown of the reactor due to a 10-gallon-per-hour leak. The second event was reported on December 13, 2010, when a radiography technician walked in front of a 30 rem per hour beam of radiation for 60 seconds due to a shutter being left open.

Table J.30: PULSTAR Nuclear Research Reactor Incident History

Emergency Declaration	Date	Description
None	12/13/2010	A radiography technician walked in front of a 30 REM per hour beam of radiation for 60 seconds due to a shutter being left open. This incident was reported to the Nuclear Regulatory Commission (NRC), but no assistance was required from the City of Raleigh or Wake County.
None	07/02/2011	PULSTAR shut down due to a 10 gallon per hour leak. No emergency was declared (less than 350 gallons per hour reporting threshold), and no action was required from the City of Raleigh or Wake County.
Unusual Event	08/23/2011	Seismic activity at the site due to a magnitude 5.8 earthquake near Mineral, VA.

Probability of Future Occurrences

A major nuclear event is a very rare occurrence in the United States due to the intense regulation of the industry. There have been incidents in the past, but it is considered unlikely (less than 1 percent annual probability).

J.2.17 Terror Threat

Location and Spatial Extent

A terror threat could potentially occur at any location in the county. However, the very definition of a terrorist event indicates that it is most likely to be targeted at a critical or symbolic resource/location. Ensuring and protecting the continuity of critical infrastructure and key resources (CIKR) of the United States is essential to the Nation's security, public health and safety, economic vitality, and way of life. CIKR includes physical and/or virtual systems or assets that, if damaged, would have a detrimental impact on national security, including large-scale human casualties, property destruction, economic disruption, and significant damage to morale and public confidence. **Table J.31** shows the U.S. Department of Homeland Security's (DHS) identified main critical infrastructure sectors.

TABLE J.31 U.S. DEPARTMENT OF HOMELAND SECURITY CRITICAL INFRASTRUCTURE SECTORS

▪ Agriculture and Food	▪ Government Facilities
▪ Banking and Finance	▪ Healthcare and Public Health
▪ Chemical	▪ Information Technology
▪ Commercial Facilities	▪ National Monuments and Icons
▪ Communications	▪ Nuclear Reactors, Materials, and Waste
▪ Critical Manufacturing	▪ Postal and Shipping
▪ Dams	▪ Transportation Systems
▪ Defense Industrial Base	▪ Water
▪ Emergency Services	
▪ Energy	

Historical Occurrences

Although there have been no major terror events in Wake County, there is some possibility that one could occur as there have been incidents in the past in the United States and the county is a population center that is home to the capital of North Carolina and has potential targets.

Probability of Future Occurrences

Wake County has had no recorded terrorist events. Due to no recorded incidents against Wake County, the probability of future occurrences of a terrorist attack is rated as unlikely with less than 1 percent annual probability of an incident occurring.

J.2.18 Conclusions on Hazard Risk

The hazard profiles presented above were developed using best available data and result in what may be considered principally a qualitative assessment as recommended by FEMA in its "How-to" guidance document titled *Understanding Your Risks: Identifying Hazards and Estimating Losses* (FEMA Publication 386-2). It relies heavily on historical and anecdotal data, stakeholder input, and professional and

experienced judgment regarding observed and/or anticipated hazard impacts. It also carefully considers the findings in other relevant plans, studies, and technical reports.

Hazard Extent

Table J.32 describes the extent of each natural hazard identified for Wake Forest. The extent of a hazard is defined as its severity or magnitude, as it relates to the planning area.

TABLE J.32 EXTENT OF WAKE FOREST HAZARDS

Atmospheric Hazards	
Drought	Drought extent is defined by the North Carolina Drought Monitor Classifications which include Abnormally Dry, Moderate Drought, Severe Drought, Extreme Drought, and Exceptional Drought (page J:4). According to the North Carolina Drought Monitor Classifications, the most severe drought condition is Exceptional. Wake Forest has received this ranking three times over the fourteen year reporting period.
Extreme Heat	The extent of extreme heat can be defined by the maximum temperature reached. The highest temperature recorded in Wake County is 107 degrees Fahrenheit in Raleigh in 1898.
Hailstorm	Hail extent can be defined by the size of the hail stone. The largest hail stone reported in Wake Forest was 1.75 inches. It should be noted that future events may exceed this.
Hurricane and Tropical Storm	Hurricane extent is defined by the Saffir-Simpson Scale which classifies hurricanes into Category 1 through Category 5 (Table 5.10). The highest magnitude hurricanes to traverse directly through Wake County were two storms which carried tropical force winds of 70 knots upon arrival in Wake County. Both an Unnamed Storm in 1893 and Hurricane Hazel in 1954 carried this maximum sustained wind speed. It should also be noted that Hurricane Fran, which struck more recently, attained maximum sustained winds of 57 knots.
Lightning	According to the NOAA flash density map (Figure 5.5), Wake Forest is located in an area that experiences 4 to 5 lightning flashes per square kilometer per year. It should be noted that future lightning occurrences may exceed these figures.
Thunderstorm Wind/High Wind	Thunderstorm extent is defined by the number of thunderstorm events and wind speeds reported. According to a 60-year history from the National Climatic Data Center, the strongest recorded wind event in Wake Forest was reported at 50 knots (approximately 58 mph). It should be noted that future events may exceed these historical occurrences.
Tornado	Tornado hazard extent is measured by tornado occurrences in the US provided by FEMA (Figure 5.6) as well as the Fujita/Enhanced Fujita Scale (Tables 5.18 and 5.19). Although there were no tornado events reported, a F5 is possible.
Winter Storm and Freeze	The extent of winter storms can be measured by the amount of snowfall received (in inches). The greatest snowfall reported in Wake County was 20-24 inches during the Blizzard of 1996. Due to variations in storm systems, extent totals vary for each participating jurisdiction and reliable data on snowfall totals is not available.

Geologic Hazards	
Earthquake	Earthquake extent can be measured by the Richter Scale (Table 5.24) and the Modified Mercalli Intensity (MMI) scale (Table 5.25) and the distance of the epicenter from Wake Forest. According to data provided by the National Geophysical Data Center, the greatest MMI to impact the county was reported in Raleigh with a MMI of VIII (destructive) with a correlating Richter Scale measurement of approximately 7.2.
Landslide	As noted above in the landslide profile, the landslide data provided by the North Carolina Geological survey is incomplete. This provides a challenge when trying to determine an accurate extent for the landslide hazard. However, when using the USGS landslide susceptibility index, extent can be measured with incidence, which is low in Wake Forest.
Hydrologic Hazards	
Dam Failure	Dam failure extent is defined using the North Carolina Division of Land Resources criteria (Table 5.30). Of the 11 dams in Wake Forest, 3 are classified as high-hazard.
Erosion	The extent of erosion can be defined by the measurable rate of erosion that occurs. There are no erosion rate records located in Wake Forest.
Flood	Flood extent can be measured by the amount of land and property in the floodplain as well as flood height and velocity. The amount of land in the floodplain accounts for 2.0 percent of the total land area in Wake Forest. Flood depth and velocity are recorded via United States Geological Survey stream gages throughout the region. While a gage does not exist for each participating jurisdiction, there is one at or near many areas. The greatest peak discharge recorded for the area was at Crabtree Creek at Ebenezer Church Road (Raleigh) in 1973. Water reached a discharge of 117,007 cubic feet per second.
Other Hazards	
Hazardous Materials Incident	According to USDOT PHMSA, the largest hazardous materials incident reported in the region is 75 LGA released on the highway in Raleigh. It should be noted that larger events are possible.
Wildfire	Wildfire data was provided by the North Carolina Division of Forest Resources and is reported annually by county from 2003-2012. Analyzing the data indicates the following wildfire hazard extent. The greatest number of fires to occur in any year was 28 in 2007. The greatest number of acres to burn in a single year occurred in 2011 when 225 acres were burned. Although this data lists the extent that has occurred, larger and more frequent wildfires are possible throughout the region.
Nuclear Accident	Although there is not any historic precedent for a nuclear accident in Wake County, it is possible that a serious to major accident could occur. This would result in severe exposure to radiation for southwest Wake County (in the 10 mile buffer) and much of the rest of the county would also be impacted (50 mile buffer).

Terror Threat	There is no history of terror threats in Wake County however; it is possible that one of these events could occur. If this were to take place, the magnitude of the event could range on the scale of catastrophic with many fatalities and injuries to the population.

Priority Risk Index Results

In order to draw some meaningful planning conclusions on hazard risk for Wake Forest, the results of the hazard profiling process were used to generate countywide hazard classifications according to a "Priority Risk Index" (PRI). More information on the PRI and how it was calculated can be found in Section 5.20.2.

Table J.33 summarizes the degree of risk assigned to each category for all initially identified hazards based on the application of the PRI. Assigned risk levels were based on the detailed hazard profiles developed for this section, as well as input from the Regional Work Groups and Coordinating Committee. The results were then used in calculating PRI values and making final determinations for the risk assessment.

TABLE J.33: SUMMARY OF PRI RESULTS FOR WAKE FOREST

Hazard	Category/Degree of Risk					
	Probability	Impact	Spatial Extent	Warning Time	Duration	PRI Score
Atmospheric Hazards						
Drought	Likely	Minor	Large	More than 24 hours	More than 1 week	**2.5**
Extreme Heat	Likely	Minor	Large	More than 24 hours	Less than 1 week	**2.4**
Hailstorm	Highly Likely	Minor	Moderate	6 to 12 hours	Less than 6 hours	**2.5**
Hurricane and Tropical Storm	Likely	Critical	Large	More than 24 hours	Less than 24 hours	**2.9**
Lightning	Highly Likely	Minor	Negligible	6 to 12 hours	Less than 6 hours	**2.1**
Thunderstorm/High Wind	Highly Likely	Critical	Moderate	6 to 12 hours	Less than 6 hours	**3.1**
Tornado	Likely	Critical	Small	Less than 6 hours	Less than 6 hours	**2.7**
Winter Storm and Freeze	Likely	Limited	Moderate	More than 24 hours	Less than 1 week	**2.5**
Geologic Hazards						
Earthquake	Possible	Minor	Moderate	Less than 6 hours	Less than 6 hours	**2**
Landslide	Unlikely	Minor	Small	Less than 6 hours	Less than 6 hours	**1.5**
Hydrologic Hazards						
Dam and Levee Failure	Unlikely	Critical	Small	Less than 6 hours	Less than 6 hours	**2.1**
Erosion	Possible	Minor	Small	More than 24 hours	More than 1 week	**1.8**
Flood	Likely	Critical	Moderate	6 to 12 hours	Less than 1 week	**3**
Other Hazards						
Hazardous Materials Incident	Likely	Limited	Small	Less than 6 hours	Less than 24 hours	**2.5**
Wildfire	Possible	Minor	Small	Less than 6 hours	Less than 1 week	**2**
Nuclear Accident	Unlikely	Critical	Large	6 to 12 hours	Less than 1 week	**2.6**
Terror Threat	Unlikely	Critical	Moderate	Less than 6 hours	Less than 24 hours	**2.4**

J.2.16 Final Determinations on Hazard Risk

The conclusions drawn from the hazard profiling process for Wake Forest, including the PRI results and input from the Regional Work Groups and Coordinating Committee, resulted in the classification of risk for each identified hazard according to three categories: High Risk, Moderate Risk, and Low Risk (**Table J.34**). For purposes of these classifications, risk is expressed in relative terms according to the estimated impact that a hazard will have on human life and property throughout all of Wake Forest. A more quantitative analysis to estimate potential dollar losses for each hazard has been performed separately, and is described in Section 6: *Vulnerability Assessment* and below in Section J.3. It should be noted that although some hazards are classified below as posing low risk, their occurrence of varying or unprecedented magnitudes is still possible in some cases and their assigned classification will continue to be evaluated during future plan updates.

TABLE J.34: CONCLUSIONS ON HAZARD RISK FOR WAKE FOREST

HIGH RISK	Severe Thunderstorm/High Wind Hurricane/Tropical Storm Tornado Flood
MODERATE RISK	Drought Extreme Heat Hailstorm Winter Storm and Freeze Hazardous Materials Incident Nuclear Accident Terror Threat
LOW RISK	Lightning Earthquake Landslide Dam and Levee Failure Erosion Wildfire

J.3 TOWN OF WAKE FOREST VULNERABILITY ASSESSMENT

This subsection identifies and quantifies the vulnerability of Wake Forest to the significant hazards previously identified. This includes identifying and characterizing an inventory of assets in the county and assessing the potential impact and expected amount of damages caused to these assets by each identified hazard event. More information on the methodology and data sources used to conduct this assessment can be found in Section 6: *Vulnerability Assessment*.

J.3.1 Asset Inventory

Table J.35 lists the number of parcels, total value of parcels, total number of parcels with improvements, and the total assessed value of improvements for Wake Forest (study area of vulnerability assessment).[17]

TABLE J.35: IMPROVED PROPERTY IN WAKE FOREST

Location	Number of Parcels	Total Assessed Value of Parcels	Estimated Number of Buildings	Total Assessed Value of Improvements
Wake Forest	12,035	$3,802,436,656	11,476	$2,819,911,530

Table J.36 lists the fire stations, police stations, EMS stations, medical care facilities, schools, and other critical facilities located in Wake Forest. These facilities were identified as primary critical facilities in that they are necessary to maintain government functions and protect the life, health, safety, and welfare of citizens. These primary facilities were geospatially mapped and used as the basis for further geographic analysis of the hazards that could potentially affect critical facilities. In addition, a list of secondary facilities was created to recognize the importance of these facilities in the event of a disaster. These facilities were not mapped, but it is important to recognize that they could be potentially impacted by nearly any of the identified hazards, especially those that are atmospheric or have no specific spatial delineation.

All critical facility information was provided by local governments and their GIS departments. Much of the information for both the county and jurisdictions was provided by Wake County GIS. In addition, **Figure J.10** shows the locations of the primary critical facilities in Wake County. **Table J.48**, near the end of this section, shows a complete list of the critical facilities by name, as well as the hazards that affect each facility. As noted previously, this list is not all-inclusive and only includes information provided by the local government.

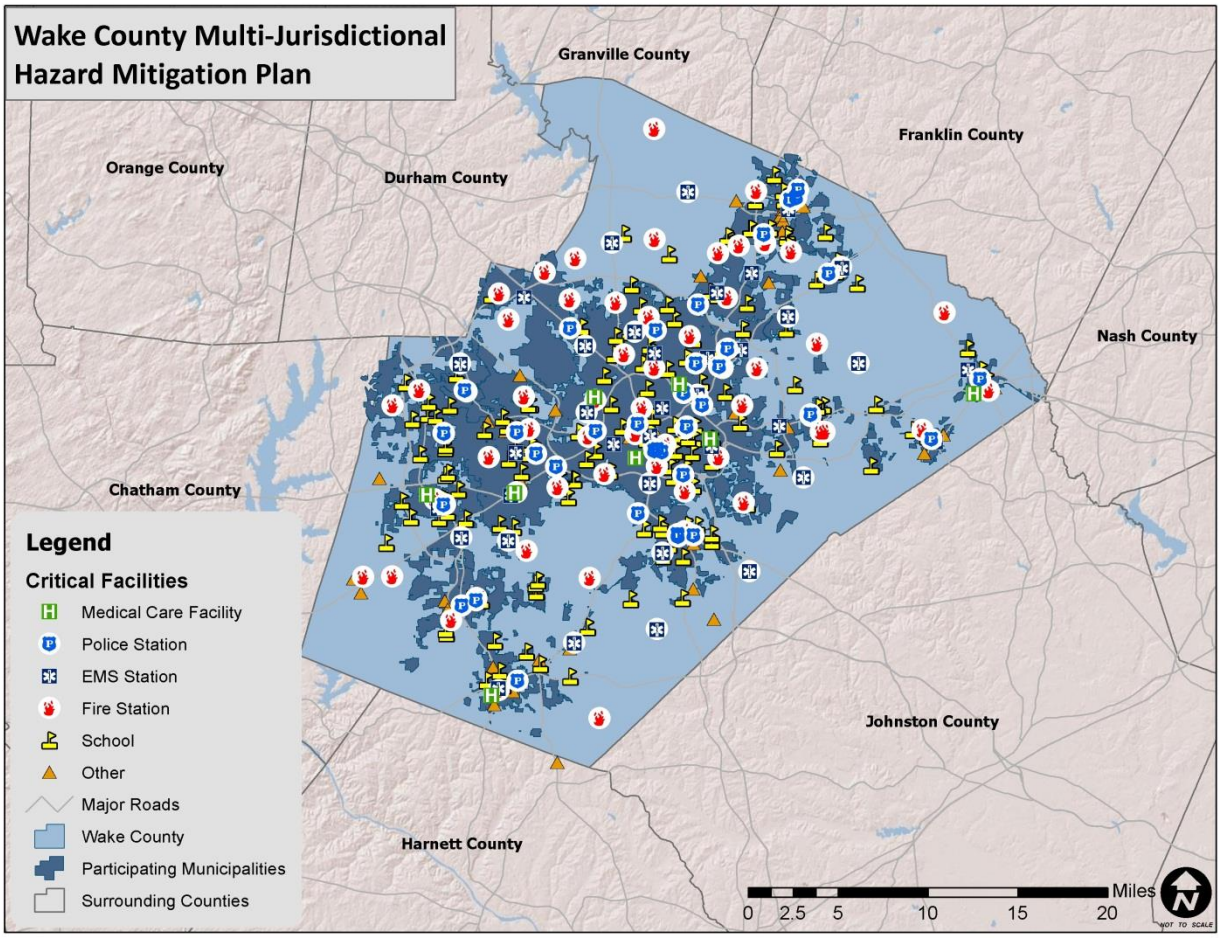
TABLE J.36: CRITICAL FACILITY INVENTORY IN WAKE FOREST

Location	Fire Stations	Police Stations	EMS Stations	Medical Care Facilities	Schools	Other
Wake Forest	4	4	2	0	8	9

Source: Local Governments

[17] Total assessed values for improvements is based on tax assessor records as joined to digital parcel data. This data does not include dollar figures for tax-exempt improvements such as publicly-owned buildings and facilities. It should also be noted that, due to record keeping, some duplication is possible thus potentially resulting in an inflated value exposure for an area.

FIGURE J.10: CRITICAL FACILITY LOCATIONS IN WAKE COUNTY



Source: Local Governments

J.3.2 Social Vulnerability

In addition to identifying those assets potentially at risk to identified hazards, it is important to identify and assess those particular segments of the resident population in Wake Forest that are potentially at risk to these hazards.

Table J.37 lists the population by jurisdiction according to U.S. Census 2010 population estimates. Unfortunately, estimates were not available at the census block level, limited the results to county-wide estimates. The total population in Wake Forest according to Census data is 30,117 persons. Additional population estimates are presented above in Section J.1.

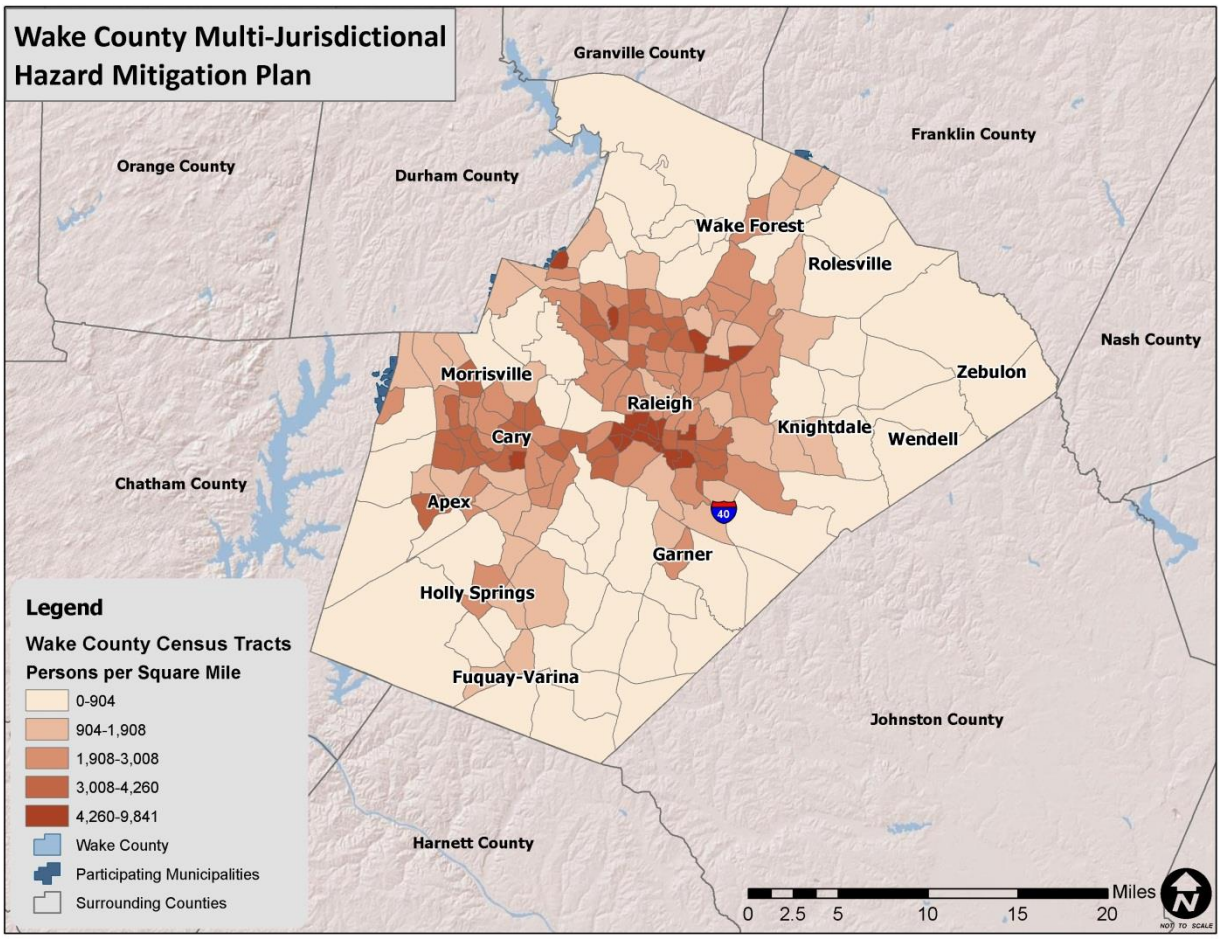
TABLE J.37: TOTAL POPULATION IN WAKE FOREST

Location	Total 2010 Population
Wake Forest	30,117

Source: U.S. Census 2010

In addition, **Figure J.11** illustrates the population density by census tract as it was reported by the U.S. Census Bureau in 2010.[18]

FIGURE J.11: POPULATION DENSITY IN WAKE COUNTY



Source: U.S. Census Bureau, 2010

J.3.3 Vulnerability Assessment Results

As noted in Section 6: *Vulnerability Assessment*, only hazards with a specific geographic boundary, modeling tool, or sufficient historical data allow for further analysis. Those results, specific to Wake Forest, are presented here. All other hazards are assumed to impact the entire planning region (drought, extreme heat, hailstorm, lightning, thunderstorm/high wind, tornado, and winter storm and freeze) or, due to lack of data, analysis would not lead to credible results (erosion, dam and levee failure, terror threat). The total county exposure, and thus risk, was presented in **Table J.35**.

The annualized loss estimate for all hazards is presented at the end of this section in **Table J.47.**

The hazards presented in this section include: hurricane and tropical storm winds, earthquake, landslide, flood, hazardous materials incident, wildfire, and nuclear accident.

[18] Population by census block was not available at the time this plan was completed.

Hurricane and Tropical Storm

Historical evidence indicates that Wake Forest has a significant risk to the hurricane and tropical storm hazard. Several tracks have come near or traversed through the county, as shown and discussed in Section J.2.4.

Hurricanes and tropical storms can cause damage through numerous additional hazards such as flooding, erosion, tornadoes, and high winds and precipitation, thus it is difficult to estimate total potential losses from these cumulative effects. The current Hazus-MH hurricane model only analyzes hurricane winds and is not capable of modeling and estimating cumulative losses from all hazards associated with hurricanes; therefore only hurricane winds are analyzed in this section. It can be assumed that all existing and future buildings and populations are at risk to the hurricane and tropical storm hazard. Hazus-MH 2.1 was used to determine annualized losses for the county as shown below in **Table J.38.** Only losses to buildings are reported, in order to best match annualized losses reported for other hazards. Hazus-MH reports losses at the U.S. Census tract level, so determining participating jurisdiction losses was not possible.

TABLE J.38: ANNUALIZED LOSS ESTIMATIONS FOR HURRICANE WIND HAZARD

Location	Building Loss	Contents Loss	Inventory Loss	Total Annualized Loss
Wake County	**$9,936,000**	**$3,892,000**	**$28,000**	**$13,856,000**

Source: Hazus-MH 2.1

In addition, probable peak wind speeds were calculated in Hazus. These are shown below in **Table J.39.**

TABLE J.39: PROBABLE PEAK HURRICANE/TROPICAL STORM WIND SPEEDS (MPH)

Location	50-year event	100-year event	500-year event	1,000-year event
Wake Forest	73.8	82.9	100.6	107.1

Source: Hazus-MH 2.1

Social Vulnerability

Given equal susceptibility across the county, it is assumed that the total population is at risk to the hurricane and tropical storm hazard.

Critical Facilities

Given equal vulnerability across Wake Forest, all critical facilities are considered to be at risk. Some buildings may perform better than others in the face of such an event due to construction and age, among other factors. Determining individual building response is beyond the scope of this plan. However, this plan will consider mitigation actions for vulnerable structures, including critical facilities, to reduce the impacts of the hurricane wind hazard. A list of specific critical facilities and their associated risk can be found in **Table J.48** at the end of this section.

In conclusion, a hurricane event has the potential to impact many existing and future buildings, critical facilities, and populations in Wake Forest. Hurricane events can cause substantial damage in their wake including fatalities, extensive debris clean-up, and extended power outages.

Earthquake

For the earthquake hazard vulnerability assessment, a probabilistic scenario was created to estimate the annualized loss for the county. The results of the analysis reported at the U.S. Census tract level do not make it feasible to estimate losses at the jurisdiction level. Since the scenario is annualized, no building counts are provided. Losses reported included losses due to building damage (structural and non-structural), contents, and inventory. However, like the analysis for hurricanes, the comparative annualized loss figures at the end of this chapter only utilize building losses in order to provide consistency with other hazards. **Table J.40** summarizes the findings.

TABLE J.40: ANNUALIZED LOSS ESTIMATIONS FOR EARTHQUAKE HAZARD

Location	Structural Building Loss	Non Structural Building Loss	Contents Loss	Inventory Loss	Total Annualized Loss
Wake County	**$119,000**	**$314,000**	**$88,000**	**$3,000**	**$524,000**

Source: Hazus-MH 2.1

Social Vulnerability

It can be assumed that all existing future populations are at risk to the earthquake hazard.

Critical Facilities

The Hazus probabilistic analysis indicated that no critical facilities would sustain measurable damage in an earthquake event. However, all critical facilities should be considered at-risk to minor damage, should an event occur. A list of individual critical facilities and their risk can be found in **Table J.48**.

In conclusion, an earthquake has the potential to impact all existing and future buildings, facilities, and populations in Wake Forest. Minor earthquakes may rattle dishes and cause minimal damage while stronger earthquakes will result in structural damage as indicated in the Hazus scenario above. Impacts of earthquakes include debris clean-up, service disruption and, in severe cases, fatalities due to building collapse. Specific vulnerabilities for assets will be greatly dependent on their individual design and the mitigation measures in place, where appropriate. Such site-specific vulnerability determinations are outside the scope of this assessment but will be considered during future plan updates if data becomes available. Furthermore, mitigation actions to address earthquake vulnerability will be considered.

Landslide

In order to complete the vulnerability assessment for landslides in Wake Forest, GIS analysis was used. The potential dollar value of exposed land and property total can be determined using the USGS Landslide Susceptibility Index (detailed in Section J.2.10), tax parcel and building footprint data, and GIS analysis. **Table J.41** presents the potential at-risk property where available. All areas of Wake Forest are identified as low incidence areas by the USGS landslide data. Since there were no high incidence levels in the county, the moderate incidence level was used to identify different areas of concern for the analysis below.

TABLE J. 41: TOTAL POTENTIAL AT-RISK PARCELS FOR THE LANDSLIDE HAZARD

Location	Number of Parcels At Risk	Number of Improvements At Risk	Total Value of Improvements At Risk ($)
Incidence Level	**Moderate**		
Wake Forest	0	0	$0

Source: USGS

Social Vulnerability
Given low susceptibility across most of Wake County, it is assumed that much of the total population is at a very low risk to landslides. However, Wake Forest is probably at somewhat higher risk than other jurisdictions.

Critical Facilities
No critical facilities are located in a moderate susceptibility area. A list of specific critical facilities and their associated risk can be found in **Table J.48** at the end of this section.

In conclusion, a landslide has the potential to impact existing and future buildings, facilities, and populations in Wake Forest, though some areas are at a higher risk than others due to a variety of factors. For example, steep slopes and modified slopes bear a greater risk than flat areas. Specific vulnerabilities for county assets will be greatly dependent on their individual design and the mitigation measures in place, where appropriate. Such site-specific vulnerability determinations are outside the scope of this assessment but will be considered during future plan updates if data becomes available.

Flood

Historical evidence indicates that Wake Forest is susceptible to flood events. A total of 3 flood events have been reported by the National Climatic Data Center resulting in $0 in damages. On an annualized level, these damages amounted to $0 for Wake Forest.

In order to assess flood risk, a GIS-based analysis was used to estimate exposure to flood events using Digital Flood Insurance Rate Map (DFIRM) data in combination with local tax assessor records for the county. The determination of assessed value at-risk (exposure) was calculated using GIS analysis by summing the total assessed building values for only those improved properties that were confirmed to be located within an identified floodplain. **Table J.42** presents the potential at-risk property. Both the number of parcels and the approximate value are presented.

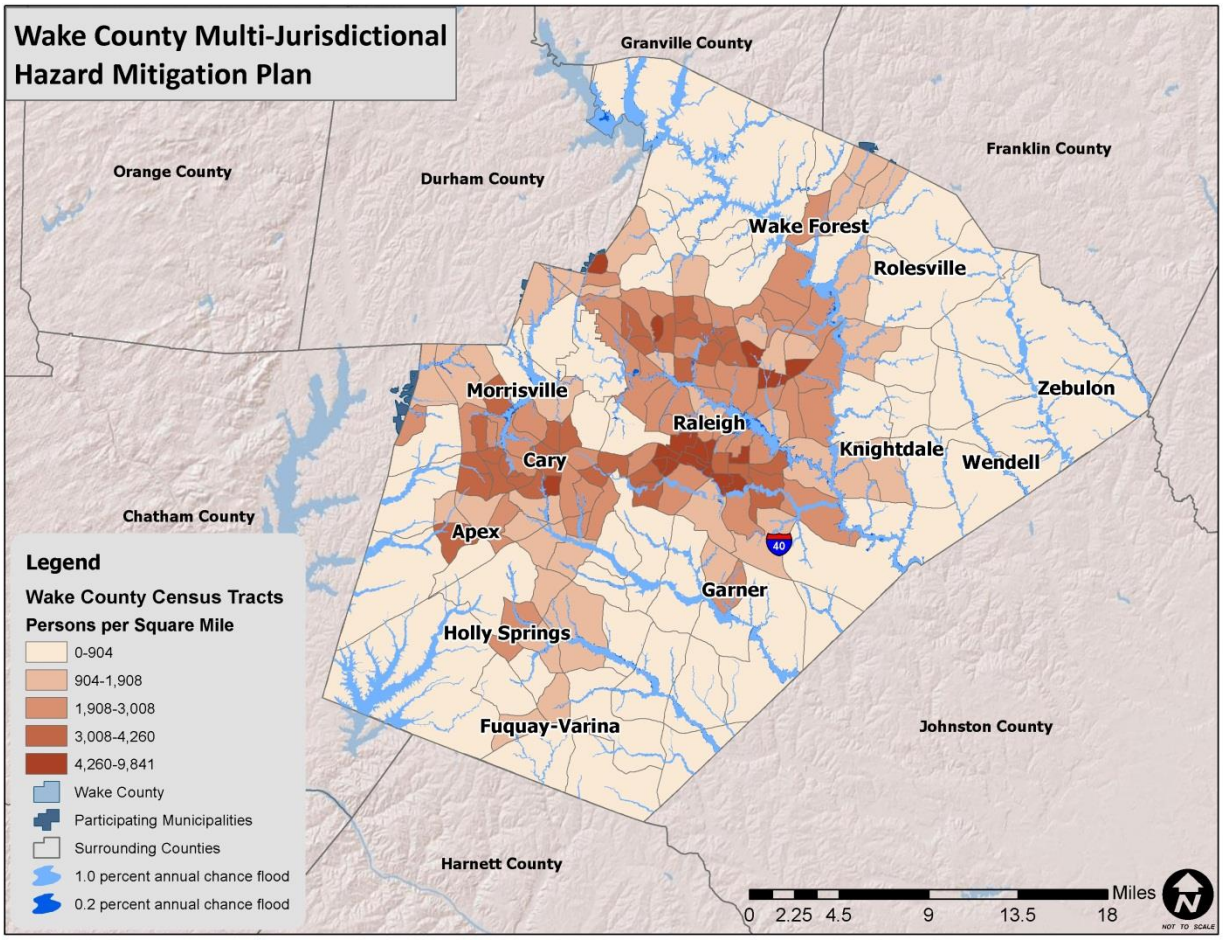
TABLE J.42: ESTIMATED EXPOSURE OF PARCELS TO THE FLOOD HAZARD

Location	1.0-percent ACF			0.2-percent ACF		
	Approx. Number of Parcels	Approx. Number Improved Buildings	Approx. Improved Value of Buildings	Approx. Number of Parcels	Approx. Number Improved Buildings	Approx. Improved Value of Buildings
Wake Forest	789	201	$370,427,376	122	81	$31,659,382

Source: FEMA DFIRM

Social Vulnerability
Since 2010 population was available at the tract level, it was difficult to determine a reliable figure on population at-risk to flood due to tract level population data. **Figure J.12** is presented to gain a better understanding of at risk population.

FIGURE J.12 : POPULATION DENSITY NEAR FLOODPLAINS



Source: FEMA DFIRM, U.S. Census 2010

Critical Facilities

The critical facility analysis revealed that there are a no critical facilities located in the Wake Forest 1.0-percent annual chance floodplain and 0.2-percent annual chance floodplain based on FEMA DFIRM boundaries and GIS analysis. A list of specific critical facilities and their associated risk can be found in **Table J.48** at the end of this section.

In conclusion, a flood has the potential to impact many existing and future buildings and populations in Wake Forest, though some areas are at a higher risk than others. All types of structures in a floodplain are at-risk, though elevated structures will have a reduced risk. As noted, the floodplains used in this analysis include the 100-year and 500-year FEMA regulated floodplain boundaries. It is certainly possible that more severe events could occur beyond these boundaries or urban (flash) flooding could impact additional structures. Such site-specific vulnerability determinations are outside the scope of this assessment but will be considered during future plan updates. Furthermore, areas subject to repetitive flooding should be analyzed for potential mitigation actions.

Hazardous Materials Incident

Although historical evidence and existing Toxic Release Inventory sites indicate that Wake Forest is susceptible to hazardous materials events, there are few reports of damage. Therefore, it is difficult to

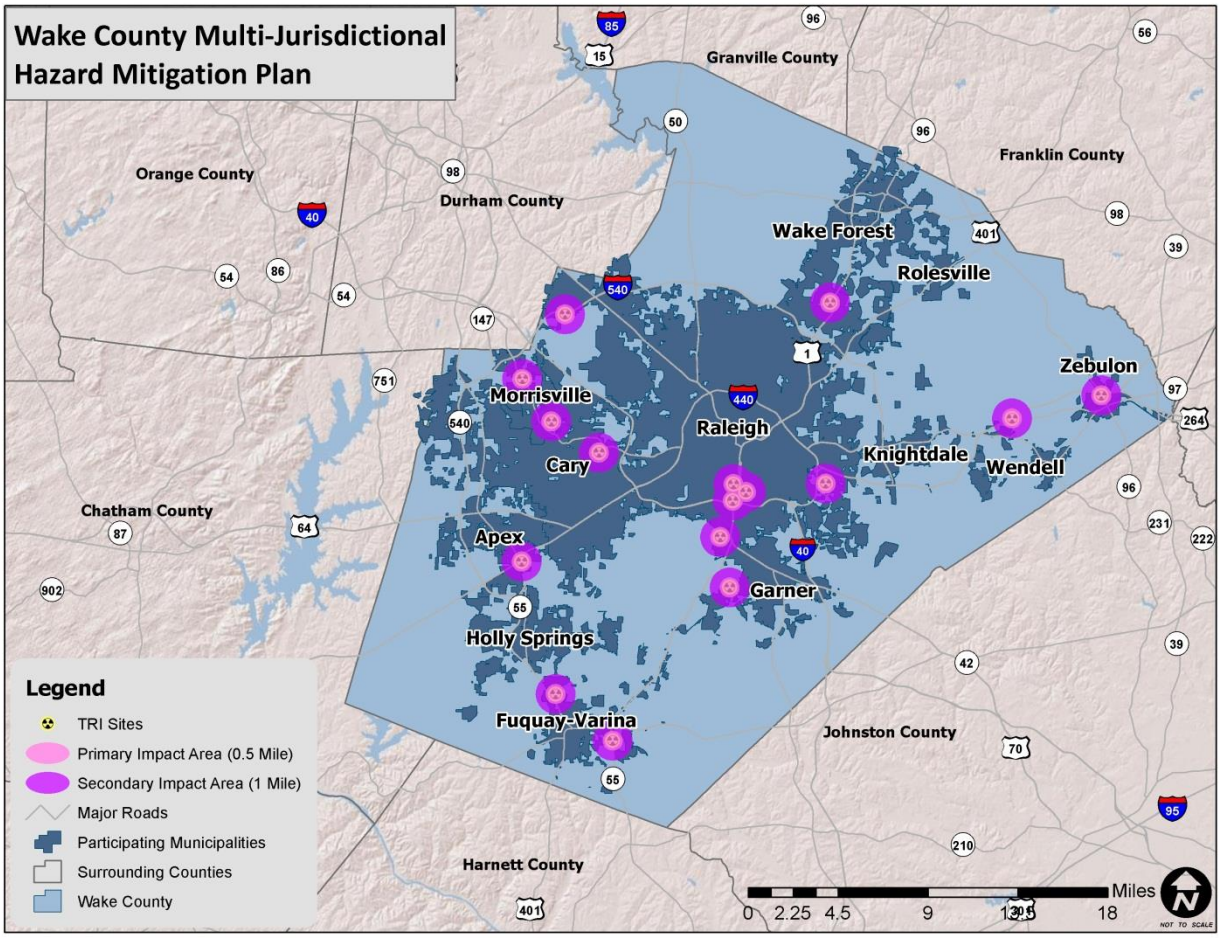
calculate a reliable annualized loss figure. It is assumed that while one major event could result in significant losses, annualizing structural losses over a long period of time would most likely yield a negligible annualized loss estimate for Wake Forest.

Most hazardous materials incidents that occur are contained and suppressed before destroying any property or threatening lives. However, they can have a significant negative impact. Such events can cause multiple deaths, completely shut down facilities for 30 days or more, and cause more than 50 percent of affected properties to be destroyed or suffer major damage. In a hazardous materials incident, solid, liquid, and/or gaseous contaminants may be released from fixed or mobile containers. Weather conditions will directly affect how the hazard develops. Certain chemicals may travel through the air or water, affecting a much larger area than the point of the incidence itself. Non-compliance with fire and building codes, as well as failure to maintain existing fire and containment features, can substantially increase the damage from a hazardous materials release. The duration of a hazardous materials incident can range from hours to days. Warning time is minimal to none.

In order to conduct the vulnerability assessment for this hazard, GIS intersection analysis was used for fixed and mobile areas and parcels.[19] In both scenarios, two sizes of buffers—0.5-mile and 1.0-mile—were used. These areas are assumed to respect the different levels of effect: immediate (primary) and secondary. Primary and secondary impact sites were selected based on guidance from the PHMSA Emergency Response Guidebook. For the fixed site analysis, geo-referenced TRI listed toxic sites in Wake Forest, along with buffers, were used for analysis as shown in **Figure J.13.** For the mobile analysis, the major roads (Interstate highway, U.S. highway, and State highway) and railroads, where hazardous materials are primarily transported that could adversely impact people and buildings, were used for the GIS buffer analysis. **Figure J.14** shows the areas used for mobile toxic release buffer analysis. The results indicate the approximate number of parcels, improved value, as shown in **Table J.43** (fixed sites), **Table J.44** (mobile road sites) and **Table J.45** (mobile railroad sites).[20]

[19] This type of analysis will likely yield inflated results (generally higher than what is actually reported after an event).
[20] Note that parcels included in the 1.0-mile analysis are also included in the 0.5-mile analysis.

FIGURE J.13 : TRI SITES WITH BUFFERS IN WAKE FOREST



Source: EPA

TABLE J.43: EXPOSURE OF IMPROVED PROPERTY TO HAZARDOUS MATERIALS (FIXED SITES)

Location	0.5-mile buffer			1.0-mile buffer		
	Approx. Number of Parcels	Approx. Number Improved	Approx. Improved Value	Approx. Number of Parcels	Approx. Number Improved	Approx. Improved Value
Wake Forest	0	0	$0	4	11	$1,078,101

FIGURE J.14 : MOBILE HAZMAT BUFFERS IN WAKE FOREST

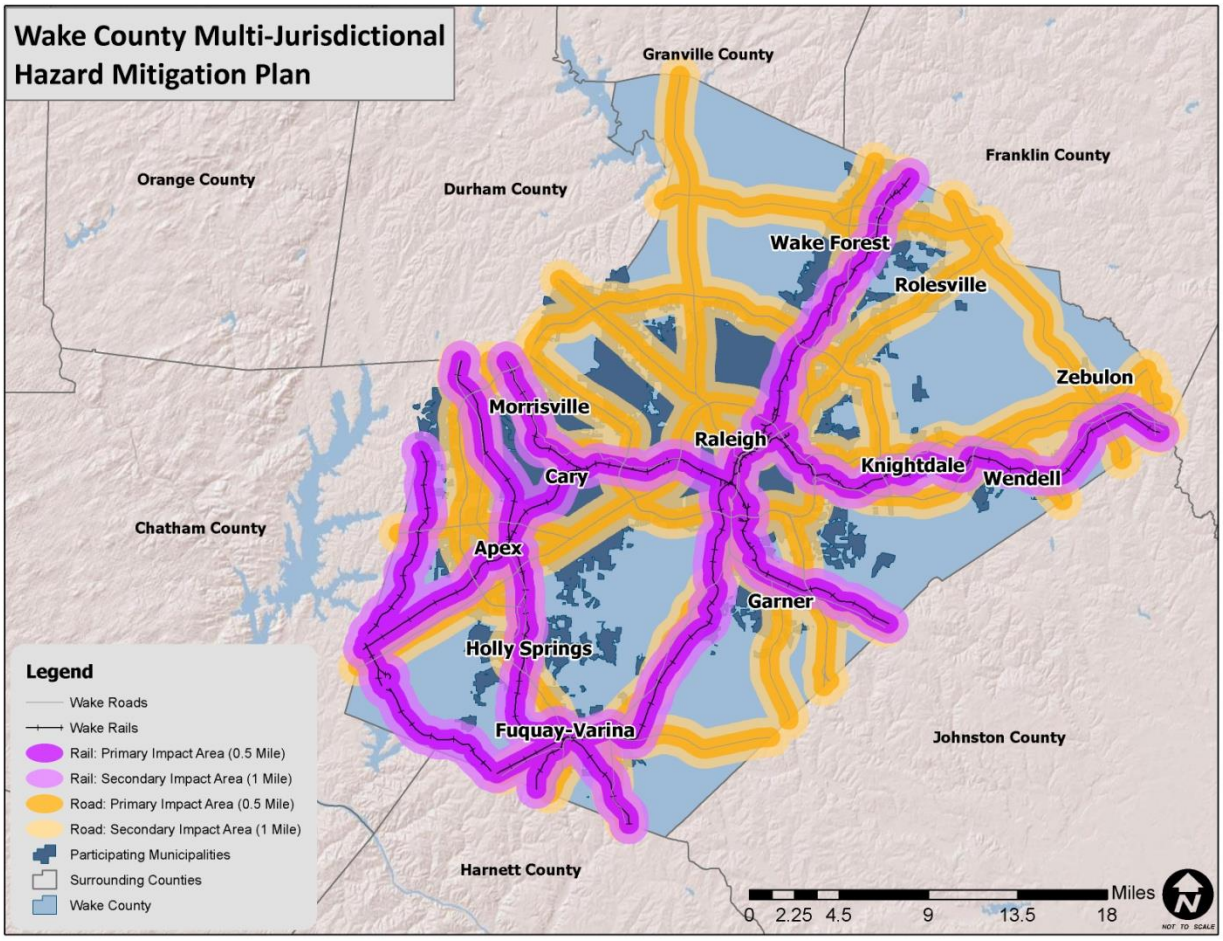


TABLE J.44: EXPOSURE OF IMPROVED PROPERTY TO HAZARDOUS MATERIALS SPILL (MOBILE ANALYSIS - ROAD)

Location	0.5-mile buffer			1.0-mile buffer		
	Approx. Number of Parcels	Approx. Number Improved	Approx. Improved Value	Approx. Number of Parcels	Approx. Number Improved	Approx. Improved Value
Wake Forest	6,844	6,987	$1,445,105,064	9,208	9,345	$2,003,231,609

TABLE J.45: EXPOSURE OF IMPROVED PROPERTY TO HAZARDOUS MATERIALS SPILL (MOBILE ANALYSIS - RAILROAD)

Location	0.5-mile buffer			1.0-mile buffer		
	Approx. Number of Parcels	Approx. Number Improved	Approx. Improved Value	Approx. Number of Parcels	Approx. Number Improved	Approx. Improved Value
Wake Forest	3,975	4,525	$803,998,355	6,645	6,942	$1,448,927,511

Social Vulnerability
Given high susceptibility across the jurisdiction, it is assumed that the total population is at risk to a hazardous materials incident. It should be noted that areas of population concentration may be at an elevated risk due to a greater burden to evacuate population quickly.

Critical Facilities
Fixed Site Analysis:
The critical facility analysis for fixed TRI sites revealed that no critical facilities are located in a HAZMAT risk zone. A list of specific critical facilities and their associated risk can be found in **Table J.48** at the end of this section.

Mobile Analysis:
The critical facility analysis for road and railroad transportation corridors in Wake Forest revealed that there are 24 critical facilities are located in a HAZMAT risk zone. The primary impact zone includes 22 facilities. The remaining facilities are in the secondary, 1.0-mile zone. The railroad buffer areas include 21 facilities with 16 in the primary impact zone. It should be noted that many of the facilities located in the buffer areas for railroad are also located in the buffer areas for road and/or the fixed site analysis. A list of specific critical facilities and their associated risk can be found in **Table J.48** at the end of this section.

In conclusion, a hazardous material incident has the potential to impact many existing and future buildings, critical facilities, and populations in Wake Forest. Those areas in a primary buffer are at the highest risk, though all areas carry some vulnerability due to variations in conditions that could alter the impact area such direction and speed of wind, volume of release, etc. Further, incidents from neighboring jurisdictions could also have an impact.

Wildfire
Although historical evidence indicates that Wake Forest is susceptible to wildfire events, there are few reports of damage. Upon conversion of the wildfire risk data (see Section 6: *Vulnerability Assessment*) and completion of the wildfire analysis, it was determined that less than 4,000 square feet in the entire county registered at over 1 on the Level of Concern scale for wildfire. This indicates that the relative risk of wildfire is extremely low compared to other counties in the state, which resulted in zero or near zero counts of buildings and facilities located in the wildfire risk zones. Therefore, no tables or figures are included and the overall risk for the jurisdiction should be assumed to be very low. As such, it is difficult to calculate a reliable annualized loss figure. Annualized loss is considered negligible though it should be noted that a single event could result in significant damages throughout the county.

Social Vulnerability
All areas have relatively equal vulnerability and there is low susceptibility across the entire county.
It is assumed that the total population is at low risk to the wildfire hazard.

Critical Facilities
The critical facility analysis revealed that there are no critical facilities located in wildfire areas of concern. It should be noted, however, that several factors could impact the spread of a wildfire putting all facilities at risk. A list of specific critical facilities and their associated risk can be found in **Table J.48** at the end of this section.

In conclusion, a wildfire event has the potential to impact some existing and future buildings, critical facilities, and populations in Wake Forest.

Nuclear Accident

The location of Shearon Harris Nuclear Station in southwest Wake County demonstrates that the county is at risk to the effects of a nuclear accident. Although there have not been any major events at this plant in the past, there have been major events at other nuclear stations around the country. Additionally, smaller scale incidents at Shearon-Harris Nuclear Station have occurred.

In order to assess nuclear risk, a GIS-based analysis was used to estimate exposure during a nuclear event within each of the risk zones described in *Section 5: Hazard Profiles*. The determination of assessed value at-risk (exposure) was calculated using GIS analysis by summing the total assessed building values for only those improved properties that were confirmed to be located within one of the risk zones. All areas of Wake County are located within one of the risk zones. **Table J.46** present the potential at-risk property. Both the number of parcels/buildings and the approximate value are presented.

TABLE J.46: ESTIMATED EXPOSURE OF PARCELS/BUILDINGS TO A NUCLEAR ACCIDENT

Location	10-mile buffer			50-mile buffer		
	Approx. Number of Parcels	Approx. Number Improved Buildings	Approx. Improved Value of Buildings[21]	Approx. Number of Parcels	Approx. Number Improved Buildings	Approx. Improved Value of Buildings[22]
Wake Forest	0	0	$0	12,035	11,476	$2,819,911,530

Social Vulnerability

Since all areas of the county are within at least the 50-mile buffer area, the total population is considered to be at risk to a nuclear accident. However, populations in the southwest part of the county are considered to be at an elevated risk.

Critical Facilities

The critical facility analysis revealed that there are no critical facilities located in the 10-mile nuclear buffer area in Wake Forest.

In conclusion, a nuclear accident has the potential to impact many existing and future buildings, facilities, and populations in Wake Forest, though areas closer to the power plant are at a higher risk than others. All structures are at some risk given that they are all located within at least the 50-mile buffer area.

Conclusions on Hazard Vulnerability

Table J.47 presents a summary of annualized loss for each hazard in Wake Forest. Due to the reporting of hazard damages primarily at the county level, it was difficult to determine an accurate annualized loss estimate for each municipality. Therefore, although an annualized loss was determined through the damage reported through historical occurrences at the municipal level, it is likely that the county-wide

[21] Improved value of buildings is estimated based on the building value associated with parcels that have been identified as being located in the 10-mile buffer, since building footprints were not associated with dollar value data.
[22] Improved value of buildings is estimated based on the building value associated with parcels that have been identified as being located in the 50-mile buffer, since building footprints were not associated with dollar value data.

estimate (found in Section 6: *Vulnerability Assessment*) is potentially a better estimate. These values should be used as an additional planning tool or measure risk for determining hazard mitigation strategies.

TABLE J.47: ANNUALIZED LOSS FOR WAKE FOREST*

Event	Wake Forest
Dam Failure	Negligible
Drought	Negligible
Erosion	Negligible
Extreme Heat	Negligible
Hail	Negligible
Hurricane & Tropical Storm	Negligible
Landslide	Negligible
Lightning	$3,723
Thunderstorm Wind/High Wind[23]	Negligible
Tornado	Negligible
Winter Storm & Freeze	Negligible
Flood	Negligible
Earthquake	Negligible
HAZMAT Incident	Negligible
Wildfire	Negligible
Nuclear Accident	Negligible
Terror Threat	Negligible

*In this table, the term "Negligible" is used to indicate that no records for the particular hazard were recorded. This could be the case either because there were no events that caused dollar damage or because documentation of that particular type of event is not kept.

As noted previously, all existing and future buildings and populations (including critical facilities) are vulnerable to atmospheric hazards including drought, hailstorm, hurricane and tropical storm, lightning, thunderstorm wind, tornado, and winter storm and freeze. Some buildings may be more vulnerable to these hazards based on locations, construction, and building type. **Table J.48** shows the critical facilities vulnerable to additional hazards analyzed in this section. The table lists those assets that are determined to be exposed to each of the identified hazards (marked with an "**X**").

[23] The annualized losses for these hazards were combined.

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TABLE J.48: AT-RISK CRITICAL FACILITIES IN WAKE FOREST

		ATMOSPHERIC								GEOLOGIC			HYDROLOGIC		OTHER									
FACILITY NAME	FACILITY TYPE	Drought	Extreme Heat	Hailstorm	Hurricane and Tropical Storm	Lightning	Thunderstorm	Tornado	Winter Storm and Freeze	Earthquake	Landslide – High Incidence	Landslide- Mod. Incidence	Flood – 100 yr	Flood – 500 yr	Fixed HAZMAT 0.5 mile	Fixed HAZMAT 1.0 mile	Mobile HZMT 0.5 mile (road)	Mobile HZMT 1.0 mile (road)	Mobile HZMT 0.5 mile (rail)	Mobile HZMT 1.0 mile (rail)	Wildfire	Nuclear Accident 10 mile	Nuclear Accident 50 mile	Terror Threat
WAKE FOREST																								
WAKE FOREST	EMS STATION	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
WAKE FOREST SOUTH	EMS STATION	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
WAKE FOREST #1	FIRE STATION	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
WAKE FOREST #2	FIRE STATION	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
WAKE FOREST #3	FIRE STATION	X	X	X	X	X	X	X	X	X													X	X
WAKE FOREST #4	FIRE STATION	X	X	X	X	X	X	X	X	X							X	X					X	X
WATER TREATMENT PLAN	OTHER	X	X	X	X	X	X	X	X	X							X	X					X	X
TOWN HALL	OTHER	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
SEWER TREATMENT PLANT	OTHER	X	X	X	X	X	X	X	X	X													X	X
PUBLIC WORKS OPERATIONS CENTER	OTHER	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
CARILLON ASSISTED LIVING	OTHER	X	X	X	X	X	X	X	X	X								X	X	X			X	X
HILLSIDE NURSING CENTER	OTHER	X	X	X	X	X	X	X	X	X							X	X		X			X	X
CAROLINA HOUSE OF WAKE FOREST	OTHER	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
THE LODGE (ELDERLY HOUSING)	OTHER	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
TURNBERRY APARTMENTS (ELDERLY HOUSING)	OTHER	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
MAIN	POLICE	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X

		ATMOSPHERIC								GEOLOGIC			HYDROLOGIC		OTHER									
FACILITY NAME	FACILITY TYPE	Drought	Extreme Heat	Hailstorm	Hurricane and Tropical Storm	Lightning	Thunderstorm	Tornado	Winter Storm and Freeze	Earthquake	Landslide – High Incidence	Landslide- Mod. Incidence	Flood – 100 yr	Flood – 500 yr	Fixed HAZMAT 0.5 mile	Fixed HAZMAT 1.0 mile	Mobile HZMT 0.5 mile (road)	Mobile HZMT 1.0 mile (road)	Mobile HZMT 0.5 mile (rail)	Mobile HZMT 1.0 mile (rail)	Wildfire	Nuclear Accident 10 mile	Nuclear Accident 50 mile	Terror Threat
	STATION																							
SUBSTATION TWO	POLICE STATION	X	X	X	X	X	X	X	X	X							X	X		X			X	X
SUBSTATION THREE	POLICE STATION	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
SUBSTATION FOUR	POLICE STATION	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
WAKE FOREST ES	SCHOOL	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
WAKE FOREST MS	SCHOOL	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
WAKE FOREST HS	SCHOOL	X	X	X	X	X	X	X	X	X							X	X	X	X			X	X
HERITAGE MS	SCHOOL	X	X	X	X	X	X	X	X	X								X		X			X	X
HERITAGE ES	SCHOOL	X	X	X	X	X	X	X	X	X								X		X			X	X
WAKEFIELD 9TH GRADE CENTER	SCHOOL	X	X	X	X	X	X	X	X	X							X	X					X	X
RICHLAND CREEK ES	SCHOOL	X	X	X	X	X	X	X	X	X							X	X					X	X
HERITAGE HS	SCHOOL	X	X	X	X	X	X	X	X	X										X			X	X

Secondary Critical Facilities are listed in slight contrast to Critical Facilities as their continued function has not been deemed as critical as primary facilities in the event of a disaster, but these facilities are extremely important. A loss of function to one of these facilities would have a definitively greater negative impact on the community's ability to respond to and recover from a disaster than a loss of function at other facilities/structures within the jurisdiction. In **Table J.49**, these facilities have been classified as either Significant Community Locations/Sheltering Centers or as Critical Resources Management Facilities. These facilities are all vulnerable to any of the atmospheric hazards and many are also likely vulnerable to other hazards identified above, though no locational analysis was carried out to this end.

TABLE J.49: WAKE FOREST SECONDARY CRITICAL FACILITIES

Facility Name	Address*	Type
Wake Forest		
Community House	133 West Owen Ave	Significant Community Location or Sheltering Center
Alston-Massenburg Recreation Center	416 Taylor St	Significant Community Location or Sheltering Center
Flaherty Park Center	North White Street	Significant Community Location or Sheltering Center
Electric Substation	West Cedar Ave	Critical Resources Management (Energy, Water, etc.)
Wake Forest Urgent Care		Significant Community Location or Sheltering Center
Fast Med		Significant Community Location or Sheltering Center
Public Service Company of NC		Critical Resources Management (Energy, Water, etc.)
Century Link Phone Service		Critical Resources Management (Energy, Water, etc.)
Wake Forest Power		Critical Resources Management (Energy, Water, etc.)
Duke Energy		Critical Resources Management (Energy, Water, etc.)
Wake Electric Membership Corporation		Critical Resources Management (Energy, Water, etc.)
Holding Oil Company		Critical Resources Management (Energy, Water, etc.)
Cruziers		Critical Resources Management (Energy, Water, etc.)
The Learning Experience		Significant Community Location or Sheltering Center
Wake Forest Child Care Center		Significant Community Location or Sheltering Center
Children's Adventure		Significant Community Location or Sheltering Center
Primrose School of Heritage		Significant Community Location or Sheltering Center
Goddard School		Significant Community Location or Sheltering Center
Wake Forest Kids-R-Kids		Significant Community Location or Sheltering Center
Kids Educational Center		Significant Community Location or Sheltering Center
Heritage Children's Academy		Significant Community Location or Sheltering Center
Rising Star Christian Academy		Significant Community Location or Sheltering Center
Wake Forest Baptist Church		Significant Community Location or Sheltering Center
St. John's Episcopal Church		Significant Community Location or Sheltering Center
Hope Lutheran Church		Significant Community Location or Sheltering Center
Wake Forest Presbyterian Church		Significant Community Location or Sheltering Center
St. Catherine of Siena Early Childhood Center		Significant Community Location or Sheltering Center

Facility Name	Address*	Type
Thales Academy		Significant Community Location or Sheltering Center
Endeavor Charter School		Significant Community Location or Sheltering Center
Wake Forest Charter Academy		Significant Community Location or Sheltering Center
Franklin Academy		Significant Community Location or Sheltering Center
St. Catherine's School		Significant Community Location or Sheltering Center
Southeastern Baptist Seminary		Significant Community Location or Sheltering Center
Dubois Center		Significant Community Location or Sheltering Center
Boys and Girls Club		Significant Community Location or Sheltering Center
US Post Office		Significant Community Location or Sheltering Center
Wake Forest Library		Significant Community Location or Sheltering Center
Wakefields		Significant Community Location or Sheltering Center
Glen Royall Apartments		Significant Community Location or Sheltering Center
Calvin Jones House		Significant Community Location or Sheltering Center
I.O. Jones House		Significant Community Location or Sheltering Center
Forestville Baptist Church		Significant Community Location or Sheltering Center
Oak Forest		Significant Community Location or Sheltering Center
Hartsfield House		Significant Community Location or Sheltering Center
Purefoy-Dunn House		Significant Community Location or Sheltering Center
Crenshaw Hall		Significant Community Location or Sheltering Center
Community House		Significant Community Location or Sheltering Center
Purefoy-Chappell House		Significant Community Location or Sheltering Center
Powell House		Significant Community Location or Sheltering Center

**Some address information could not be provided or was not applicable to the facility*

J.4 TOWN OF WAKE FOREST CAPABILITY ASSESSMENT

This subsection discusses the capability of the Town of Wake Forest to implement hazard mitigation activities. More information on the purpose and methodology used to conduct the assessment can be found in Section 7: *Capability Assessment*.

J.4.1 Planning and Regulatory Capability

Table J.50 provides a summary of the relevant local plans, ordinances, and programs already in place or under development for the Town of Wake Forest. A checkmark (✓) indicates that the given item is currently in place and being implemented. An asterisk (*) indicates that the given item is currently being developed for future implementation. Each of these local plans, ordinances, and programs should be considered available mechanisms for incorporating the requirements of the Wake County Hazard Mitigation Plan.

TABLE J.50: RELEVANT PLANS, ORDINANCES, AND PROGRAMS

Planning Tool/Regulatory Tool	Hazard Mitigation Plan	Comprehensive Land Use Plan	Floodplain Management Plan	Open Space Management Plan (Parks & Rec/Greenway Plan	Stormwater Management Plan/Ordinance	Natural Resource Protection Plan	Flood Response Plan	Emergency Operations Plan	Continuity of Operations Plan	Evacuation Plan	Disaster Recovery Plan	Capital Improvements Plan	Economic Development Plan	Historic Preservation Plan	Flood Damage Prevention Ordinance	Zoning Ordinance	Subdivision Ordinance	Unified Development Ordinance	Post-Disaster Redevelopment Ordinance	Building Code	Fire Code	National Flood Insurance Program (NFIP)	NFIP Community Rating System
Wake Forest	✓	✓		✓	✓			✓				✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	

A more detailed discussion on the town's planning and regulatory capabilities follows.

Emergency Management

Hazard Mitigation Plan
The Town of Wake Forest has previously adopted a hazard mitigation plan.

Emergency Operations Plan
The Town of Wake Forest has adopted the Wake County Emergency Operations Plan. The town also maintains a municipal-level emergency operations plan.

General Planning

Comprehensive Land Use Plan
The Town of Wake Forest has adopted the *Wake Forest Community Plan*.

Capital Improvements Plan
The Town of Wake Forest has a five-year capital improvement plan in place.

Historic Preservation Plan
The Town of Wake Forest has adopted a historic preservation plan.

Zoning Ordinance
The Town of Wake Forest includes zoning regulations as part of the local unified development ordinance.

Subdivision Ordinance
The Town of Wake Forest also includes subdivision regulations as part of the local unified development ordinance.

Building Codes, Permitting, and Inspections
North Carolina has a state compulsory building code which applies throughout the state. The building code is enforced within the town's planning jurisdiction by the Town of Wake Forest Inspections Department.

Floodplain Management

Table J.51 provides NFIP policy and claim information for the Town of Wake Forest.

TABLE J.51: NFIP POLICY AND CLAIM INFORMATION

Jurisdiction	Date Joined NFIP	Current Effective Map Date	NFIP Policies in Force	Insurance in Force	Closed Claims	Total Payments to Date
Wake Forest	07/02/78	04/16/13	123	$35,436,900	0	$0

Source: NFIP Community Status information as of 3/20/14; NFIP claims and policy information as of 12/31/13

Flood Damage Prevention Ordinance
All communities participating in the NFIP are required to adopt a local flood damage prevention ordinance. The Town of Wake Forest participates in the NFIP and has adopted flood damage prevention regulations.

Open Space Management Plan
The Town of Wake Forest has adopted an open space and greenways plan as well as a parks and recreation master plan.

Stormwater Management Plan
The Town of Wake Forest has not adopted a stormwater management plan; however, the town includes stormwater management regulations as part of the local unified development ordinance.

J.4.2 Administrative and Technical Capability

Table J.52 provides a summary of the capability assessment results for the Town of Wake Forest with regard to relevant staff and personnel resources. A checkmark (✓) indicates the presence of a staff member(s) in the town with the specified knowledge or skill.

TABLE J.52: RELEVANT STAFF / PERSONNEL RESOURCES

Staff / Personnel Resource	Planners with knowledge of land development/land management practices	Engineers or professionals trained in construction practices related to buildings and/or infrastructure	Planners or engineers with an understanding of natural and/or human-caused hazards	Emergency Manager	Floodplain Manager	Land Surveyors	Scientists familiar with the hazards of the community	Staff with education or expertise to assess the community's vulnerability to hazards	Personnel skilled in GIS and/or Hazus	Resource development staff or grant writers
Wake Forest	✓	✓	✓	✓	✓		✓	✓	✓	

Credit for having a floodplain manager was given to those jurisdictions that have a flood damage prevention ordinance, and therefore an appointed floodplain administrator, regardless of whether the appointee was dedicated solely to floodplain management. Credit was given for having a scientist familiar with the hazards of the community if a jurisdiction has a Cooperative Extension Service or Soil and Water Conservation Department. Credit was also given for having staff with education or expertise to assess the community's vulnerability to hazards if a staff member from the jurisdiction was a participant on the existing hazard mitigation plan's planning committee.

J.4.3 Fiscal Capability

Table J.53 provides a summary of the results for the Town of Wake Forest with regard to relevant fiscal resources. A checkmark (✓) indicates that the given fiscal resource is locally available for hazard mitigation purposes (including match funds for state and federal mitigation grant funds) according to the previous hazard mitigation plan.

TABLE J.53: RELEVANT FISCAL RESOURCES

Fiscal Tool / Resource	Capital Improvement Programming	Community Development Block Grants (CDBG)	Special Purpose Taxes (or taxing districts)	Gas/Electric Utility Fees	Water/Sewer Fees	Stormwater Utility Fees	Development Impact Fees	General Obligation, Revenue, and/or Special Tax Bonds	Partnering Arrangements or Intergovernmental Agreements	Other: PDM, FMAP, HMGP, PA, other Federal and state funding sources, etc.
Wake Forest	✓								✓	✓

J.4.4 Political Capability

The Town of Wake Forest is currently a participant in the NFIP and has adopted the required Flood Damage Prevention Ordinance. The Unified Development Ordinance also includes erosion, stormwater, and watershed standards. This demonstrates to some extent both favorable political support and a willingness to adopt hazard mitigation efforts in an active manner.

J.4.5 Conclusions on Local Capability

Table J.54 shows the results of the capability assessment using the designed scoring methodology described in Section 7: *Capability Assessment*. The capability score is based solely on the information found in existing hazard mitigation plan and readily available on the town's government website. According to the assessment, the local capability score for the town is 40, which falls into the high capability ranking.

TABLE J.54: CAPABILITY ASSESSMENT RESULTS

Jurisdiction	Overall Capability Score	Overall Capability Rating
Wake Forest	40	High

J.5 TOWN OF WAKE FOREST MITIGATION STRATEGY

This subsection provides the blueprint for Wake Forest to follow in order to become less vulnerable to its identified hazards. It is based on general consensus of the Regional Work Groups and the findings and conclusions of the capability assessment and risk assessment. Additional Information can be found in Section 8: *Mitigation Strategy* and Section 9: *Mitigation Action Plan*.

J.5.1 Mitigation Goals

Wake Forest developed seven mitigation goals in coordination with Wake County and the other participating municipalities. The county-wide mitigation goals are presented in **Table J.55**.

TABLE J.55: WAKE COUNTY MITIGATION GOALS

	Goal
Goal #1	Protect public health, life, safety, and welfare by increasing public awareness and education of hazards and by encouraging collective and individual responsibility for mitigating hazard risks.
Goal #2	Improve technical capability to respond to hazards and to improve the effectiveness of hazard mitigation actions
Goal #3	Enhance existing or create new policies and ordinances that will help reduce the damaging effects of natural hazards.
Goal #4	Minimize threats to life and property by protecting the most vulnerable populations, buildings, and critical facilities through the implementation of cost-effective and technically feasible mitigation actions.
Goal #5	Generally reduce the impact of all natural hazards
Goal #6	Ensure that hazard mitigation is considered when redevelopment occurs after a natural disaster.
Goal #7	Ensure that disaster response and recovery personnel have the necessary equipment and supplies available in order to serve the public in the event of a disaster

J.5.2 Mitigation Action Plan

The mitigation actions proposed by Wake Forest are listed in the following Mitigation Action Plan.

Town of Wake Forest Mitigation Action Plan

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
Prevention							
P-1	Consider preventing all unnecessary development in the flood plains.	Flood	High	Wake Forest Planning	Local	Completed	The town prevents all unnecessary development in the floodplain through regulation. This action will be removed from the next update.
P-2	Examine and modify, if needed, policies and procedures for utility stream crossings.	All	High	Wake Forest Engineering	General Fund	Completed	Through 2014, the town has examined and modified procedures for stream crossings so this action has been completed and will be removed from the next update.
P-3	Prepare a Storm Drainage Master Plan to include all storm drainage, infrastructure, and capacity analysis.	Flood	High	Wake Forest Engineering	General Fund	2017	A Storm Drainage Master Plan has been developed to include drainage, infrastructure and capacity analysis. However, this plan will need to be reviewed and updated going forward so the action will remain in the plan.
P-4	Maintain inventory of dams.	Dam Failure	High	Wake Forest Engineering	General Fund	Completed	An inventory of dams has been built and is updated when necessary. This action will be removed from the next update.
P-5	Maintain clear right-of-ways by removing fallen trees.	Flood, Hurricane, Thunderstorm	High	Wake Forest Power	Electric Fund	Completed	Fallen trees are cleared as quickly as possible so that right of ways can be maintained. This action will be removed from the next update as a capability.
P-6	Ensure that as many electric lines as possible are looped.	Flood, Hurricane, Thunderstorm	High	Wake Forest Power	Electric Fund	Completed	Electric lines are looped whenever possible. This action will be removed from the next update as a capability.

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
P-7	Ensure that underground equipment is installed above the flood plain.	Flood, Hurricane, Thunderstorm	High	Wake Forest Power	Electric Fund	Completed	No development is permitted in floodplains by ordinance. This action will be removed from the next update as a capability.
P-8	Enforce burn bans and the littering ordinance regarding the discarding of cigarette butts during times of drought.	Wildfire	High	Wake Forest Police	General Fund	Completed	Burn bans and the littering ordinance are enforced, especially during drought periods. This action will be removed from the next update as a capability.
P-9	Update annually the hazardous material inventory, as required by law.	Hazardous Materials Incident	High	Wake Forest Inspections and Fire	General Fund, Fire Tax Revenue	Completed	The hazardous material inventory is reviewed and updated annually. This action will be removed from the next update as a capability.
P-10	Add amendments to the hazardous materials inventory as frequently as the information is available.	Hazardous Materials Incident	High	Wake Forest Inspections and Fire	General Fund, Fire Tax Revenue	Completed	Amendments have been added to the inventory very quickly in the past and this will continue to be done in the future. This action will be removed from the next update as a capability.
P-11	Obtain an inventory of hazardous material storage sites within a five mile radius of town.	Hazardous Materials Incident	High	Wake Forest Fire and/or Wake and Franklin Counties	General Fund, Fire Tax Revenue, County	Completed	An inventory of these sites has been obtained. This action will be removed from the next update as a capability.
P-12	Coordinate with Wake County and with the Wake County Plan on nuclear accident planning.	Nuclear	High	Wake Forest Fire and Police	General Fund	Completed	The town regularly coordinates with Wake County on nuclear planning. This action will be removed from the next update as a capability.
P-13	Identify high occupancy areas along US#1 which may be heavily impacted in the event of an accident along the highway.	Nuclear	Moderate	Wake Forest Fire and Police	General Fund	Completed	High occupancy areas along US 1 have been identified. This action will be removed from the next update as a capability.

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
P-14	Cooperate with Wake County Public Safety in developing a Terrorist Response Plan.	Terrorist Threat	High	Wake Forest Fire and Police Coordinator	General Fund	Completed	Wake County has developed a Terrorist Response Plan. This action will be removed from the next update as a capability.
P-15	Identify security issues with utilities.	Terrorist Threat	High	Wake Forest Public Works and Power	General Fund and Electric Fund	Completed	The town has identified high risk utilities and potential security issues. This action will be removed from the next update as a capability.
P-16	Security measures in effect at the new Town Hall, when completed.	Terrorist Threat	High	Wake Forest Town Administration	General Fund	Completed	The town has implemented security measures at the new town hall. This action will be removed from the next update as a capability.
P-17	Review and revise the existing response plan and call list, as needed	All	High	Wake Forest Administration	General Fund	2016	The town has reviewed and revised the existing response list. However, this list will need to be updated in the near future, so this action will remain in the plan.
P-18	Put electric distribution lines underground.	All	Low	Wake Forest Power	Electric Fund and General Fund	2019	Where feasible, electric lines have been put underground. However, there are still some lines that could be buried and the town will look into carrying that out going forward.
P-19	Require, where possible, multiple accessibility routes through proper design of the street layout.	All	High	Wake Forest Planning	General Fund	Completed	Transportation Plan updated to include multiple accessibility in many areas. Plan is being implemented.
P-20	Coordinate with nearby counties, including Franklin and Granville, as well as Wake.	All	High	Wake Forest Fire and Police and Communications	General Fund and Fire Tax Revenue	Completed	The town coordinates across several counties on many planning and EM activities. This action will be removed from the next update as a capability.

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
P-21	Develop a policy for preplanning before an event.	All	High	Wake Forest Public Works, Fire, Police, Administration, and Communications	General Fund and Fire Tax Revenue	Completed	The town has developed a policy for pre-planning prior to an event that coordinates with Wake County. This action will be removed from the next update as a capability.
P-22	Review and revise the existing call list, as needed.	All	High	Wake Forest Administration	General Fund	Deleted	This action has been determined not to be extremely applicable to mitigation so it was deleted
P-23	Adopt and implement a tree trimming and maintenance procedure for power lines.	All	High	Wake Forest Electric, Urban Forestry Board	Electric Fund	Completed	A tree trimming and maintenance policy was developed and is in place. This action will be removed from the next update as a capability.
P-24	Adopt and implement a policy of tree swapping (tall for understory trees under lines).	All	Moderate	Wake Forest Power, Urban Forestry Board	Electric Fund, General Fund	Completed	A policy for tree swapping has also been developed and is in place. This action will be removed from the next update as a capability.
P-25	Adopt a policy to power down before major damage is done and make the public aware of this policy.	All	High	Wake Forest Electric	Electric Fund	Completed	A policy to power down before major events and reduce the risk of major damage has been adopted and implemented. This action will be removed from the next update as a capability.
P-26	Develop and implement a policy to inspect utility poles and replace them, as needed.	All	High	Wake Forest Electric	Electric Fund	Completed	A policy to inspect utility poles prior to events has been adopted and is currently being implemented. This action will be removed from the next update as a capability.
P-27	Review problem areas, determine needs, and set priorities for putting lines underground or for relocating overhead lines.	All	High	Wake Forest Power	Electric Fund	Deleted	Similar to P-18, combine and delete

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
P-28	Require that new development install underground wiring.	All	High	Wake Forest Planning and Power	General Fund and Electric Fund	Completed	New development is required to install underground wiring. This action will be removed from the next update as a capability.
P-29	Develop policy to include putting lines underground as other town projects are constructed.	All	High	Wake Forest Administration and Power	General Fund and various project grants	Completed	When other town projects are constructed, lines are put underground. This action will be removed from the next update as a capability.
P-30	Implement the water conservation policy.	All	High	Wake Forest Administration and Power	General Fund	Completed	The town follows City of Raleigh Policy for water conservation. This action will be removed from the next update as a capability.
P-31	Prohibit new in-ground irrigation systems that are tapped into the City of Raleigh system.	All	High	Wake Forest Inspections	General Fund	Deleted	This action was determined to not be technically feasible so it was deleted.
Structural Projects							
SP-1	Conduct stream mitigation projects on Old Mill Stream, Richland Creek, and others subject to flooding or erosion.	Erosion	Moderate	Wake Forest Engineering	General Fund, Clean Water Management Trust Fund, Ecosystem Enhancement Program	2019	Some mitigation projects have been conducted on these water bodies, but there is significant effort that is still needed to reduce potential erosion. The town will work to complete more erosion control projects going forward.
Emergency Services							
ES-1	Require lockboxes at hazardous material storage sites for the Fire Dept.	Hazardous Materials Incident	High	Wake Forest Fire	Property owners	Completed	Lockboxes are required at HazMat storage sites. This action will be removed from the next update as a capability.

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
ES-2	Forward inventory updates and amendments, along with information on risks and potential hazards, to all emergency response organizations.	Hazardous Materials Incident	High	Wake Forest Emergency Management Coordinator (Police)	General fund	Completed	Inventory updates and other information are forwarded to all emergency response organizations. This action will be removed from the next update as a capability.
ES-3	Coordinate with County school system, local school personnel, including Franklin Academy, and Wake County Public Safety Emergency Management.	All	High	Wake Forest Fire, Police, and Emergency Management Coordinator	General Fund	Completed	The town coordinates with the school system, including private schools, on emergency management issues. This action will be removed from the next update as a capability.
ES-4	Provide for primary or mobile generators to shelter sites.	All	Moderate	Wake County Emergency Management	General Fund	2018	Generators in some form are available to shelter sites. However, additional generators would be useful and will be pursued where possible.
ES-5	Coordinate with suppliers of all basic supplies for shelters.	All	High	Wake Forest Administration and Finance	General Fund	Completed	The town coordinates with suppliers to ensure that all shelters are well-equipped with the necessary supplies. This action will be removed from the next update as a capability.
ES-6	Coordinate with suppliers and develop a resource list for fuel and power generation.	All	High	Wake Forest Finance	General Fund	2016	The town coordinates with suppliers to ensure that all shelters are well-equipped with fuel and power generation. This action will be removed from the next update as a capability.
ES-7	Investigate methods of encouraging gas stations to acquire backup generators.	All	High	Wake Forest Public Works and Inspections	General Fund	2017	The town has looked into ways to encourage gas stations to acquire backup generators. In some cases this has occurred, but more work is needed to ensure adequate supply.

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
ES-8	Assess facilities for the need for emergency generation, giving consideration to alternate facility sites.	All	High	Wake Forest Public Works	General Fund	2018	The town has assessed facilities for the need for emergency generation and many facilities have been fitted with generators. However, additional facilities with emergency generation would be useful.
ES-9	Locate generators at necessary facilities, including alternate emergency sites.	All	High	Wake Forest Public Works and Public Buildings	General Fund	Deleted	Similar to ES-8, combine and delete
ES-10	See that all nursing homes and assisted living facilities have backup generators.	All	High	Property owners	Property owners	2018	Although many nursing homes and assisted living facilities have backup generators, this is still a task that remains incomplete so it will remain in the plan.
ES-11	Require, in the contract, that fuel suppliers have backup generators.	All	High	Wake Forest Administration, Finance, and Public Works	Contract holder	2018	Although many fuel suppliers have backup generators, this is still a task that remains incomplete so it will remain in the plan.
ES-12	Develop one or more clearance teams of emergency personnel, coordinating with the Wake Forest Fire Department in this process.	All	High	Wake Forest Fire and Public Works	General Fund and Fire Tax Revenue	Completed	The Fire Department has developed clearance teams to help remove downed trees and other potential debris. This action will be removed from the next update.
ES-13	Train the clearance teams and supply them with chain saws and other emergency equipment.	All	High	Wake Forest Fire and Public Works	General Fund and Fire Tax Revenue	Completed	The Fire Department has trained clearance teams to help remove downed trees and other potential debris. This action will be removed from the next update.

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
ES-14	Follow a specified policy on the use of brine, sand, and plowing to reduce the impact of a storm.	Severe Winter Weather	High	Wake Forest Public Works	General Fund	Completed	A policy has been developed to guide the use of brine, sand, and plowing to reduce the impact of winter storms. This action will be removed from the next update.
ES-15	Implement the county-wide 800 trunking system.	All	High	Wake Forest Police	General Fund, Electric Fund	Completed	A county-wide trunking system has been developed and is in place. This action will be removed from the next update.
ES-16	Purchase necessary communication equipment.	All	High	Each department purchases their own	General Fund	Completed	Communication equipment has been purchased and is utilized by each department in the town. This action will be removed from the next update.
ES-17	Train personnel to use communication equipment.	All	High	Wake Forest Administration	General Fund	Completed	Personnel in each department have been trained to use the communication equipment. This action will be removed from the next update.
ES-18	Coordinate with the natural gas company regarding the gas supply and potential hazards after an event.	All	High	Wake Forest Fire and Police	General Fund	Completed	The natural gas company has been coordinated with concerning how to supply gas after a hazard event. This action will be removed from the next update.
Public Education and Awareness							
PEA-1	Develop or revise a procedure for communication with employees and the public, including alternatives if the existing system fails.	All	High	Wake Forest Communication	General Fund	Completed	The town has developed a system for communicating with employees and the public concerning severe weather and alternative means of contact have been developed as well. This action will be removed from the next update.

Action #	Description	Hazard(s) Addressed	Relative Priority	Lead Agency/ Department	Potential Funding Sources	Implementation Schedule	Implementation Status (2014)
PEA-2	Inform the public periodically about emergency policies.	All	High	Wake Forest Communications	General Fund	Completed	Done – Town contacts residents on call / email list when emergencies happen. This action will be removed from the next update.
PEA-3	Develop a policy and advise the public that all outside above ground LP or propane gas tanks be cut off during a major event.	All	Moderate	Wake Forest Communications	General Fund	2017	A policy is in place to advise the public of turning off propane tanks during a storm, but better outreach is needed to ensure this occurs. Therefore the town will continue to work on an outreach program.