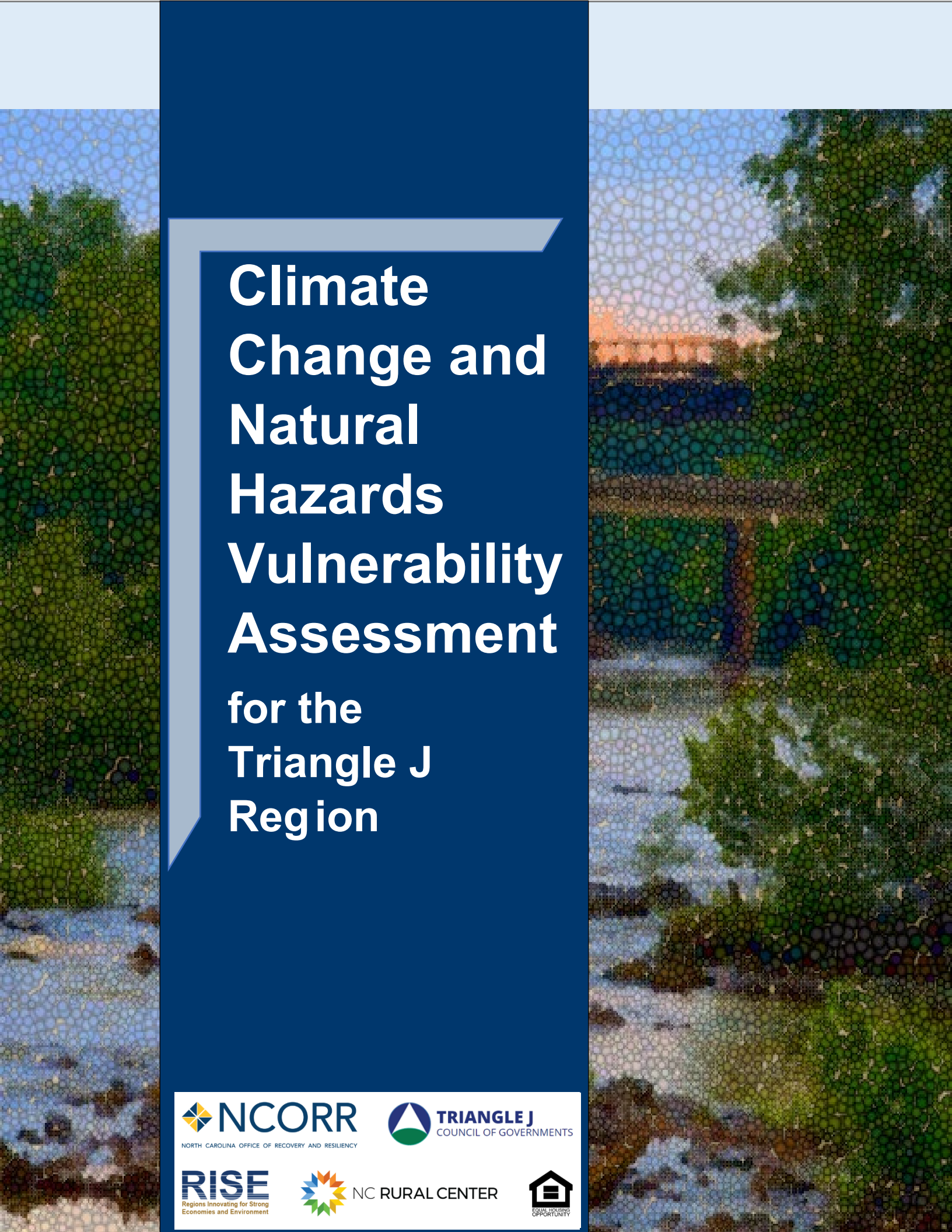

Climate Change and Natural Hazards Vulnerability Assessment

for the Triangle J Region

NCORR
NORTH CAROLINA OFFICE OF RECOVERY AND RESILIENCY

TRIANGLE J
COUNCIL OF GOVERNMENTS

RISE
Regions Innovating for Strong Economies and Environment

NC RURAL CENTER

EQUAL HOUSING OPPORTUNITY

Climate Change and Natural Hazards Vulnerability Assessment for the Triangle J Region

Chatham, Johnston, Lee and Moore Counties

December 2022

About NCORR

In the wake of Hurricane Florence in 2018, the State of North Carolina established the Office of Recovery and Resiliency (NCORR) to lead the state's efforts in rebuilding smarter and stronger. At that time, eastern North Carolina communities were still recovering from Hurricane Matthew, which had impacted the State in 2016. NCORR manages nearly a billion dollars in U.S. Department of Housing and Urban Development (HUD) funding in two grant types, Community Development Block Grant – Disaster Recovery (CDBG-DR) and Community Development Block Grant – Mitigation (CDBG-MIT). These are aimed at making North Carolina communities safer and more resilient from future storms. Additional funding is provided through the State Disaster Recovery Acts of 2017 and 2018, the Storm Recovery Act of 2019 and Economic Development Administration Disaster Supplemental Funds. NCORR manages programs statewide that include homeowner recovery, infrastructure, affordable housing, resilience and strategic buyouts. NCORR is a division of the North Carolina Department of Public Safety. To learn more about NCORR programs, visit ReBuild.NC.Gov.

Land Acknowledgement

We wish to acknowledge and honor the Indigenous communities native to this region and recognize that this vulnerability assessment covers communities and structures that are built on Indigenous homelands and resources. We recognize the Lumbee, Skaruhreh/Tuscarora, Cheraw and Mánu: Yį Įsuwą people as past, present and future caretakers of this land. We also recognize the unnamed tribes that once oversaw these lands and have since relocated or been displaced.

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TRIANGLE J
COUNCIL OF GOVERNMENTS

November 30, 2022

Greetings TJCOG Region,

Our region, encompassing Wake, Durham, Orange, Moore, Lee, Chatham, and Johnston counties, is the heart of North Carolina. We have a great community in which to live, work, and play. Yet, the region faces long-lasting impacts from Hurricanes Matthew and Florence, heat waves, an increasing number of high heat nights, droughts, increasing intensity of rainfall events, and wildfires. However, there is good news in that our region can be highly prepared for these potential impacts.

Considering these challenges, our goal for all seven counties in the Triangle J Region is to take action to strengthen our resilience. In 2018 the urban communities in our region collaborated to create a pilot Triangle Regional Resilience Assessment* (TRRA). Fortunately, in 2021 and 2022 the Department of Environmental Management's Office of Recovery and Resilience coordinated a project called Regions Innovating for Strong Economies & Environment, commonly referred to as the RISE Program. The RISE Program was able to include the four TJCOG counties not in the TRRA, Moore, Lee, Chatham, and Johnston, to create a vulnerability assessment and list of projects to build resilience in these counties as well.

Resilience work includes reducing the immediate and long-lasting risks that natural and climate disasters pose for people, property, infrastructure, and natural resources. The Triangle J Vulnerability Assessment Report, that was part of the RISE process, used rigorous technical analysis combined with local knowledge to outline the major gaps in the four-county-area's preparedness for future natural hazards, climate events, and their impacts. The report is the result of numerous meetings with residents, elected officials, local leaders, the North Carolina Office of Recovery and Resiliency, North Carolina Rural Center, and a contractor called AECOM.

These findings helped identify and prioritize efforts to become more resilient. The Vulnerability Assessment was used develop a suite of up to ten resilience projects for the four-county section of Triangle J. The Vulnerability Assessment is a tool that can be used for those in our region seeking to build independent resilience efforts through community projects and grant applications. As you read through this review of our region's susceptibility to climate impacts, we hope you will think about ways you can work with us to prepare neighborhoods, communities, and the region for the days ahead.

Sincerely,

Lee Worsley, Executive Director, Triangle J Council of Governments

*This document is available on the Triangle J Council of Governments website at www.tjcog.org.

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1. Executive Summary

The Triangle J Region, like much of eastern and central North Carolina, is vulnerable to climate change and natural hazards. Past experiences with disasters and climate stressors demonstrate the vulnerabilities the region faces. However, climate change is also shifting the profile of risk and vulnerability in the region, and it is critical to understand how the future may look different from the past. Anticipating these impacts helps to build a region's resilience.

This vulnerability assessment, paying particular attention to the changes in the area's climate happening now and by the 2050s, establishes a common understanding of the region's hazards, hazard-prone areas, associated impacts and affected populations. The report also reviews the region's strengths and challenges associated with building climate resilience. With this information, stakeholders can craft solutions that respond to highest priority needs and address lesser-known concerns that emerge in the study. This document emphasizes regional analyses and results, but each individual community can use these findings for internal planning, programming and decision-making.

This document presents a vulnerability assessment for **Chatham, Johnston, Lee and Moore Counties** in the Triangle J Council of Governments region, **referred to here as the "Triangle J region."** The three counties not included in this document were included in the 2019 Triangle Regional Resilience Assessment.[1]

The project team—including staff from the North Carolina Office of Recovery and Resiliency (NCORR), the Triangle J Council of Governments, North Carolina Rural Center and AECOM—developed this assessment using data from the state and local governments, academia and previous planning documents; local knowledge and experiences; and information from previous natural disasters.

1.1 Major Hazards

The Triangle J region is most vulnerable to the following climate change and natural hazard risks:

- Hurricanes, storms and flooding
- Extreme temperatures, including high heat indexes and wet bulb globe temperature
- Drought and wildfires

1.2 Summary of Vulnerabilities

This assessment describes several primary issues that drive vulnerability in the region.

[1] Triangle J Council of Governments, *Triangle Regional Resilience Assessment*. 2019. https://www.tjcog.org/publications/triangle-regional-resilience-assessment.

Flood vulnerability

The Triangle J region is vulnerable to flooding from hurricanes and other storms. This vulnerability was demonstrated clearly by Hurricane Matthew (2016), which flooded hundreds of homes and businesses in the region, closed roads and led to other infrastructure failures. One of the challenges the region faces is that the context for flooding is changing rapidly. Furthermore, the context for flooding is changing rapidly as climate change increases the likelihood of more intense storms with heavier rainfall amounts inside and outside the region. These occurrences directly impact homes, businesses, people and infrastructure.

Flood vulnerability and land use change

One of the challenges to reducing flood risk is that new development and growth are accelerating in and around the Triangle J region. Growth contributes to a community's economic prosperity, associated land use changes and increases in impervious surfaces, all of which drive increased flood risk for new and old residents alike. An increase in impervious surfaces has adverse impacts on natural systems like forested ecosystems and wetlands, which act as sponges to absorb precipitation and runoff. More impervious surface area leads to less infiltration and more stormwater runoff. This reduction in natural water absorption is straining stormwater systems and increasing flood impacts. Any new development placed in or near the floodplain also creates new vulnerabilities. However, it is evident that the region needs additional housing development, as regional growth has strained the existing housing stock and there is a shortage of housing to meet growing population.

Housing conditions and disparities

In the Triangle J region, pockets of high social vulnerability and concentrations of inadequate housing and housing characteristics put people at risk. Flooding is the greatest threat to a building in North Carolina, but wind and extreme heat also present problems for the region's housing stock. Moore, Lee, Chatham and Johnston Counties have high concentrations of mobile homes, which typically are less able to withstand severe weather of all kinds. The lowest income residents have some of the greatest vulnerabilities, facing cost burden from housing and energy consumption.

Infrastructure at Risk

The Triangle J region's infrastructure is at risk, especially from flooding. There are many roadways that overtop during typical rain events, in addition to hurricanes and other extreme storms. Hurricane Matthew exposed weaknesses in stormwater systems, many of which were built with older design standards set when engineers needed to account for fewer users and lower precipitation levels. Hurricane Matthew also demonstrated catastrophic impacts typical of larger storms in the region, such as overtopping wastewater systems and closing interstates.

Health Concerns

Public health impacts are a major concern, as well, in the Triangle J region. Cardiovascular and respiratory systems are taxed by high heat and humidity, as well as poor indoor air quality after floods. While high heat is the number one weather-related cause of death in the country according to NOAA and the Centers for Disease Control and Prevention (CDC), major storms in the region have also led to injuries and deaths. Experiencing a major disaster is often traumatic,

and mental health burdens are among the least reported health problems associated with disaster. Collective levels of trauma lead to adverse impacts inside and outside the home.

1.3 Strengths and Challenges

The Triangle J's past and current work in hazard mitigation, emergency management and adaptive capacity has built some resilience to climate impacts. The region is also strengthened by its experience with disaster and its strong planning capacity. Nevertheless, improvements are needed. Hurricanes and floods have been prioritized in hazard mitigation efforts, while heat and drought have not received considerable attention in past planning processes or projects. Additionally, the Triangle J region is challenged by the increased frequency and intensity of hazards due to climate change, rapid growth, aging infrastructure and limited experience with communication and collaboration among local governments throughout the region.

1.4 Methodology

To conduct this vulnerability assessment, the project team—including staff from NCORR, the Triangle J Council of Governments, NC Rural Center and AECOM—reviewed existing data and literature, gathered input from the region's residents and workers, and analyzed the results to provide guidance on the next phase of the RISE program—prioritizing projects to include in the regional portfolio.

The literature and data review outlined what resources exist within the built and natural environments that could be exposed to the identified hazards. The team assessed how each asset has been impacted by past weather events, as well as how projected climate changes will impact those assets in the future. The team determined how those impacts correlate to region-scale impacts, then presenting those findings to the stakeholders for their input.

The project team emphasized stakeholder engagement throughout the development of this vulnerability assessment. They began by establishing a Stakeholder Partnership made up of local leaders from all four Triangle J Counties and from the public, private and nonprofit sectors. A trained facilitator guided the monthly Stakeholder Partnership meetings with technical support provided by AECOM and NCORR. The project team also hosted a public meeting and created a virtual meeting room at risecentralnc.com to provide an online location for information and input opportunities relevant to the vulnerability assessment. The project team used these meetings to identify natural hazards of concern; infrastructure, natural resources and people repetitively impacted by these hazards; recurrent losses and damages; and anticipated impacts to the surrounding environments and to residents as the climate changes.

Before the project team finalized this vulnerability assessment, they vetted a draft with the Stakeholder Partnership and the public.

2. Introduction

North Carolina's residents, businesses, nonprofits and governmental organizations are increasingly concerned by the growing frequency and intensity of heat waves, storms, precipitation patterns and their impacts. These weather events always hit an area larger than an individual town or county. To encourage regional coordination on identifying vulnerabilities and solutions, the North Carolina Office of Recovery and Resiliency (NCORR), with staff support from North Carolina Rural Center (NC Rural Center), created the Regions Innovating for Strong Economies and Environment (RISE) program. Each of the nine regions participating in this iteration of RISE are developing a vulnerability assessment (this document) and a portfolio of projects (forthcoming) to increase multi-county resilience to the impacts of climate change.

The primary objective of this vulnerability assessment is to analyze how natural hazards, paying particular attention to the changes in the area's climate happening now and by the 2050s, impact **Chatham, Johnston, Lee and Moore Counties**, referred to in this document as the "**Triangle J region**," shown in **Figure 1**. The authors were particularly concerned about the area's residents, economy, infrastructure, resources and landscapes. This document helps each county and municipality within the region better understand its unique risks to natural hazards and be better prepared to evaluate and prioritize specific resilience actions for the final portfolio of projects.

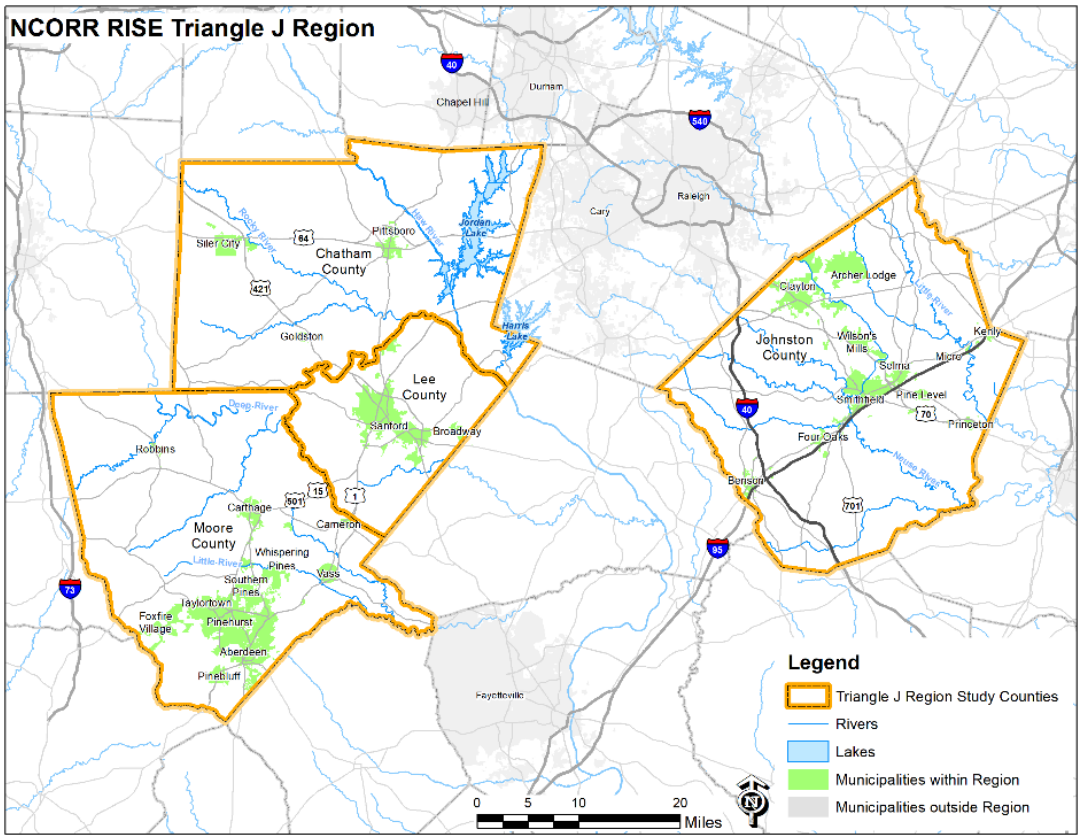


Figure 1. Map of Counties included in the RISE Triangle J Vulnerability Assessment

2.1 About RISE

Developed in partnership with North Carolina Rural Center, NCORR's RISE program supports resilience in North Carolina by:

- Facilitating the Regional Resilience Portfolio Program, which provides coaching and technical assistance to regional partners in the eastern half of the state to build multi-county vulnerability assessments, identify priority actions to reduce risk and enhance resilience in their region, and develop paths to implementation.
- Developing the North Carolina Resilient Communities Guide, a statewide resource that will provide tools, guidance and opportunities for building community resilience.
- Hosting the Homegrown Leaders program, a NC Rural Center leadership training workshop, which operates in the eastern half of the state, that emphasizes resilience as a tool for community economic development.

The RISE Regional Resilience Portfolio Program covers nine areas that align with the North Carolina Council of Governments regions, as shown in **Figure 2**. This vulnerability assessment covers Chatham, Johnston, Lee and Moore Counties. The RISE program includes these four counties, out of the full seven-county Triangle J region, because they were not part of the 2019 Triangle Regional Resilience Assessment. This vulnerability assessment is the first deliverable of the Regional Resilience Portfolio Program for the Triangle J region.

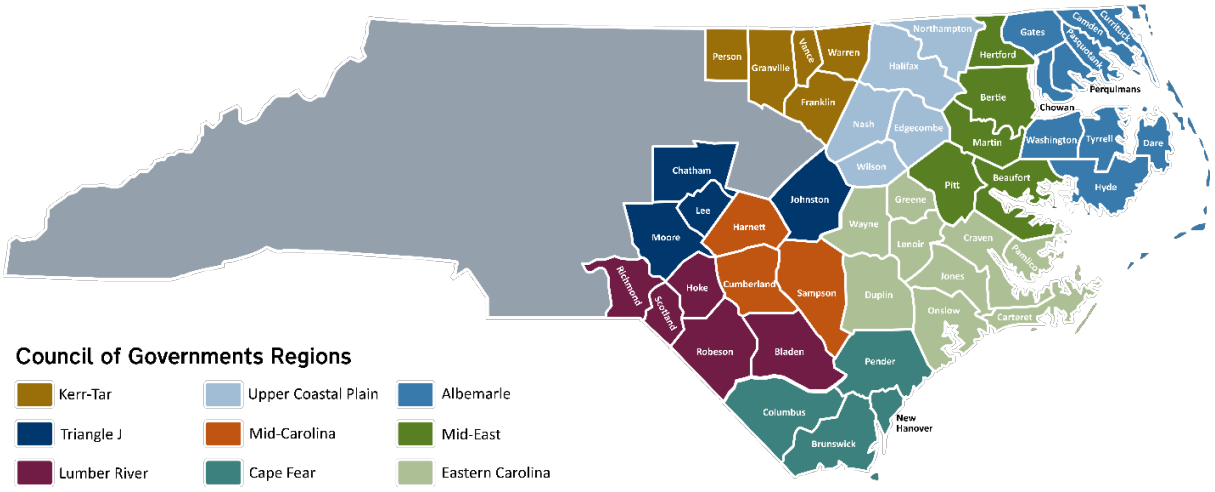


Figure 2. Council of Government Regions

The second and final deliverable of each region's RISE Regional Resilience Portfolio Program will be a portfolio of 5-10 projects identified through community input and expert consultation. The portfolio document will outline funding opportunities and potential project partners to enable a clear path toward implementation for each project.

RISE is funded by the U.S. Economic Development Administration and the U.S. Department of Housing and Urban Development's Community Development Block Grant – Mitigation funds, with in-kind support from NCORR and North Carolina Rural Center. In addition, the Duke Energy Foundation committed $600,000 in grant funding to support the Regional Resilience Portfolio Program.

2.2 Identified Hazards

This assessment focuses on three hazards that significantly impact the Triangle J region at the local, county and regional scale, prioritizing the hazards that are most pervasive and disruptive to everyday life. The identified hazards are:

- Hurricanes, storms and flooding
- Extreme temperatures, including high heat indexes and wet bulb globe temperature
- Drought and wildfires

The project team selected these hazards using information from the "North Carolina Climate Science Report." These hazards are also identified in the state and regional hazard mitigation plans and have greatly impacted the region in the past, as reported by NOAA's National Centers for Environmental Information. The project team confirmed the validity of these hazards with stakeholders in the region. The intention of this vulnerability assessment is to help the region address today's natural hazards and to minimize the impacts and threats of hazards for future generations.

2.3 Vulnerability Assessment Methodology

To conduct this vulnerability assessment, the project team—including staff from NCORR, the Triangle J Council of Governments, NC Rural Center and AECOM—reviewed existing data and literature, discussed findings from residents and workers, gathered input from the region's residents and workers, and analyzed the results to provide guidance on the next phase of the RISE program—prioritizing projects to include in the regional portfolio.

2.3.1 Review of Literature and Data

The team began with a review of relevant literature and data. They pulled useful information from the reports listed below and aggregated the features and critical assets of the region's built and natural environments that are exposed to climate change impacts. Those features include buildings, infrastructure and natural areas. The team gathered information on how each feature and critical asset has been impacted by past weather events, as well as how projected climate changes in the next 30 years will impact those assets in the future.

Reports Included in the Literature Review

- Cape Fear Regional Hazard Mitigation Plan (2020)
- Hurricane Matthew Resilient Redevelopment Plans (May 2017)
- North Carolina Climate Science Report (September 2020)
- North Carolina Enhanced State Hazard Mitigation Plan (February 2018)
- North Carolina Emergency Management – Risk Management Data and Analyses
- Economic Development Plans, Comprehensive Plans, Land Use Plans, County Public Health Assessments and other relevant county plans

2.3.2 Stakeholder and Public Engagement

The project team gathered local input and expertise from stakeholders to corroborate the findings of the literature review and to guide the RISE deliverables for the region. Local leaders offer unique insight into the impacts of hazards, as well as the strengths and challenges of the region in its ability to meet the vulnerabilities of today and tomorrow. For this reason, the project team emphasized stakeholder input throughout the development of this vulnerability assessment.

The project team created multiple formats for stakeholders to provide input. They created a Stakeholder Partnership, described below. During stakeholder partnership meetings, the members participated in full-group discussions, breakout discussions and used online engagement and polling aids. Members of the public also participated in a virtual public workshop as well as a "virtual meeting room," which offered an ongoing opportunity to provide input asynchronously. Local leaders and members of the public shared their concerns about natural hazards and climate change, including the places, infrastructure, natural resources and people that have been impacted in the past.

All vulnerability assessment meetings were held virtually due to the Covid-19 pandemic and the size of the region.

Before the project team finalized this vulnerability assessment, they vetted a draft with the Stakeholder Partnership and the public.

The Stakeholder Partnership

The project team established the Triangle J Stakeholder Partnership to support the development of this vulnerability assessment and the regional resilience portfolio. NCORR, the Triangle J Council of Governments and a local representative identified by NC Rural Center (see the "Facilitator" section below) recruited local leaders from the four Triangle J RISE counties—Chatham, Johnson, Lee and Moore—across the public, private and nonprofit sectors (See **Table A-1** in **Appendix A** for a list of participants). A trained facilitator guided monthly Stakeholder Partnership meetings with technical support provided by AECOM and NCORR.

Through monthly meetings beginning in January 2022 and lasting until the completion of the portfolio in December 2022, each Stakeholder Partnership member offered valuable insight on the region's strengths, weaknesses, opportunities and constraints that will influence the course of action taken to reduce the impacts of natural hazards exacerbated by climate change. This feedback is integrated with research findings throughout Chapters 3, 4, 5 and 6.

Facilitator

NC Rural Center hired a facilitator to work with each RISE region, including Triangle J. This facilitator supported and often led outreach and engagements efforts. The facilitator:

- Helped recruit Stakeholder Partnership members
- Followed up with individual Stakeholder Partnership members to boost their engagement
- Provided facilitation services at each Stakeholder Partnership meeting
- Helped plan the Stakeholder Partnership meetings

- Served as a spokesperson for the region
- Offered their viewpoints based on their areas of expertise
- Helped identify strengths and vulnerabilities of the region
- Brainstormed projects to increase regional resilience
- Provided input to shape the two main deliverables of this project: a vulnerability assessment and a regional portfolio of projects ready for implementation

Public Meetings

The project team hosted a virtual public meeting in April 2022 to continue ground-truthing data, literature and analysis. During the meeting, the team gave a quick overview of the project scope and facilitated group discussion. The facilitator and the rest of the project team collected input about areas of local vulnerability and challenges to climate resilience.

Virtual Meeting Room

To facilitate greater input from the public and stakeholders, the project team created a virtual meeting room at risecentralnc.com to provide an online location for information and input opportunities relevant to the vulnerability assessment. This user-friendly website supplemented the main public workshop described above and kept participants comfortable, safe and healthy amidst the COVID-19 pandemic.

Participants entered the virtual room through an online lobby, a screenshot of which can be seen in **Figure 3**, where they were prompted to select their region of interest (Triangle J: Chatham, Lee, Moore or Johnston Counties or Mid-Carolina: Cumberland. Harnett or Sampson Counties). Each region's virtual room offered ample information for each participant to explore, such as a project overview, funding opportunities and key challenges faced by the region. The virtual room also shared links to subscribe to RISE updates, submit additional comments or questions, identify problem areas on the interactive mapping tool, described below. Some content on the website was offered in Spanish.

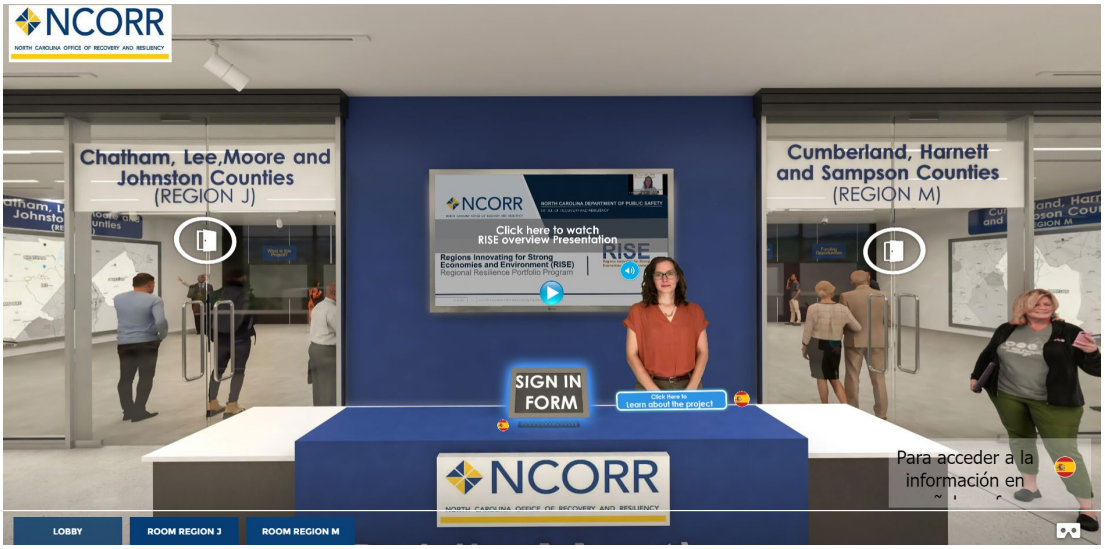


Figure 3: A Screenshot of the Virtual Room at risecentralnc.com

Interactive Mapping Tool

The project team created an interactive mapping tool to increase ground-truthing data collection. Accessible to participants through the virtual meeting room and during Stakeholder Partnership and public meetings, the map enabled individuals to demarcate areas of vulnerability across the region. The tool itself outlined county boundaries for the Triangle J RISE region encompassing Chatham, Johnson, Lee and Moore Counties. Users input information on areas of past and potential impact by selecting a point, line or polygon, then identifing the hazard of concern, any specific occurrence(s) worth noting, name and organization of submitter and any issue(s) caused by the identified hazard. The project team received information provided through the map and reviewed it with members of the Stakeholder Partnership.

2.3.3 Analysis

The project team used the literature review and stakeholder input to understand the region's resilience strengths and needs. The team also considered the anticipated changes in climate and hazards within the next 30 years using the information provided in the 2020 NC Climate Science Report. The team identified potential impacts to housing, critical infrastructure, economic development, public health, historic and cultural resources, natural environmental systems and socially vulnerable populations. The team also looked at locations where impacts overlap, or "hot spots," to identify where actions are needed to increase resilience of the region.

2.4 Report Overview

The remainder of this report reviews the results of the analysis, describing the region's climate resilience strengths, challenges, hazards, potential impacts and hot spots.

Chapter 3 explores the region's overall strengths and challenges related to resilience. This section highlights the knowledge sustained from recent flooding disasters as well as planning capacity as strengths. Challenges include the increased frequency and intensity of hazards, rapid growth, aging infrastructure and common barriers to effective collaboration among local governments.

Chapter 4 overviews the hazards of greatest concern in the region. These hazards include hurricanes and severe storms, which cause flooding and wind damage. Extreme temperatures, particularly high heat, also pose a risk to the region. Drought and its accompanying risk for wildfire are also discussed.

Chapter 5 reviews the vulnerability of the region's housing, infrastructure, economic development assets, environmental systems, historic and cultural resources, public health and socially vulnerable populations. These vulnerabilities often overlap with one another, leading to cascading effects that may disrupt the region's families, businesses and communities.

Chapter 6 identifies the region's vulnerability "hot spots," or those places where multiple vulnerabilities overlap in one location. These areas will need priority attention.

The final sections of the report include a list of participants on the Stakeholder Partnership, as well as a listing of data sources and reports used to build the assessment.

3. Resilience Strengths and Challenges

The Triangle J region seeks to build upon existing strengths and capacities to heighten resilience. Resilience is defined in the North Carolina Climate Risk Assessment and Resilience Plan as “the capacity of individuals, a community, business, or natural environment to prevent, withstand, respond to and recover from a disruption.”

The capacity of the Triangle J region is reflected in its ongoing work to support communities, the economy and the environment. Its work in hazard mitigation, emergency management and adaptive capacity serves as the basis for building resilience. Strengths of the region include its past experience with disaster and its strong planning capacity. Nevertheless, those natural hazards that have caused massive devastation and destruction are prioritized for hazard mitigation, while chronic and pernicious hazards, such as heat and drought, have not received considerable attention in past planning processes. Challenges include the increased frequency and intensity of hazards, rapid growth, aging infrastructure and common barriers to effective collaboration among local governments.

3.1 Strengths Related to Resilience

Because North Carolina has suffered multiple large-scale flooding and coastal storm disasters in recent years, there has been an urgent focus on planning for recovery and resilience. The Triangle J region has increased awareness of flood risk and the need to prioritize mitigation measures.

3.1.1 Strong Planning Capacity and Previous Planning Efforts

At the county scale, the Triangle J region has a breadth of plans, ordinances and capabilities that reflect capacity to build resilience and commitment to strategic action in all four counties (**Table 1**). Each county also has a Hurricane Matthew Resilient Redevelopment Plan, discussed in the next section. Notably, all the counties have comprehensive plans, open space management plans and zoning ordinances. These plans and ordinances can be helpful for directing county in safe areas and aligning hazard resilience with local vision. Within these plans are programs, policies and ordinances that help protect environmental, historic and cultural resources within each community. These tools present significant opportunities to integrate resilience principles and practices into the local decision-making processes to increase resilience at the regional scale. Specific to flood hazards, all counties have floodplain ordinances and flood damage prevention ordinances, and all participate in the National Flood Insurance Program. Only Lee County does not have a Stormwater Management Plan or Ordinance.

Table 1. Capability Assessment Summary for the Triangle J Region

Existing Capabilities	Chatham	Johnston	Lee	Moore
Hazard Mitigation Plan	Cape Fear Regional HMP			
Resilient Redevelopment Plan	Y	Y	Y	Y
Comprehensive Plan/Master Plan	Y	Y	Y	Y
Open Space Management Plan	Y	Y	Y	Y
Local Emergency Operations Plan	Y	Y	Y	Y
Economic Development Plan	Y	N	Y	Y
Capital Improvement Plan	Y	Y	Y	Y
Continuity of Operations Plan	Y	Y	Y	Y
Disaster Recovery Plan	N	N	Y	N
Zoning Ordinance	Y	Y	Y	Y
Subdivision Ordinance	Y	Y	Y	Y
Floodplain Ordinance	Y	Y	Y	Y
Flood Damage Prevention Ordinance	Y	Y	Y	Y
Stormwater Management Plan/Ordinance	Y	Y	N	Y
Building Code	Y	Y	Y	Y
Fire Code	Y	Y	Y	Y
Site Plan Review Requirements	Y	Y	Y	Y
National Flood Insurance Program (NFIP)	Y	Y	Y	Y

Source: Cape Fear Regional Hazard Mitigation Plan

3.1.2 Hurricane Matthew Resilient Redevelopment Plans

In December 2016, the North Carolina General Assembly established the North Carolina Resilient Redevelopment Planning program as part of the 2016 Disaster Recovery Act in response to Hurricane Matthew. All 50 of the affected counties, including Chatham, Johnston, Lee and Moore, among others, developed a Hurricane Matthew Resilient Redevelopment Plan. The purpose of these plans was to empower communities to prepare locally driven, resilient redevelopment plans. These plans aimed to identify redevelopment strategies, innovative construction projects and other actions which allow each county to adequately respond to natural hazards as they continue to increase in frequency and intensity. This planning effort highlights the region's capacity to proactively respond to devastation in effort to reduce future impacts. The development and implementation of the resilient redevelopment plans involved

collaboration between state, county and local agencies displaying the region's ability to leverage efforts to achieve the most beneficial outcome.

Based on the work that each County in the region has completed on Hurricane Matthew Resilient Redevelopment Plans, intact emergency management plans and operations centers, the region has a good foundation from which to further address vulnerabilities and increase resilience.

3.2 Challenges Related to Resilience

The region faces some challenges to building resilience, as well. These challenges include increasing frequency and intensity of storms, increased development, aging and undersized infrastructure, challenges to regional collaboration and complex disaster recovery programs.

3.2.1 Frequency and Intensity of Hazards

As the climate continues to warm, hazards such as intense precipitation, flooding and extreme temperatures are likely to increase in both frequency and intensity in this region. This reinforces the need to implement long-term strategies that build resilience. As is common across the state and nation, current policies and practices in the region are based on the assumption that the future will look like the past. Unfortunately, this assumption is inadequate to address the climate risks that the region faces. Shifting the current approach toward greater resilience would place climate change at the forefront of planning efforts to mitigate against hazards and their associated impacts as well as all efforts to develop the region in a manner that capitalizes on its unique assets and sustains them into the future.

3.2.2 Increased Development

The counties and many municipalities in the Triangle J region have experienced growth equal to and well above the state average of 9% between 2010 and 2020 (**Table 2**).

Table 2. Triangle J Region County Growth Rates 2010-2020

County	Growth Rate (2010-2020)
Chatham County	28.7%
Lee County	9.7%
Johnston County	27.9%
Moore County	13%

In many ways, growth supports prosperity and indicates the external interest in living in this region. However, growth at this rate creates challenges for a community and for resilience. Growth can strain local planners and challenge the plans and ordinances (such as Floodplain Management ordinances and others) that are in place to ensure that increased growth does not increase vulnerability to hazards. While growth may be well managed through comprehensive

plans, land development ordinances and policies, increases in people, cars, houses, businesses and the needed infrastructure also present more exposure to hazards.

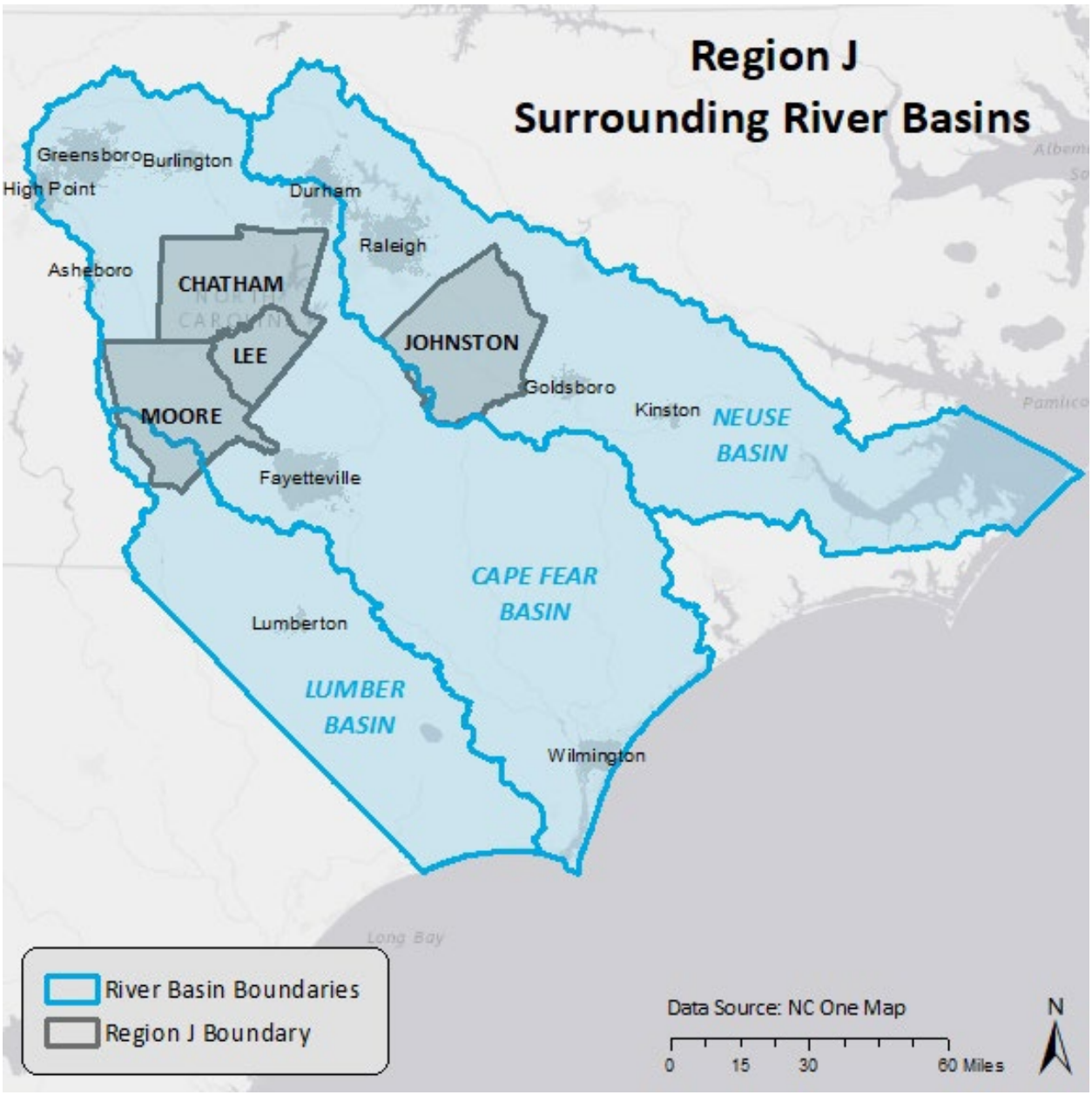


Figure 4. Cape Fear River Basin and Triangle J Region

Changes in land use associated with urban development affect flooding and its impact on the built environment. Increased freshwater flooding caused by hurricanes will be exacerbated by increasing urbanization that adds impervious surfaces and development in low-lying areas[2]. For

[2] NC Climate Science Report, 2020

example, “removing vegetation and soil, grading the land surface and constructing drainage networks increase runoff to streams from rainfall and snowmelt. As a result, the peak discharge, volume and frequency of floods increase in nearby streams. Changes to stream channels during urban development can limit their capacity to convey floodwater—nearby, downstream and upstream. (See **Figure 4** for a map of the Triangle J River Basins.) Roads and buildings constructed in flood prone areas are expected to increase flood hazards, including inundation and erosion, as new development continues” (Konrad, 2016). Many roadways and major highways were identified as problem areas by local stakeholders, which creates barriers for evacuation routes and emergency services during the time of a disaster.

Changes in land use can make the Triangle J region more vulnerable to hazards outside of flooding as well. For example, increasing the “wildland-urban interface” (or the perimeter between natural areas and developed areas) increases vulnerability to wildfire. This growth can increase the strain on water supplies, especially during drought.

While rapid regional growth can increase vulnerability to climate hazards, if the growth is thoughtful and planned, it can serve economies and communities without adding to their risk.

3.2.3 Aging and Undersized Infrastructure

Physical infrastructure, including roads, bridges, buildings and utility systems, are intended to have a lifespan of several decades. Infrastructure in the Triangle J region will need to perform under the conditions of climate change, even though present and historic construction standards did not account for increasing flooding or higher heat. We lack a systematic understanding of the impacts of the climate warming and associated conditions on infrastructure design standards for North Carolina, including in the Triangle J region[3].

Aging infrastructure in the region is extremely vulnerable to natural hazards. Both the integrity and function of infrastructure are threatened. Dams, levees, culverts and bridges are problem areas throughout the region. They have deteriorated over the years due to lack of rehabilitation, repairs and upgrades. This in turn increases their susceptibility to disastrous events and any associated impacts.

3.2.4 Collaboration and Communication among Local Governments

Collaboration and consistent communication between municipalities is essential for addressing climate change impacts at the local and regional level, particularly because the activities of adjacent communities affect one another. However, collaboration and communication across administrative boundaries can be hard for many communities, including within the Triangle J region. For example, stakeholders described that it was sometimes unclear whether a county or municipality was responsible for certain roads, streams, or structures (particularly in the unincorporated areas).

3.2.5 Complex Disaster Recovery Programs

The Triangle J region has experienced numerous disasters in recent years, and so the region has been eligible for disaster recovery programs administered by the state or federal

[3] NC Climate Science Report, 2020

governments. However, these programs are complex and can be difficult to administer or access. This complexity has made it difficult for municipalities and individuals to obtain assistance. In other cases, municipalities and residents do not even know about programs for which they are eligible. Education and outreach to bolster, explain and recommend specific programs based on circumstances would benefit municipalities and individuals with limited resources or understanding.

4. Hazards

This section discusses the most impactful climate hazards in the Triangle J region. These hazards include hurricanes and severe storms, which cause flooding and wind damage. Extreme temperatures, particularly high heat, also pose a risk to the region. Finally, drought and its accompanying risk for wildfire are also discussed.

For each hazard type, risk is identified today and in 30 years. Climate projections are derived from the Piedmont region analysis in the NC Climate Science Report, which covers most of the region.

4.1 Presidential Disaster Declarations

Disaster declarations provide initial insight into hazards that have historically impacted the Triangle J region. Since 1968, fifteen presidential disaster declarations have been reported in the Triangle J region (**Table 3**). Fourteen of these events have occurred since 1996 and seven events since 2011. These events correspond to an observed upward trend in the number of heavy rainfall events (24-hour periods with 3 inches or more) in the Piedmont region, particularly since 2015. [4] The North Carolina State Climate Summary states that climate models show an overall increase in extreme precipitation in the North Carolina Piedmont region as global climate continues to warm.[5]

Table 3. Presidential Disaster Declarations in the Triangle J Region

Year	Description	Chatham County	Johnston County	Lee County	Moore County
1968	Severe Ice Storm		X	X	X
1996	Blizzard of 96	X	X	X	X
1996	Hurricane Fran	X	X	X	X
1999	Hurricane Floyd	X	X	X	X
2000	Severe Winter Storm	X	X	X	X
2003	Severe Ice Storm	X	X	X	X
2003	Hurricane Isabel		X		
2005	Hurricane Katrina Evacuation	X	X	X	X
2011	Severe Storms, Tornadoes and Flooding		X	X	

[4] North Carolina Climate Science Report. North Carolina Institute for Climate Studies, 2020, p134. https://ncics.org/nccsr
[5] North Carolina State Climate Summary 2022. NOAA Technical Report NESDIS 150-NC. NOAA/NESDIS, Silver Spring, MD

Year	Description	Chatham County	Johnston County	Lee County	Moore County
2011	Hurricane Irene		X		
2016	Hurricane Matthew	X	X	X	X
2018	Hurricane Michael	X			
2018	Hurricane Florence	X	X	X	X
2019	Hurricane Dorian	X	X	X	X
2020	Hurricane Isaias	X	X	X	X
TOTAL	**Triangle J Region Total: 15**	**11**	**14**	**12**	**11**

Source: FEMA Disaster Declaration Database

4.2 Hurricanes, Storms and Flooding

The Triangle J region is at risk from hurricanes and other severe storms. Flooding is one of the most significant climate impacts that affects the Triangle J region. This flooding is expected to worsen in the coming decades due to climate change. Severe storms also cause wind damage. The region has experienced 50 unique flash flood, flood and heavy rain events since 2007.[6] Of those 50 events, 15 resulted from hurricanes, remnants of hurricanes or tropical storms moving into the region.

4.2.1 Hurricanes

The Triangle J region does not frequently experience storms that are still classified as hurricanes due to its inland location in the state. However, the region still experiences impacts from the remnants of these storms. Hurricane impacts in the region are exhibited as flash flood, flood and heavy precipitation.

Hurricanes are relatively regular occurrences in the state as a whole; North Carolina has experienced a long-term average of slightly more than one tropical storm or hurricane near or in the state every year since 1900.[7]

NC Climate Science Report finds that it is *likely* that the intensity of the strongest hurricanes will increase with a warming climate, which could lead to stronger hurricanes affecting North Carolina. Accordingly, in the next thirty years hurricane events that do cross the state to the Triangle J region may also have increased impact and precipitation.

4.2.2 Flooding

Most large-scale flooding events in the state result from tropical storms and hurricanes, although winter storms also can cause severe flooding. Heavy precipitation accompanying

[6] NOAA NCDC
[7] North Carolina Climate Science Report. North Carolina Institute for Climate Studies, 2020, p 83. https://ncics.org/nccsr

hurricanes is very likely to increase, increasing freshwater flood potential.[8] Eastern North Carolina experienced three extreme flood-producing hurricanes in the last 25 years—Floyd, Matthew and Florence (see the details of these storms in **Table 4**), all of which caused flash floods and floods in the Triangle J region as result of torrential rainfall. In April of 2017, an extratropical event impacted central and eastern North Carolina.

Table 4. Hurricanes Florence, Matthew and Floyd

Storm	Year	Rainfall (inches)*	Damage (Billions)	FEMA Disaster Counties	Fatalities
Florence	2018	25-35	$17.0	28	40
Matthew	2016	18-20	$4.8	45	28
Floyd	1999	17-20	$9.4	66	51

The NC Climate Science Report concludes that it is likely that the intensity of the strongest hurricanes will increase with a warming climate, leading to stronger hurricanes affecting North Carolina. The NC Climate Science Report also concludes that the risk of extreme precipitation is very likely to increase everywhere in the Piedmont. This may result in an increase in the number of flooding events, posing increased risk for human life, public health and property damage.

Flooding impacts to major transportation infrastructure networks create difficulty for public services and emergency response, as well as for trucking, commuters and travelers. According to the N.C. Department of Transportation Statewide Operations Center, more than 1,760 roads were closed during Hurricane Matthew and more than 2,500 roads closed during Florence. Road closures, particularly on major routes and interstates, impair emergency service response and restrict the movement of essential supplies and services to critical areas. In the Triangle J region during and after Hurricane Matthew, portions of I-95 to the southwest of Johnston County (between mile markers 67 and 70) were flooded with and access closed. Improvements have since been planned for these (and other) sections of I-95 including increasing the elevation of the roads and the addition of pipe crossings to improve stormwater drainage capacity and flow. Section of I-95 will also be widened to eight lanes.[9]

Changes in flooding occur due to changing climate conditions, such as changing precipitation patterns, changes in water management or changes in land use and land cover. Additionally, watersheds store moisture and as a result, periods of wetness or dryness impact the likelihood and severity of flooding.

[8] North Carolina Climate Science Report. North Carolina Institute for Climate Studies, 2020, p 83 https://ncics.org/nccsr
[9] NCDOT I-95 / I-40 Flood Resilience Feasibility Study, 2019.

4.2.3 Heavy Precipitation

The Triangle J region, due to its location in the Piedmont, is generally drier than the Coastal Plain and Mountain regions. However, heavy precipitation regularly causes flooding in the region.

The risk of extreme precipitation (defined as days with three or more inches of precipitation) is *very likely* to increase everywhere in the Piedmont.[10] In the Coastal Plain, to which Region J is adjacent, there has been an upward trend in precipitation since 1995 where the average number of heavy precipitation days has been roughly 35 percent above the long-term average. Four out of the five highest years on record include 1995, 1998, 2009 and 2016.

Precipitation can have a large impact on public health and well-being as well as on the natural and built environment. Precipitation and precipitation patterns can affect the amount of surface water and groundwater available for consumption, irrigation and industry and influence river and flash-flooding. Changes in precipitation also influence habitats and the species that can survive in specific geographic locations. Greater amounts of heavy precipitation and flooding can lead to more injuries, deaths, property damage and other flooding-related impacts. Additionally, runoff from precipitation can impair water quality as pollutants on land wash into water bodies.

4.3 Extreme Temperatures, including High Heat Indexes

4.3.1 Average Daytime and Nighttime Temperatures/Heat Indexes

Temperature trends have wide-ranging effects on human life, the built environment and natural ecosystems. North Carolina has become warmer in the last decade, and the future is projected to be even hotter. Six of the past 10 years have ranked as one of the top 10 warmest on record for the state[11].. In the Piedmont, 16 of the last 18 years have been warmer than the long-term annual temperature average. According to the North Carolina Climate Science Report, in 30 years, annual average temperatures in North Carolina are expected to increase 2°–5°F under the higher scenario (RCP8.5) and 2°–4°F under the lower scenario (RCP4.5), compared with the period 1996-2015. By 2100, temperatures in the Piedmont are projected to increase 6-10° F under the higher carbon emissions scenario, and 2-6° F under the lower carbon emissions scenario.

Despite its slow onset relative to other hazards, extreme heat is the leading cause of weather-related deaths nationwide.[12] As seen in **Figure 5**, the 10- and 30-year averages of heat-related deaths are the highest of all weather-related fatalities. This underscores the severity of heat impacts, particularly for communities already made vulnerable, the elderly and young, and those with pre-existing health conditions.

[10] NC Climate Science Report, 2020
[11] NOAA NCEI https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/statewide/haywood/31/tavg/12
[12] https://www.weather.gov/hazstat/

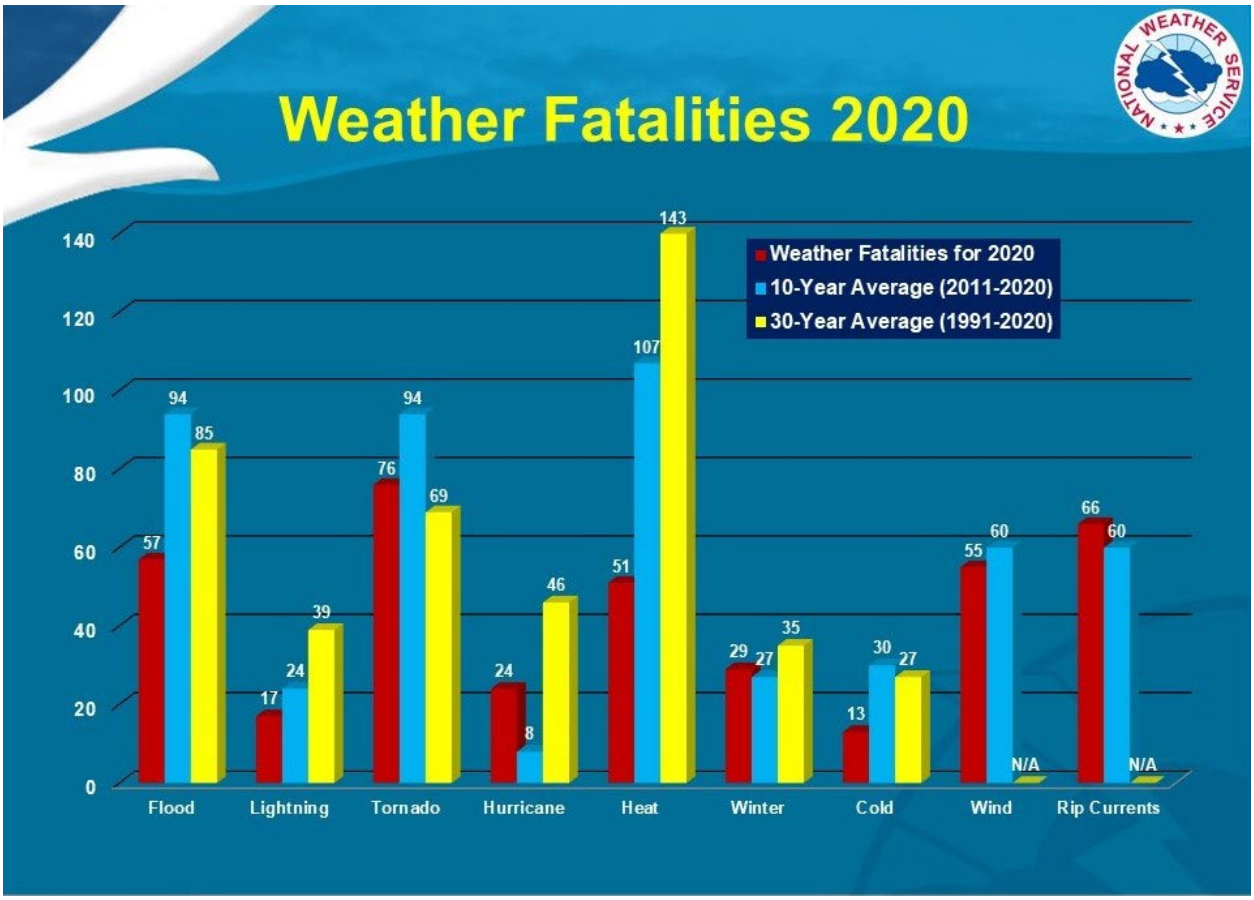


Figure 5. 2020 Weather Fatalities, 10-year and 30-year averages (National Weather Service)

4.3.2 Frequency of Very Hot Days, Very Warm Nights and Heat Waves

Although the Triangle J Region is not yet experiencing an overall increase in frequency of very hot days—characterized as having a maximum temperature of 95°F or higher, the number of very warm nights—nights with a minimum temperature of 75°F or higher—have been on an upward trajectory since the 1970s. The annual count of hot days and very warm nights are anticipated to increase in the coming decades. In the period 2021-2040, the number of hot days is projected to increase by 10 to 20 annually, compared with the period 1996-2015. The number of hot nights is expected to increase by 3 to 15 during this same period. By 2041-2060 and later periods this century, the projected number of hot days and nights is substantially higher.

The upward trend in very warm nights is especially concerning because of its health implications. By the end of the century, the number of very warm nights—minimum temperature of 75°F or higher—is *very likely* to increase. End-of-century projections are for increases of 7-34 nights under the lower emissions scenario, and 36-79 nights under the higher emissions

scenario, relative to the 1996-2015 average.[13] The number of very warm nights is associated with increase in hospital visits. Normally, cooler temperatures at night help regulate human body temperature. Hot nights, especially several hot nights in a row, place stress on the body, leading to adverse health outcomes.

Prolonged periods of hot weather, known as heat waves, can lead to illness and death, particularly among older adults, the very young and other vulnerable populations. As the Earth's climate warms overall, heat waves are expected to become more frequent and intense, increasing the need to heighten resilience against heat-related natural hazards.

Heat waves often come with extreme temperatures. The annual hottest maximum temperature in the Coastal Plain is projected to increase by 2°-6°F under the lower emissions scenario, and by 5°-12°F under the higher emissions scenario by the end of the century, compared to the 1996-2015 average.[14]

4.3.3 Heat Indexes

The heat index—a measure of the combination of heat and humidity—is expected to increase across the Triangle J region, yet another concern for human health. In fact, the NC Climate Science Report concludes that "it is *very likely* that summer heat index values will increase because of increases in absolute humidity."[15] The heat index is often referred to as the "feels like" temperature, because meteorologists often report temperatures as, for example, "94°F but it will feel like 102°F." The combination of high temperatures and humidity, a common occurrence in North Carolina, makes health impacts occur at much lower actual temperatures.

4.3.4 Urban Heat Islands

An additional complication of increasing temperatures in the Triangle J region is urban heat islands. Despite its name, urban heat islands affect urban and rural areas. No matter how big or how small, a concentration of man-made surfaces (concrete, asphalt, etc.) absorb, hold and release heat throughout the day and well into the evening hours. These urban heat islands, which can be up to 22°F warmer than nearby green spaces,16 can lead to higher energy costs, increased air pollution and additional challenges for more socially vulnerable populations. As hard surfaces hold on to heat and slowly release it into the evening, urban heat islands also cause night-time temperatures to be higher than they would be otherwise, leading to more individuals visiting emergency rooms.

4.3.5 Urban Heat Island Effects

The Urban Heat Island (UHI) effect is a tendency for temperatures to be higher in cities and developed areas than in rural and less developed areas. This is due to the absorption and emission of heat by buildings and impervious surfaces. As North Carolina continues to grow and rural areas become more developed with impervious surfaces and buildings, the tendency for

[13] Climate Science Report, pp 95-99
[14] Ibid p. 104
[15] NC Climate Science Report, 2020, pg. 6
[16] The High Cost of Heat, retrieved from: June2018_CMN_Heat.pdf (climatecentral.org)

more UHI effects is projected to be stronger and more significant. North Carolina cities have already experienced longer summer heat waves, and these trends will continue.[17] UHI is a climate stress multiplier, worsening, for example, the impacts of elevated air pollutants and compromised human health. Populations that are already vulnerable – lower income, communities of color and the elderly – are disproportionately affected by UHI effects.

4.4 Drought and Wildfires

4.4.1 Drought

The recent flooding events of Hurricane Matthew and Florence have led to an emphasis on flood mitigation and recovery in the Triangle J region and across the state. However, other climate hazards, such as drought, pose serious threats to the region. Drought, although given less consideration, is a hazard that should receive notable consideration in the resilience building process. Prolonged droughts in particular pose a serious threat to public health and populations who depend on land and water supplies economically and socially.

Drought is generally defined as a prolonged period of dry weather that is caused by lack of precipitation, which leads to a severe water shortage. Drought in the Triangle J region is becoming more common and more severe. In the Piedmont, the periods of 1925–1929, 1985–1989, 2000–2004 and 2010–2014 experienced the most frequent drought, with an average of about five months per year with moderate or more severe drought conditions (measured by dryness, based on temperature and precipitation). The years 1926, 2010 and 2011 each experienced 10 or more months with drought conditions.[18] North Carolina's drought of record occurred 2007-2009, with the central part of the state experiencing more than 12 consecutive months.[19] According to the NC Climate Science Report, it is likely that future drought will increase in frequency and intensity.

Droughts impact people, the economy and natural systems in a variety of ways. Droughts reduce soil moisture, diminishing non-irrigated agriculture and natural vegetation. Future droughts are expected to be warmer[20], which further reduces soil moisture. Drought can also reduce the availability of water in rivers, lakes and aquifers. The strain on drinking water supplies is particularly concerning given the high rate of growth in the Triangle J region and surrounding counties. Droughts also can affect energy production and human health in the region. Drought conditions change frequently and can be tracked at the U.S. Drought Monitor website which is updated weekly.[21] More localized, state-specific information for drought can be found from the North Carolina Drought Management Advisory Council.[22]

[17] NC Climate Science Report, 2020, p. 196
[18] NC Climate Science Report, 2020, p. 136
[19] US Drought Monitor
[20] NC Climate Science Report, 2020, pg. 69
[21] National Drought Mitigation Center, 2022, retrieved from US Drought Monitor
[22] North Carolina Drought Management Advisory Council, 2022, retrieved from US Drought Monitor of North Carolina

4.4.2 Wildfire

One of the most serious implications of increasing frequency and severity of droughts and higher temperatures is an increase in the risk of wildfire. A wildfire is a wildland fire originating from an unplanned ignition, such as lightning, unauthorized/accidental human caused fires and prescribed fires that are declared wildfires. Wildfires are natural occurrences that play a long-term role in the health of ecosystems. However, wildfires have the potential to harm property, livelihood and human health. The frequency, extent and severity of fires is a concern heightened by increased temperatures and drought.

Climate change has increased the frequency and severity of wildfires globally, nationally and in the Southeast.[23] North Carolina has experienced a long-term increase in the number of wildfires, including notable recent wildfires in the eastern and western reaches of the state, but the acreage burned in these wildfires has decreased over time.[24] The Triangle J region has a relatively lower risk of wildfire compared with the mountains and coastal plain regions of the state.

However, the expansion of residential development, from urban centers to less dense and rural areas such as Johnston, Moore, Lee and Chatham Counties, increases the potential for wildfire to threaten public safety and property. The Wildland Urban Interface (WUI) is described as the area where structures and other human improvements meet and intermingle with undeveloped wildland or vegetative fuels. Population growth within the WUI substantially increases the risk of wildfire. North Carolina has the largest WUI nationwide of 13.5 million acres, with approximately 50% of all homes located within the WUI.[25] As North Carolina continues to grow and development continues, the WUI will also continue to grow. **Figure 6** provides a depiction of the WUI areas in the Triangle J region. All four counties in the region are in the top 25 fastest growing counties in the state (Johnston County #1, Chatham County #7, Moore County #17 and Lee County #24).

More information about wildfire risk in North Carolina can be obtained from the North Carolina Forest Service and the North Carolina State Climate Office.[26]

[23] NC Climate Science Report, 2020, pg. 188
[24] https://www.ncforestservice.gov/fire_control/wildfire_statistics.htm
[25] North Carolina Forest Service, 2020, retrieved from 2020 North Carolina Forest Action Plan
[26] http://ncforestservice.gov/fire_control/fc_wui.htm and https://climate.ncsu.edu/fire/

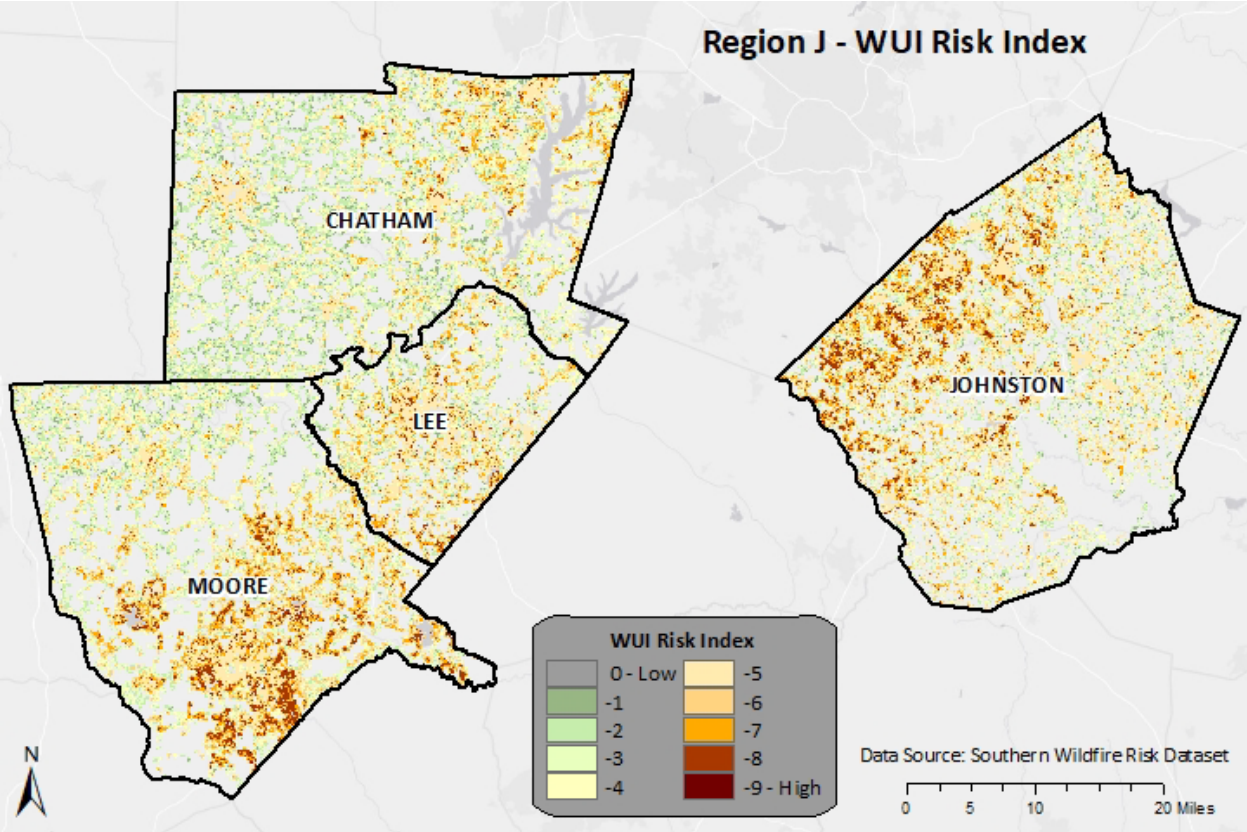


Figure 6. Wildland Urban Interface Areas in the Triangle J Region

5. Impacts

This section describes the most serious impacts of hazards and climate change on the following sectors in the Triangle J region.

- Housing
- Infrastructure
- Major Economic Development Assets
- Public Health
- Historical and Cultural Resources

5.1 Hazard Impacts on Housing

This section provides information about impacts of climate change and natural hazards on housing in the Triangle J region. Over 2,000 structures in the region are located in the 100- and 500-year floodplains, many of which are housing. In addition, housing in the region faces other vulnerability issues, such as housing and energy cost burden, standards to which manufactured or other housing were built, issues with new development and availability of affordable alternatives to vulnerable housing.

The greatest strain on housing in the Triangle J region is the shortage of housing to meet growing population and the impacts that housing development may have on natural systems such as forested ecosystems and their role in absorbing and storing water. Encroachment of development into the interface between undeveloped natural areas increases the risk of wildfire.

Some housing in the Triangle J region has specific characteristics which potentially worsen vulnerability to hazards such as heavy precipitation and hurricanes, extreme temperatures and compound hazards. These factors are

- Housing type – manufactured housing is vulnerable to high winds, extreme temperatures and flooding. Approximately 14 to 17 percent of housing in the region is manufactured.
- Age of housing – older houses may have been built following building codes that are not up to date with current climate conditions. Older homes also may not be well maintained. Approximately 30 percent of housing in the region is considered older, built in 1979 or before.
- Housing and energy cost burden – for extremely low- and low-income renters or homeowners, the cost of housing and utilities may be greater than 30% of gross income. During and following disasters, these residents may have great difficulty funding needs such as temporary housing or repairs to their home

5.1.1 Triangle J Region's Housing Characteristics

In the Triangle J region, there were 193,107 housing units in 2020. Housing information for the four participating counties is presented in **Table 5**.

Table 5. Housing Characteristics of Triangle J Region Counties

Jurisdiction	Housing Units (2000)	Housing Units (2010)	Housing Units (2020) (ACS 2016-2020)	Median home value of an owner-occupied home (2019) (ACS 2015-2019)	Estimated number of housing units built in 1979 or before, 2015-2019
Chatham County	21,358	28,753	33,947	$281,700	10,248 (30%)
Johnston County	50,196	67,682	84,340	$165,100	23,328 (28%)
Lee County	19,909	24,136	26,583	$144,200	11,046 (43%)
Moore County	35,151	43,940	48,237	$216,500	15,778 (33%)
Total	**126,614**	**164,511**	**193,107**	**-**	**60,400 (31%)**

Source: US Census 2000, 2010: HMP; 2020: ACS 5-Year Estimates (2016-2020) county data profiles https://data.census.gov/cedsci/profile?g=0500000US37037); Median value: Policy Map, ACS 5-year estimates 2015-2019: https://www.policymap.com/newmaps#/)

As indicated in the Census data, new homes are continuing to be built in Chatham, Johnston, Lee and Moore County. This growth is generally attributed to population moving into the state and people moving from the Triangle and Triad metropolitan areas to communities in the surrounding areas that are more affordable. [27] While new homes have positive and widespread impacts, especially amid a housing crisis, they also typically require additional infrastructure and amenities. New development in rural areas of the Triangle J region is *likely* to increase the frequency of impact from natural hazards, heightening the risk to lives and structures within those areas. This is due to factors such as clearing development sites without leaving sufficient buffer between new structures and areas with vegetative fuels, thus increasing fire risk; clearing of forested areas and leaving exposed soils to increased moisture loss and drying, thus increasing risk from fire or flooding; expanding development into areas that are further or more difficult to reach from current emergency services; development that may flood or experience downstream impacts of flooding caused by clearing of river and stream-side vegetation in areas upstream for development (even when outside of special flood hazard areas); increased air and water pollution from increased traffic and emissions; and reduction of areas that can absorb and/or hold pollutants and sediment before draining into downstream waterbodies.

The effects and risks caused by urbanization and development can be reduced and mitigated with sound comprehensive land use planning practices that account for potential hazards and how they may change or worsen impacts. A watershed-scale planning approach is also a sound practice, where development and land alteration and improvement is considered at the scale of a watershed, with cooperation across the political boundaries within a watershed. Areas within each watershed and the Triangle J region that should be carefully planned are those that fall within the WUI, areas within the special flood hazard floodplain (e.g., the 100-year storm map) and areas outside of it (e.g., up to the 500-year storm map).

[27] https://www.ncdemography.org/2021/08/12/first-look-at-2020-census-for-north-carolina/

5.1.2 Aging Housing Stock

Aging housing stock, defined as houses built prior to 1980, may be extremely vulnerable to disaster events. This is due to changes in building code standards since 1980 and the lack of use of hazard-resistant building codes that are now used more frequently. Examples include roof tie-downs to protect against high-velocity winds, use of building materials made to withstand fire more effectively and changes in required building setbacks and buffers from vegetated areas.

In the Triangle J region, approximately one-third of the housing stock was built before 1980. Johnston County has the highest number of housing units and correspondingly, the highest number of houses built before 1980 (23,328) as well as since 1980 (61,012). Lee County has the smallest number of housing units (26,583) with approximately 43% (11,046) of that total built before 1980. Further examination of the location of the older housing stock relative to floodplains, low-lying areas and proximity to forested or heavily vegetated areas may be beneficial for reducing hazard risk.

5.1.3 Rental Housing and Mobile Homes

Roughly 40 percent of the nation's housing occupied rental stock, representing 17.6 million units, is located in areas that are likely to experience substantial annual losses from increasingly common hazards such as flooding, wildfires and hurricanes.[28] In the Triangle J region, a quarter to a third of all householders are renters, as **Table 6** illustrates. North Carolina is one of several states with large numbers of rental units at risk, primarily due to their location in areas of hazard risk. Renters, specifically low-income renters, face heightened exposure to natural hazards due to their limited resources to change locations or have hazard-resistant improvements made. They also face additional challenges in receiving federal disaster aid, which is typically aimed more toward homeowners, as disaster relief minimums are often too high to encompass their loss of personal property.[29] There are usually few, if any, resources for landlords to rebuild or rehab their units after disaster, so rental units may remain unsafe and unsanitary.

Mobile homes, or manufactured homes, are at high risk of hazard impact in the Triangle J region. Across the region, 14 to 17 percent of all housing units are mobile homes, as **Table 6** illustrates. Mobile homes are typically less structurally sound in the face of hazards such as high winds or hurricanes. Other types of housing are also easier to rebuild after flooding because drywall can be removed and replaced while studs remain. Mobile housing cannot be rehabbed in this way and often is a total loss after flooding. Finally, mobile homes are often less energy efficient, which makes cooling the unit during hot days expensive and/or impossible. Mobile home construction standards in the United States have increased over the decades, so older mobile homes in the Triangle J region are especially at risk.

[28] America's Rental Housing 2022 report, retrieved from: America's Rental Housing 2022 | Joint Center for Housing Studies (harvard.edu)
[29] Gauthier, 2021, retrieved from: The Devastating Effects of Climate Change on US Housing Security - The Aspen Institute

5.1.4 Cost Burden

Cost-burdened homeowners and renters are those whose gross housing costs (i.e., rent or mortgage plus cost of utilities) is 30 percent of their household income or greater. In the Triangle J region and statewide, households with lower incomes are more likely to be cost-burdened. These homeowners and renters often face serious financial strain following a disaster, compared with households that have more flexibility in their budgets. In the Triangle J region, as shown in **Table** 6, 36 to 44 percent of renters are cost burdened. Homeowners have a lower rate of cost burden; roughly 20 percent of homeowners are cost burdened.

This data highlights a need within the region to identify and implement programs that support households with increased vulnerability to hazards because of their housing condition. This could include assisting homeowners and renters with preparation for hazards, especially hurricane and high-wind high-precipitation events, and the need for plans to efficiently assess damages and efficiently secure disaster relief and grants following events.

Table 6. Housing Cost Burden Characteristics

Jurisdiction	Estimated number of renters (percent of households that rent a home)	Homeowners that are cost-burdened (percent of all homeowners)	Renters that are cost-burdened (percent of all renters)	Number of housing units that are mobile homes (percentage of all units)
Chatham County	6,866 (27%)	4,149 (19%)	2,594 (38%)	5,434 (17%)
Johnston County	18,632 (27%)	9,840 (20%)	8,230 (44%)	12,770 (17%)
Lee County	7,293 (33%)	3,200 (22%)	3,046 (42%)	3,368 (14%)
Moore County	9,678 (24%)	6,209 (21%)	3,523 (36%)	7,128 (15%)

Source: ACS 5-year estimates 2015-2019 (https://www.policymap.com/newmaps#/)

5.1.5 Energy Burden

High energy cost burden is another strain for households in the Triangle J region, especially for poor households. The Department of Energy (DOE) Office of Energy Efficiency & Renewable Energy defines energy burden as "the percentage of gross household income spent on energy costs"[30]. Extremely low-income households in the region, whose income is 0 to 30 percent of the area median income (AMI),[31] are putting around 20 percent of their income toward energy costs, over twice the state average of nine percent. **Table 7** shows that in three of four counties, the average energy burden for extremely low-income households is more than double that of households in the next highest income bracket (30 to 60 percent AMI). Extreme temperatures can place a heavy burden on low-income households due to higher cooling or heating demand

[30] DOE 2020

[31] Area Median Income is the midpoint of a region's income distribution – half of the families in a region earn more than the median and half earn less than the median.

and higher energy costs; this may force households to make difficult decisions among paying for energy, groceries, medication, or other essentials.

Table 7. Average Housing Energy Burden of Low-Income and All Households

Jurisdiction	Average energy burden (% income) for low-income households at 0-30% AMI)	Average energy burden (% income) for low-income households at 30-60% AMI	Average energy burden (% income) for low-income households at 60-80% AMI	Average energy burden (% income) for all households
Chatham County	19%	7%	5%	8%
Johnston County	16%	6%	4%	6%
Lee County	19%	10%	6%	10%
Moore County	21%	9%	6%	9%

Source: DOE LEAD Tool, ACS 5-Year Average 2012-2015 (https://www.energy.gov/eere/slsc/maps/lead-tool)

5.1.6 Flood Hazard Areas

Some of the Triangle J region housing stock is vulnerable because it is located in an area known to be at risk of flooding. Property within the regulatory flood zones, at greater risk of flooding, is presented in **Table 8**. There are nearly 19,500 parcels and 2,600 buildings within the Triangle J region within the 1.0 percent annual chance flood area (ACF) (also called the 100-year flood) and 20,505 parcels and 3,250 buildings within the 0.2 percent ACF area (the 500-year flood). The assessed value, $2,456,676,749 for the region, was calculated by summing the total assessed building values for those improved properties located within the floodplain.

Parcels and buildings within the 100- and 500-year flood zones are more vulnerable to hurricanes and storms that produce heavy rains and flooding. While these storms may sound rare, North Carolina has experienced multiple 100- and 500-year floods in recent years, which highly suggests that the odds of occurring are greater than 1.0 or 0.2 percent each year, respectively.

Further, it's important to note that flooding impacts housing located outside of mapped flood hazard areas as well. FEMA flood maps provide an indication of what houses may be at greater risk, but do not capture the full picture of risk. For example, during Hurricanes Matthew and Florence, many of the houses that flooded were located outside of any mapped flood hazard areas. FEMA flood maps rely on historical data, and so they underestimate future flood risk due to changes in climate and development patterns, both of which are expected to influence flooding in the Triangle J region.

The impact of flooding on housing include damage to carpets, flooring, walls, furniture, electrical wiring and plumbing. Some housing may be a total loss after flooding. Other housing may be able to be repaired. It's also critical to note that storms bring high winds that can damage

roofs, windows and any material that is not fixed in place. Major property damage occurs when trees fall on homes during high wind events in the region.

Table 8. Estimated Exposure of Parcels to Flood Hazard

Location	1% Annual Chance Flood			0.2% Annual Chance Flood		
	Number of Parcels	Number of Buildings	Improved Value of Buildings	Number of Parcels	Number of Buildings	Improved Value of Buildings
Chatham County	**3310**	**237**	**$305,691,462**	**3336**	**256**	**$312,724,009**
Goldston	0	0	$-	0	0	$-
Pittsboro	82	17	$25,250,289	85	18	$25,486,153
Siler City	210	77	$19,683,496	219	89	$25,167,039
Unincorporated	3018	142	$260,757,657	3032	148	$261,969,797
Johnston County	**7386**	**920**	**$620,984,390**	**8171**	**1373**	**$709,408,930**
Archer Lodge	42	2	$3,039,260	42	2	$3,039,260
Benson	4	1	$51,270	4	1	$51,270
Clayton	213	20	$58,841,010	281	54	$69,337,020
Four Oaks	29	3	$1,501,390	52	7	$4,147,240
Kenly	0	0	$-	0	0	$-
Micro	1	0	$-	1	0	$-
Pine Level	1	0	$31,870	1	0	$31,870
Princeton	1	0	$120,110	1	0	$120,110
Selma	23	2	$1,070,130	23	2	$1,070,130
Smithfield	609	287	$105,484,330	881	465	$140,132,830
Wilson's Mills	14	1	$536,410	14	1	$536,410
Unincorporated	6449	604	$450,308,610	6871	841	$490,942,790
Lee County	**2819**	**532**	**$435,806,000**	**2901**	**612**	**$448,966,900**
Broadway	0	0	$-	0	0	$-
Sanford	627	197	$137,463,600	694	256	$146,889,900
Unincorporated	2192	335	298,342,400	2207	350	$302,077,000
Moore County	**5949**	**838**	**$973,217,800**	**6097**	**1010**	**$985,576,910**
Aberdeen	92	68	$8,715,810	135	93	$12,657,370
Cameron	20	1	$145,810	20	1	$145,810
Carthage	0	0	$-	0	0	$-
Foxfire Village	0	0	$-	0	0	$-

Location	1% Annual Chance Flood			0.2% Annual Chance Flood		
	Number of Parcels	Number of Buildings	Improved Value of Buildings	Number of Parcels	Number of Buildings	Improved Value of Buildings
Pinebluff	21	0	$981,520	29	7	$1,049,240
Pinehurst	651	154	$372,422,300	658	159	$373,608,850
Robbins	12	4	$500,040	14	10	$2,734,870
Southern Pines	142	9	$41,464,100	146	12	$42,000,900
Taylortown	11	1	$107,130	11	1	$107,130
Vass	4	0	$-	4	0	$-
Whispering Pines	179	35	$24,426,800	194	76	$25,954,090
Unincorporated	4817	566	$524,454,290	4886	651	$527,318,650
Regional Totals	**19,464**	**2527**	**$2,335,699,652**	**20,505**	**3250**	**$2,456,676,749**

Source: NC RISK Building-Level Database, FEMA NFHL Layers

5.1.7 Drought and Wildfire Impacts

Drought does not typically cause physical damage to housing, but can contribute to an increased risk of wildfire, due to dryer soils and vegetation. Wildfire can have devastating impacts. While Triangle J does not have a history of wildfire, North Carolina does. Houses located in the wildland urban interface and near dry vegetation are vulnerable to this growing risk. Land use ordinances and building codes that focus on fire prevention and mitigation are effective tools for reducing the risk of wildfire, as well as outreach and communication to residents in higher risk areas about property maintenance practices.

5.2 Hazard Impacts on Critical Infrastructure

Critical infrastructure vital for public health and safety in the Triangle J region includes medical facilities, police and fire stations and facilities, emergency operations centers, emergency shelters, school and community facilities (especially if used for emergency shelter). Critical infrastructure also includes the highway network and connecting bridges.

In the Triangle J region, roads and infrastructure are vulnerable to flooding and blockage, particularly low-lying sections and those near or adjacent to rivers and streams. A small number of police, fire and school facilities are located within the 100-year and 500-year flood zones, warranting review of access and operability issues that may arise during intense and/or prolonged rain events.

There are several medical facilities in the region. The largest is Moore Regional Hospital in Pinehurst, which is also a referral center for a 15-county region. There are three additional acute care hospitals, Johnston Medical Center in Smithfield, Central Carolina Hospital in Sanford and

the Betsy Johnson Hospital in Dunn (which is in Harnett County). A smaller hospital, Chatham Hospital, is located in Siler City, along with two other smaller hospitals in nearby Harnett County.

There are 72 fire stations, 35 police stations and 161 schools in the region. Of these facilities, as shown in **Table 9**, four are located within the 100-year flood zone and five within the 500-year flood zone. It is imperative that all police, fire and medical facilities continue operation during and following a disaster to reduce the severity of impacts and accelerate recovery. For all the critical facilities, and especially the police and fire facilities that are within the 500-year (and 100-year) flood zones, it is crucial to assess the accessibility to and from these facilities, noting road blockages on key routes due to flood hazard, the location of vital equipment such as power supply generators, heating and cooling units and water supply lines, as well as structural integrity and content value.

For a map of major infrastructure and critical facilities in each county, see **Appendix B**.

Table 9. Critical Facilities and Flood Zones

Category	Name	Municipality	County
100-year flood zone			
Police	NC State Highway Patrol Troop D District 1	Siler City	Chatham
Fire/EMS	Aberdeen Rescue Squad	Aberdeen	Moore
School	South Campus Community High	Smithfield	Johnston
School	South Campus Community Middle	Smithfield	Johnston
500-year flood zone (Includes the facilities in the 100-year flood zone)			
Fire/EMS	East Chatham Rescue Squad	Pittsboro	Chatham

5.2.1 Transportation Systems

The primary interstate highways in the region are I-75 to the west of Moore County, I-95 which runs in a northeast-southwest direction from Fayetteville south of the region through Johnston County and I-40 which runs north-south through Johnston County and connects to the Triangle cities. As mentioned earlier, sections of I-95 to the southwest of Johnston County were closed during and after Hurricane Matthew. This road closure affected the region as I-95 traffic had to be re-routed, demonstrating that climate change and natural hazard impacts that occur outside the region can still have effects within the region.

Other roadways throughout the Triangle J region have experienced flooding that caused temporary blockages and delays. These examples are described below and were collected during the stakeholder discussions on the hazards and impacts experienced in the region.

- Several roadways within Chatham County experience flooding during heavy rain events. South 2nd Avenue in Siler City is overtopped by Loves Creek during heavy rain events. The greenway trail adjacent to Moonrise Meadow Drive in Siler City is

located in the Special Flood Hazard Area and floods regularly during heavy rain events. In Pittsboro, Oakwood Drive and Thompson Street both experience flooding. When Thompson Street overtops, the communication tower for the fire and police department at the top of Pittsboro Fire Tower Rd is cutoff from the west. Other roadways that have been identified as experiencing flooding are Jeremiah Drive, Everett Dowdy Road and Alton King Road.

- In Johnston County, the bridge over the Neuse River on US 70 Business (Market Street) is noted for flooding. Other transportation infrastructure that is prone to flooding is the CSX railroad in Kenly and Micro (near the North Johnston Middle School). The railroad in both municipalities have culverts or stormwater pipes that are undersized in heavy rain events.
- In Lee County, heavy rain events cause Lee Avenue to flood in the vicinity of the Gasters Creek Crossing and R Jordan Road near Deep River Park has also experienced flooding when the Deep River overtops.
- Roads in Moore County that experience flooding during heavy rain events include the area around Midland Road and US 1 and the area around May Street. Both roads are in Southern Pines. West of Carthage, Kelly Plantation Road has experienced flooding, particularly during Hurricane Matthew.

The Triangle J region has several General Aviation Airports including the Siler City Municipal Airport, the Johnston County Airport in Smithfield, the Moore County Airport in Carthage / Pinehurst and a relief airport in Lee County, Raleigh Executive Jetport, northeast of Sanford.

The region is served by rail from Norfolk Southern, CSX and G&W Atlantic & Western Railway.

5.2.2 Ongoing Resilience Studies

There are several ongoing studies in the region that NCDOT is conducting as part of its resilience strategy. These are opportunities for the Triangle J region to integrate key regional transportation needs with NCDOT.

- Incorporating the section of the Fixing America's Surface Transportation (FAST) Act that requires agencies to take resiliency into consideration during the transportation planning process. NCDOT is doing so by recommending that Municipal Planning Organizations (MPOs) consult with agencies and officials responsible for natural disaster risk reduction when developing a metropolitan transportation plan and the transportation improvement program.
- Incorporating resilience into the Integrated Project Delivery model, an approach that helps all transportation projects move effectively from planning to construction.
- Inventorying and addressing gaps in the planning and standards for its Aviation, Ferry and Rail Divisions. The aviation and ferry studies are ongoing, however NCDOT has completed the rail study, which included a flood inundation analysis of statewide rail Strategic Transportation Corridors, and their vulnerabilities to the 10-, 25-, 50- and 100-year flood events. Two strategic transportation rail lines are also in the region—CSX and ASWR, going through Moore, Lee and Johnston Counties.

5.2.3 Utility Services

Power in the region is provided by public utilities, Duke Energy, as well as numerous solar farms located throughout the region and two hydropower plants. Water supply and wastewater services are provided by municipalities and each County. Some areas use wells and septic systems. In Johnston County, the pharmaceutical manufacturing industry relies upon reliable high-quality water and wastewater services.

The Harris Nuclear Plant is a power station located in southwest Wake County. The Emergency Planning Zone includes Chatham, Lee, Harnett and Wake Counties.

5.2.4 Critical Impacts from Hurricanes, Storms, Flooding and Heavy Precipitation

Hurricane Matthew in 2016 provides a useful snapshot of the potential impacts that may be experienced due to hurricane and storm hazards, flooding and heavy precipitation. Overall, in the region, the compound effect of heavy rains from a tropical storm 10 days before Hurricane Matthew resulted in significant flooding, especially along many of the rivers and streams in the Cape Fear River basin (in Moore County) and severely along the Neuse River, Little River and Hannah Creek in the eastern part of the region (in Johnston County).

Johnston County schools were closed for one week due to road closures and schools damaged by rain and floodwater. The Johnston Memorial Hospital Authority needed potable water brought in for the hospital to function properly. As mentioned, flooding overtopped I-95 in several locations, as well as I-40, and both were closed in several sections. There were also multiple power outages in Johnston County and in Smithfield, where police were required to direct traffic because of traffic lights that were down. This drained needed resources away from the community and critical responses. The Central Johnston County Regional Wastewater Treatment Facility, located in the 100-year floodplain, was overtopped. Johnston County conducted a study to evaluate the cost-to-benefit ration to raise the existing levee or located relocated the facility to outside the floodplain.[32]

Moore County experienced significant impacts in the southeastern portion of the County, where many of the rivers and streams in the Cape Fear River basin drain. During Hurricane Matthew, water line breaks in Moore County resulted in loss of pressure and boil water advisories.[33] There were also power outages at the Emergency Operations Center in Lee County and schools that were operating as shelters, requiring the use of generators for backup power.

Flooding has been observed in this area even during less-severe rainfall events[34], between Crystal Lake Dam and Spring Lake. There is a need for river and stream gauges to collect riverine flooding data.

In Chatham County, riverine flooding was not county-wide and did not impact large numbers of the County population. Several roads in the area were impassable during the storm due to

[32] Hurricane Matthew Resilient Redevelopment Plan for Johnston County, page 3-6.
[33] Hurricane Matthew Resilient Redevelopment Plans
[34] Hurricane Matthew Resilient Redevelopment Plans

localized flooding, but road closures were not widespread or long lasting. A bridge crossing a creek on the secondary access road for the wastewater treatment plant in Siler City experienced overtopping, highlighting the need for "comprehensive stormwater enhancements" to solve recurring flooding issues at several locations. This includes upsizing culverts and daylighting underground pipe systems.[35]

5.2.5 Wind Damage Impacts

High winds can result in compound impacts during or after very heavy precipitation events in the Triangle J region. For example, the combination of heavily saturated soils and wind can cause trees to blow down, bringing down power lines, blocking roads, or falling on buildings, house, cars, or people. During events, high winds can severely limit access and/or visibility and the ability of emergency services to respond in a timely manner. Following storms, debris and downed power lines create dangerous conditions for workers and citizens. Wind was not a significant impact during Hurricane Matthew.

5.2.6 Extreme Temperature, Including High Heat Indexes Impacts

Extreme heat has a smaller impact on the built environment than on agriculture and human health. Excessive heat can warp roads and railways, as well as weaken the structural integrity of bridges. Systems in older buildings may fail when inadequate ventilation or insulation leads to excessive heat build-up.[36]

5.2.7 Drought and Wildfire Impacts

The entire region is at risk to wildfire, especially as development and growth continue, and more development is within the wildland-urban interface. As development expands into rural and forested areas, critical facilities located in the WUI are at greater risk of wildfire and associated damages.

5.3 Hazard Impacts on Economic Development Assets

This section focuses on identifying hazard vulnerabilities and impacts of the Triangle J Region's major economic development assets and drivers. The greatest hazard vulnerability to the region's employers, businesses, industry and agriculture is flooding and the cascading impacts flooding causes to mobility of workers, commuters, the ability of businesses to transport goods and materials. Power outages impacted many businesses in the region and their ability to continue uninterrupted production.

5.3.1 Employment Characteristics

The top largest employers[37] in each of the Triangle J region counties are summarized in **Table 10** and mapped by County in **Appendix C**. These are a mix of public and private sector industries, with each county's public school system at or near the top employer, followed by

[35] Hurricane Matthew Resilient Redevelopment Plans
[36] Cape Fear Regional HMP, 2020.
[37] North Carolina Department of Commerce

health care, public administration, agriculture, manufacturing, accommodations and food service. Many of the companies and employers have multiple locations throughout the region.

Table 10. Largest Employers in the Triangle J Region (2020)

Company	Industry	Class	Employment Range	Rank
Chatham County				
Chatham County Schools	Educational Services	Public Sector	1000+	1
Chatham County	Public Administration	Public Sector	500-999	2
Mountaire Farms of NC Inc	Agriculture, Forestry, Fishing and Hunting	Private Sector	250-499	3
Carolina Meadows Inc	Health Care and Social Assistance	Private Sector	250-499	4
Johnston County				
Johnston County Public Schools	Educational Services	Public Sector	1000+	1
Johnston Health	Health Care and Social Assistance	Public Sector	1000+	2
Grifols Therapeutics Inc	Manufacturing	Private Sector	1000+	3
Johnston County	Public Administration	Public Sector	1000+	4
Lee County				
Lee County Schools	Educational Services	Public Sector	1000+	1
Caterpillar Inc	Manufacturing	Private Sector	1000+	2
Pilgrim's Pride Corporation	Manufacturing	Private Sector	500-999	3
Pentair Water Pool & Spa Inc	Manufacturing	Private Sector	500-999	4
Moore County				
Moore Regional Hospital Montgomery	Health Care and Social Assistance	Private Sector	1000+	1
Moore County Schools	Educational Services	Public Sector	1000+	2
Pinehurst LLC	Accommodation and Food Services	Private Sector	1000+	3
Moore County	Public Administration	Public Sector	500-999	4

5.3.2 Hurricane Matthew Impacts

Hazard impacts to these employers and other businesses include blocked transportation routes due to extreme storms and precipitation, manufacturing and transport shut-downs, school

closures due to blocked and/or unsafe transportation routes, and power and energy outages. Power outages often cause larger or cascading impacts such as spoilage of products that need to be frozen or kept cold, inability of businesses to function without power, and impacts to wastewater treatment and water pumping and the ability to supply fresh water for agriculture / farm operations, hospitals and daily needs.[38]

During Hurricane Matthew, power outages in the Triangle J region impacted customers causing closures and delays at schools, municipal buildings and businesses, as well as traffic issues for commuters. The farming community and agribusiness was the most heavily impacted sector in Johnston County, as floodwaters caused significant damage to crops. The Hurricane Matthew Resilient Redevelopment Plan estimated nearly $19 million in crop, livestock and structural losses in the county.

Failure of critical infrastructure such as electricity, natural gas and water facilities during Hurricane Matthew had large economic impacts. Multiple streets and businesses were flooded in Johnston County. Power outages interrupted pharmaceutical manufacturing. Johnston County schools were closed due to road closures and flood or rain-damaged schools; and some were used as shelters. When schools close, caregivers cannot go to work, even if their job was not affected by the disaster. The loss of water and wastewater service from Johnston County created a production shut down and development of a continuity process using additional resources. An expansion of one million square feet by pharmaceutical manufacturing company Novo Nordisk at a site in Clayton is a future consideration regarding stormwater management, flood exposure and development of emergency action plans. [39]

In Moore County, none of the top 10 businesses experienced major impacts due to Hurricane Matthew. However, there were significant flooding impacts to commercial and residential structures in downtown Aberdeen, located in the flood zone. Flooding of parking lots is common in Aberdeen during heavy rainfall events, often due to blocked storm drains.

5.4 Hazard Impacts on Public Health

This section provides an analysis of the climate threats, vulnerabilities and adaptive capacities applicable to the region's public health. The most significant public health concerns for climate change and natural hazards in the region include respiratory and cardiovascular stress, individuals and workers in outdoor labor and industries, mold growth in low-income and rental households, algal blooms and impact on water quality, septic system overflows, mental health and adverse traumatic impacts to children.

Community Health Assessments are developed annually for each county within the Triangle J region and provide a solid basis for understanding health issues, engaging community members and developing a plan for community health improvement. Access to health care, healthy eating and active living and economic resilience have been identified as priorities in previous community health assessments. For all four counties, access to health care, substance use,

[38] Hurricane Matthew Resilient Redevelopment Plan for Chatham County, 2017.
[39] Hurricane Matthew Resilient Redevelopment Plan for Johnston County, 2017.

mental health, obesity and transportation are high priorities.[40] Each priority area is at risk of worsening due to climate change and more devastating natural hazards. For example, physical access to needed health care services may be impeded by flood waters on key transportation routes.

5.4.1 Hurricane, Storm and Flooding Impacts

Hurricanes and storms can have devastating impacts on public health during events as well as long-term effects that occur later. Hurricane and storm events make travel dangerous and can contribute to unintended accidents and injuries. Emergency services may have difficulties reaching those who have health emergencies which can contribute to adverse health effects. Long-term, the stress of preparing for and recovering from hurricanes and storms can catalyze latent and chronic health issues like cardiovascular and cerebrovascular issues which are top causes of death in Chatham, Johnston, Lee and Moore counties. Recent studies have shown that hurricanes and storms have a negative impact on mental health especially where these weather events are recurring.[41] Studies have also shown that these negative health effects disproportionally affect communities experiencing poverty and communities of color.[42]

Flooding not only has impacts on the built environment but on public health as well. When flood water recedes, it leaves a perfect environment for mosquitoes, mold and other bacteria, all of which can bring infectious disease. Low-income households without sufficient resources to rehabilitate flooded homes may be forced to live in mold infested dwellings. Living with mold exacerbates existing respiratory illnesses and encourages new respiratory illnesses. As with hurricanes and storms, the prevalence of recurring flooding often has a negative impact on mental health. As flooding within this region often affects those communities living in poverty and communities of color, they may experience a disparity of health effects.

Heavy precipitation in this region often leads to flash floods and rising waters days after the heavy precipitation. Flash floods present a danger to travelers caught unaware as well as create flood situations in low lying areas. Wind damage can cause unexpected injuries from debris and falling trees. Fallen trees can cause accidents or impede emergency services.

5.4.2 Extreme Temperature, Including High Heat Indexes Impacts

Excessive heat is a dangerous occurrence in North Carolina. By mid-century, average annual temperatures are projected to increase in the state, along with at least two to three additional weeks of days when the maximum temperature exceeds 95 °F and an increase in very warm nights (minimum temperature of 75 °F or higher) by 18 – 35 night per year across the majority of the Piedmont and Coastal Plain.[43] Prolonged periods of high daytime temperatures coupled with warmer nighttime temperatures increase stress and lessen the ability to recover from hot days. In addition, extreme heat contributes to poor air quality, resulting in greater risk for the elderly, individuals with respiratory or other health issues, children with asthma or other respiratory

[40] Chatham County Health Department, 2021; Johnston County Health Department, 2021; Lee County Public Health Department, 2018; Moore County Public Health Department, 2019
[41] Waddell et. al., 2021
[42] Ndugga, 2022
[43] NC Climate Science Report 2020, 49-50.

conditions and outdoor workers. The impacts of extreme heat are expected to be higher in underserved communities, where residents do not have the means to adapt to warming temperatures and may already experience greater respiratory and cardiovascular disease.[44]

Excessive heat coupled with other climate hazards, such as wildfires and smoke, increased pollen and increased mold growth, can all trigger asthma, allergies and respiratory symptoms and contribute to increased emergency room visits. In 2008, the wildfire season saw a 42-66% increase in cardiovascular and respiratory emergency room visits.[45]

Harmful algal blooms (HABs) in the state are closely tied to high temperatures and reduced precipitation. These carry toxins that may be harmful when ingested or inhaled and are especially harmful to children and pets. HABs reduce the amount of dissolved oxygen in water and lead to fish kills, impacting communities who may rely on fish for food, and reducing recreation opportunities. Water and food-borne illness events may increase in the state.[46]

5.4.3 Drought and Wildfire Impacts

Surface water is at risk with decreases in precipitation and population growth. Similarly, well water is at-risk to contaminants, which may enter waterways during heavy rains and flooding then concentrate in the soils as streams, rivers and lakes dry up. Human and agricultural activities will place a larger demand on the use of wells as surface waters dry up.

As discussed above, wildfire and smoke can trigger and worsen respiratory issues such as asthma and allergies and has contributed to an increase in emergency room visits.[47]

5.5 Hazard Impacts on Historic and Cultural Resources

This section provides an analysis of the vulnerability of historic and cultural resources to natural hazards and climate change. The greatest vulnerabilities in Triangle J are historic properties located within the 100-year floodplain, at grave risk of impact and damage from flood water.

As valued assets within a community, historic buildings and sites are typically vulnerable due to their age and structural integrity. There are 108 historic properties in the region.[48] In Chatham County, nine of the 39 properties listed on the National Register are within a floodplain. In Johnston County, four of the 30 National Register properties are within a floodplain. Lee County has 14 properties on the National Register, all of which are in the floodplain. Finally, in Moore County, six of the 25 National Register properties are in a floodplain. These historic properties include historic neighborhoods, individual houses, schools, churches, industrial plants, battlefields and farms.

[44] NC Climate Science Report 2020; NC Climate Health Profile
[45] NCDHHS, 2022
[46] NCDHHS, 2022
[47] NCDHHS, 2022
[48] National Register of Historic Places

5.5.1 Climate Change and Natural Hazard Impacts

Hurricanes and storms have a significant impact on historic buildings.[49] There are a number of historic buildings both on and off the national register within Chatham, Johnston, Lee and Moore counties that are at risk of irrevocable damage. The historic land features such as farms and battlefields may have moderate impacts as wind and flood water from the hurricanes and storms may alter the landscape and disturb any cultural resource features.

In **Figure 7**, the locations of historic sites are overlaid on the FEMA NFHL Data and show numerous sites that are in close proximity to floodplains. These sites are the most vulnerable to flooding due to extreme precipitation or hurricanes. They may also be vulnerable to wildfire.

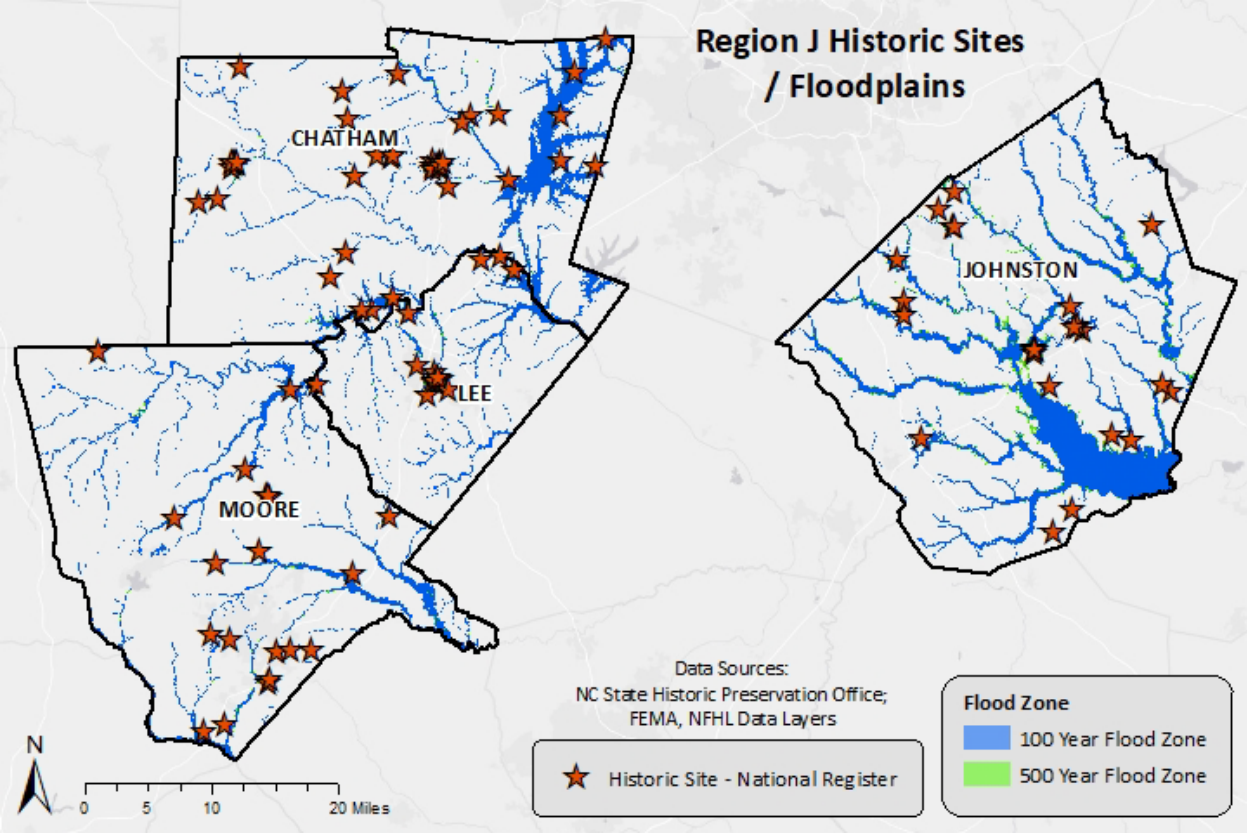


Figure 7. Overlay of Historic Sites on FEMA NFHL Data

5.6 Natural Environmental Systems

This section includes an analysis of the climate threats, vulnerabilities and adaptive capacities applicable to the region's natural environmental systems.

As a whole, the greatest vulnerability to environmental systems in the region is impacts to water systems. Reliable and high-quality water supply is at risk as the Triangle J region continues to

[49] Emergency Management Accreditation Program (EMAP)

grow and water demand increases. Many of the resources cited in this section such as parks, managed areas and forests serve a secondary function of improving water quality because of limited impervious surfaces.

Drought and variations in precipitation patterns may impact the amount of available water, compromise water quality due to increased algae growth, or create more flooding situations where water quality may be compromised. Impacts from drought may be cascading. For example, extended periods of dry weather may increase fire risk if power lines are blown down during storms, or the power grid is heavily burdened due to cooling demand.

5.6.1 Environmental Profiles by County

Chatham County

Chatham County is located within the Cape Fear River basin. The Rocky River flows east-west through the middle of Chatham County. The Deep River flows along Chatham's southeastern border with Lee County. Also, the Haw River is located in the eastern portion of the county. Jordan Lake can be found in the eastern portion of Chatham County, covering over 13,000 acres. The southern end of Shearon Harris Reservoir also lies in Chatham County.

According to the North Carolina Natural Heritage Program (NCNHP), there are several natural areas of high, very high or exceptional value in Chatham County. They are found along the Rocky River and its tributaries, along the Deep River and along the Haw River. There are several managed areas under state ownership within Chatham County. Managed areas are properties and easements where natural resource conservation is one of the current primary management goals or are of conservation interest. Managed areas in Chatham County are located along the Haw River.[50]

The NCNHP also produces a biodiversity and wildlife habitat assessment for the state. According to this assessment, areas in Chatham County with the highest rating for biodiversity and wildlife habitat are along the Rocky River and its tributaries and along the Haw River. These areas rank between a 7 and 10, with 10 being the highest possible score. Other areas of the county rank 5 to 6. Most of the county is unrated.

The Chatham County Parks and Recreation Department maintains several parks and facilities in Chatham County. The Northeast District Park has recreational baseball fields; the Northwest District Park has boating. There is also the Southwest District Park and the Park at Briar Chapel. The American Tobacco Trail also passes through the north of Chatham County.

Johnston County

Johnston County is located mostly within the Neuse River basin and within the Cape Fear River Basin in the south of the county, near Benson, along the Mingo Swamp. The two most prominent rivers in Johnston County are the Neuse River and the Little River. The Neuse River runs the entire length of the county from the northwest to the southeast. Other notable water features are the Buckhorn Reservoir and Holts Lake. The Buckhorn Reservoir is in the extreme northernmost tip of the county. It serves as the primary water supply for the City of Wilson,

[50] Chatham County Resilient Redevelopment Plan

outside of Johnston County, but also doubles as a source of recreation for the citizens of the surrounding counties. Holts Lake is a private lake serving the residents of the community at the Country Club of Johnston County.

According to the NCNHP, Johnston County has natural areas of high, very high or exceptional value. There are several managed areas under state ownership within Johnston County including Howell Woods and the Neuse River southeast of I-95.

The higher biodiversity and wildlife habitat assessment scores in Johnston County from the NCNHP are along the Neuse River and its tributaries. These areas rank between a 7 and 10, with 10 being the highest possible score. Other areas of the county rank between 5 and 6. Most of the county is unrated.

The Johnston County Parks and Recreation Department maintains several parks and facilities in Johnston County. Facilities available include Clemmons Educational State Forest, Howell Woods Environmental Learning Center, Legend Park—Mountain Biking Trail, Neuse Adventure Canoe & Kayak, Tucker Lake and the Mountains to Sea Trail.

Lee County

Lee County is located within the Cape Fear River Basin. The Cape Fear River and Deep River form the northern border for Lee County. Various tributaries to each of these rivers flow to the north. Wetlands are present at each of these rivers and their tributaries. Wetlands also are present in the southern portion of the county near the Upper Litter River, its tributaries and Trace Lake. The most common wetland type in Lee County is freshwater forested/shrub wetland.

According to the NCNHP, there are very few natural areas of high, very high, or exceptional value in Lee County. There are several managed areas under state ownership within Lee County. These areas in Lee County are mostly all along the Cape Fear River and Deep River.

The areas with the highest biodiversity and wildlife habitat assessment scores in Lee County according to the NCNHP are along the Cape Fear River, Deep River and their tributaries. These areas rank between a 7 and 10, with 10 being the highest possible score. Other areas of the county rank 5 to 6. Most of the county is unrated.

The Lee County Parks and Recreation Department maintains several parks and facilities in Lee County. The most prominent is San-Lee Park. It is located on 177 acres off of US 421 east of downtown Sanford. The park includes a nature center, mountain bike trail, nature trails, a fishing program, boat rentals and a campground.

Moore County

Moore County is mostly located within the Cape Fear River Basin while the southwest corner of the county is within the Lumber River Basin. Moore county is home to a number of significant water bodies, namely the two major rivers that are located within the county's boundaries: Deep River and Little River which are part of the Cape Fear River Basin as well as other smaller rivers and streams that are identified as part of the Lumber River Basin. The Deep River runs through the northern part of the county and The Little River runs mainly through the central and southern

part of the county. Several locations along these rivers have been dammed and thus there is some human control over these features.

Moore county is also home to a number of significant water bodies, namely the many lakes, like Pinehurst Lake, Watsons Lake and Thagards Lake included as part of the numerous golf courses across the county. The majority of these small lakes are often used as stormwater management features, and many were formed damming one of the 68 identified rivers, creeks and branches located in the county. Wetlands are present throughout the county, especially along the Deep and Little Rivers and their tributaries

In terms of environmental assets, the county has leveraged the Sandhills to develop significant green space and areas as golf courses throughout the county. According to the NCNHP, there are several natural areas of high, very high or exceptional value in Moore County. Areas identified as having exceptional or very high importance (highest levels) include:

- Nicks Creek/Eastwood Sandhills
- Voncanon Longleaf Pine Stand
- CPF/Deep River below High Falls Aquatic Habitat
- Deep River Spiderwort Slopes
- Carbonton Diabase Sill
- Spies Longleaf Pine/Wiregrass Site
- CPF/Bear Creek Aquatic Habitat
- Upper Drowning Creek Swamp Forest
- Walthour Moss Longleaf Pine Forest
- Weymouth Woods State Natural Park
- Paint Hill
- Little River Flatwoods

Besides these areas, there are several managed areas under state ownership within Moore County. Managed areas are properties and easements where natural resource conservation is one of the current primary management goals or are of conservation interest. These areas in Moore County include, among others: Goodwin State Forest, Sandhills Area Land Trust Preserve, Eastwood Plant Conservation Program, Sandhills Game Land and Weymouth Woods-Sandhills Nature Preserve.

The NCNHP produces a biodiversity and wildlife habitat assessment for the state. According to this assessment, areas with the highest rating for biodiversity and wildlife habitat are concentrated in the southern areas of the county and along major rivers such as the Deep River and Little River. Many of these areas rank between a 9 and 10 on the biodiversity and wildlife habitat scale, with 10 being the highest possible score. Much of the county that is in the southern, urbanized area is unrated or has a much lower rating than areas north of the river.

Finally, the county has a considerable number of municipal-level recreational and park facilities such as Hillcrest Park and Lake Luke Marion in Carthage. In addition, the Town of Southern Pines and the Village of Pinehurst are developing greenway trail systems for their residents. Although the two greenway systems do not connect, more than 15 miles of nature trails are available for hiking, biking, walking, running and nature observation. These and all the

environmental assets are especially critical to Moore County as they drive many of the recreational activities of the residents and enhance the local economy via eco-tourism.

5.6.2 Hurricane and Storm Impacts on Natural Environmental Systems

Hurricanes and other storms can be just as disruptive in natural areas as in developed areas. Hurricane winds can down trees and cause disruptions to local ecosystems, especially if damage is heavy in areas where endangered or protected species are present. Depending on the strength, severity and duration of the event, hurricanes can remove the foliage from forest canopies and drastically alter habitats causing the indigenous animal populations to suffer. High winds from hurricane events can also strip fruits, seeds and berries from bushes and trees, resulting in specific food shortages.

5.6.3 Flooding and Heavy Precipitation Impacts on Natural Environmental Systems

Modifying stream banks and removing vegetation from a riverside can create negative consequences from flooding. When these modifications are present, flooding can cause unnatural erosion of sediment into the waterway and create an imbalance of nutrients in the water, which may harm ecosystems and have a negative impact on downstream water quality.

Natural areas are often, but not always, adept at managing inundations. The fluctuation of water levels in a wetland, especially flood water, supports the biological diversity of low-lying areas by releasing nutrients into the soil and germinating wetland flora. Flooding also offers some control of invasive water weeds. Most features of the environment have adapted to the effects of a flood and respond quickly, although it is possible that some species may not be resilient enough to survive and will experience population loss.

5.6.4 Extreme Temperature Impacts on Natural Environmental Systems

The natural environment is also impacted by extreme heat. Plants and animals that are not able to withstand the heat may die off, just as crops and livestock may be impacted by unusually high temperatures, resulting in death or illness. Heat waves can also contribute to higher levels of air pollution. Hot air is more likely to become stagnant and trap emitted pollutants, often causing increased levels of surface ozone.

5.6.5 Drought and Wildfire Impacts on Natural Environmental Systems

Like other hazards, wildfires and droughts impact ecosystems. Wildfires have the potential to damage or destroy forage on grazing lands, destroy secondary forest products and cause degradation and loss of wildlife habitat on public lands. On private lands, vegetation losses could include agricultural crops that are either burned or impacted by wildfire smoke. Indirect impacts could include loss of growing stock and irrigation systems. Another potential loss

includes damage and destruction to a wide variety of common or protected habitats in the state. Finally, the release of smoke from wildfires can pollute the air and reduce air quality.

It should also be noted, however, that wildfires are a naturally occurring element of the environment and play an important part in the development of many ecosystems. Wildfires regenerate and provide vital nutrients the soil needs to sustain a forest habitat for all the organisms living within it. Therefore, although there are some negative impacts of wildfire, there are some positive environmental impacts as well.

Natural areas are often adept at managing drought, but not always. Drought can increase pollution levels in water sources since there is an insufficient supply of rainwater to dilute industrial and agricultural chemical runoff. This contamination poses a risk to plants and animals and makes it difficult to maintain a clean drinking water supply. Lack of rainfall may also cause the ground to become dry, bare and unstable. The resulting lack of ground cover can then lead to severe erosion and loss of topsoil when high-intensity rainfall returns. These environmental impacts often lead to degraded habitats.

5.7 Social Vulnerability

Socially vulnerable populations are those who, by nature of their characteristics such as age, economic background, or ability to speak English, are at greater risk of climate change and natural hazards impacts. The greatest climate concerns for socially vulnerable populations in the Triangle J region are poverty and socioeconomic status.

In this section, we explore social vulnerability of the Triangle J region using the Centers for Disease Control's Social Vulnerability Index (CDC SVI).[51] The CDC SVI describes each tract based on 15 social factors, including poverty, lack of vehicle access and crowded housing. These factors are grouped into four themes: socioeconomic status, household composition, race/ethnicity/language and housing/transportation. **Figure 8** displays the data components for each of the themes.

[51] CDC SVI uses U.S. Census data to determine the social vulnerability of every census tract. Census tracts are subdivisions of counties for which the Census collects statistical data. (https://www.atsdr.cdc.gov/placeandhealth/svi/fact_sheet/pdf/SVI_FactSheet_v10152020-H.pdf).

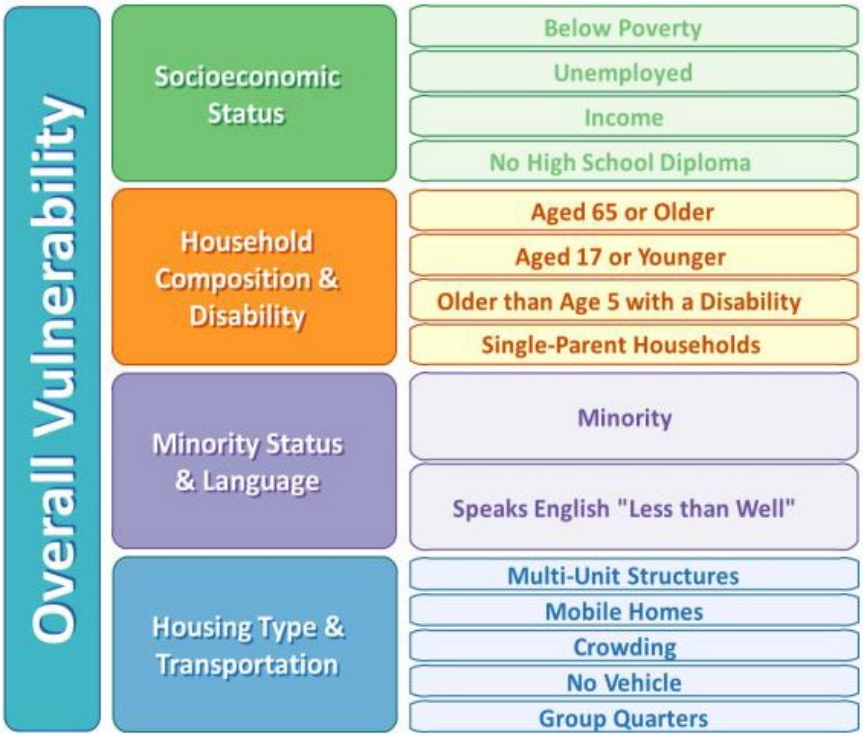


Figure 8. SVI Themes and Factors

Social vulnerability scores are grouped into four indicates, from high to low vulnerability, as illustrated in **Table 11**.

Table 11. Summary of SVI Scores for Vulnerability Identification

Vulnerability Indication	CDC SVI Score
High vulnerability	0.75 – 1.0
Moderate to high vulnerability	0.50 - 0.75
Low to moderate vulnerability	0.25 – 0.5
Low vulnerability	0 - 0.25

Source: ATSDR, 2018

5.7.1 Chatham County

In Chatham County, the areas of highest social vulnerability according to CDC SVI are two census tracts located in Siler City (**Figure 9** and **Table 12**). Siler City has a population of 8,008 which includes the largest population of Hispanic/Latino people in Chatham County. The median income in 2019 was $38,222 and median house value was $106,000.[52]

[52] https://datausa.io/profile/geo/siler-city-nc

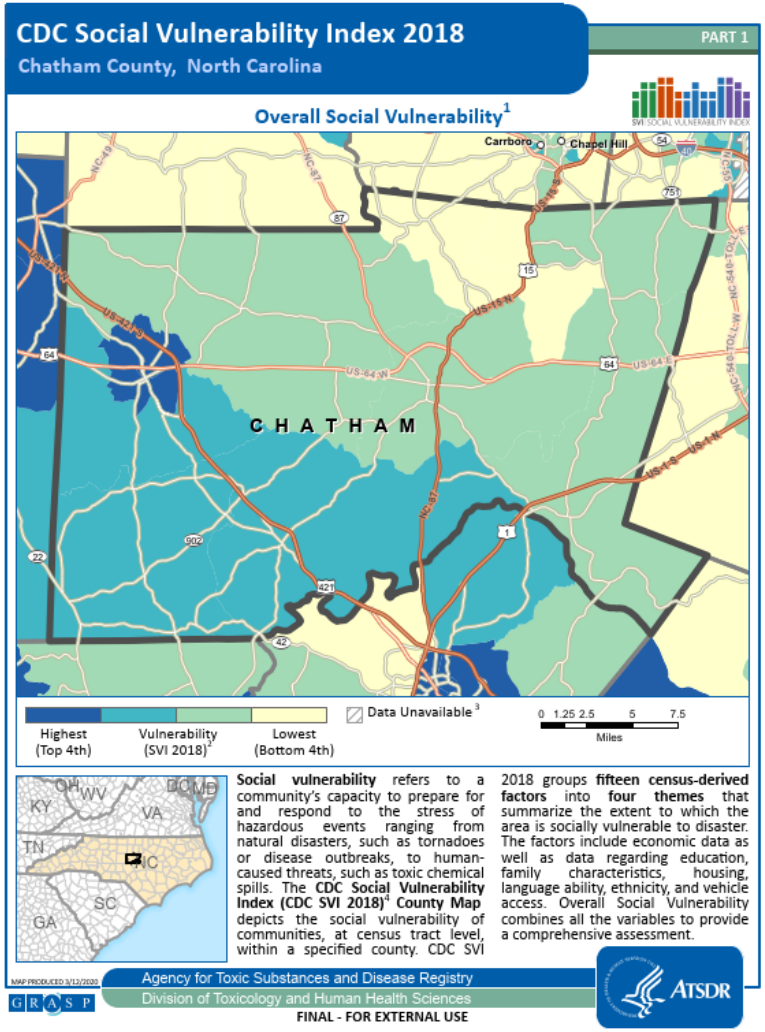
Table 12. CDC SVI Scores for Tracts with High Vulnerability in Chatham County

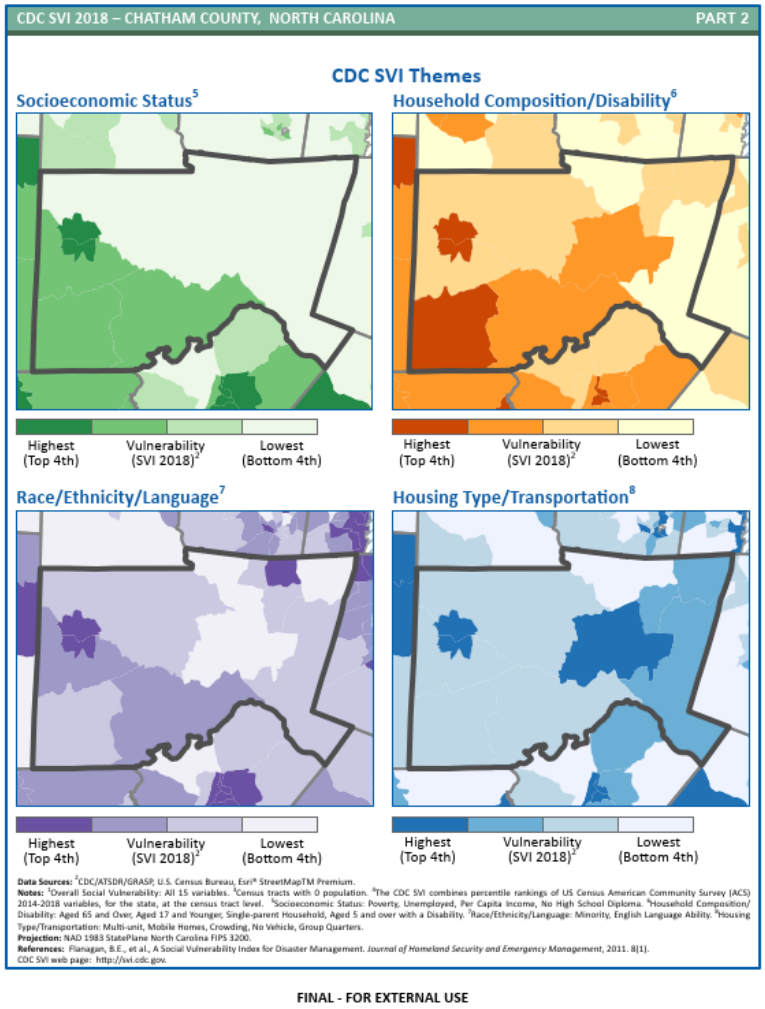
Census Tract	Overall CDC SVI	Theme 1: Socioeconomic Status	Theme 2: Household Composition & Disability	Theme 3: Minority Status & Language	Theme 4: Housing Type & Transportation
Tract 204.02	0.9884	0.9556	0.9247	0.9737	0.9307
Tract 204.01	0.9463	0.8473	0.8157	0.9507	0.9362

Source: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html (data download)

In the northern census tract of consideration in Siler City (census tract 204.02), more than a quarter of residents are living in poverty, and the area's high number of children and single-parent households also adds to its social vulnerability. In the two high SVI census tracts identified, more than 44% to 46% of the population is Hispanic or Latino. These two census tracts have a high estimated percentage of non-English speakers at 19% and 24%. Drivers within housing type and transportation include the "no vehicle" factor. Although more than 90% of the population in both census tracts drive to work, almost 15% of households in census tract 204.02 have no car.[53]

[53] ACS 2015-2019, Policy Map, https://www.policymap.com/newmaps#/





Source: https://svi.cdc.gov/map.html (interactive map)

Figure 9.Overall CDC SVI in Chatham County

5.7.2 Lee County

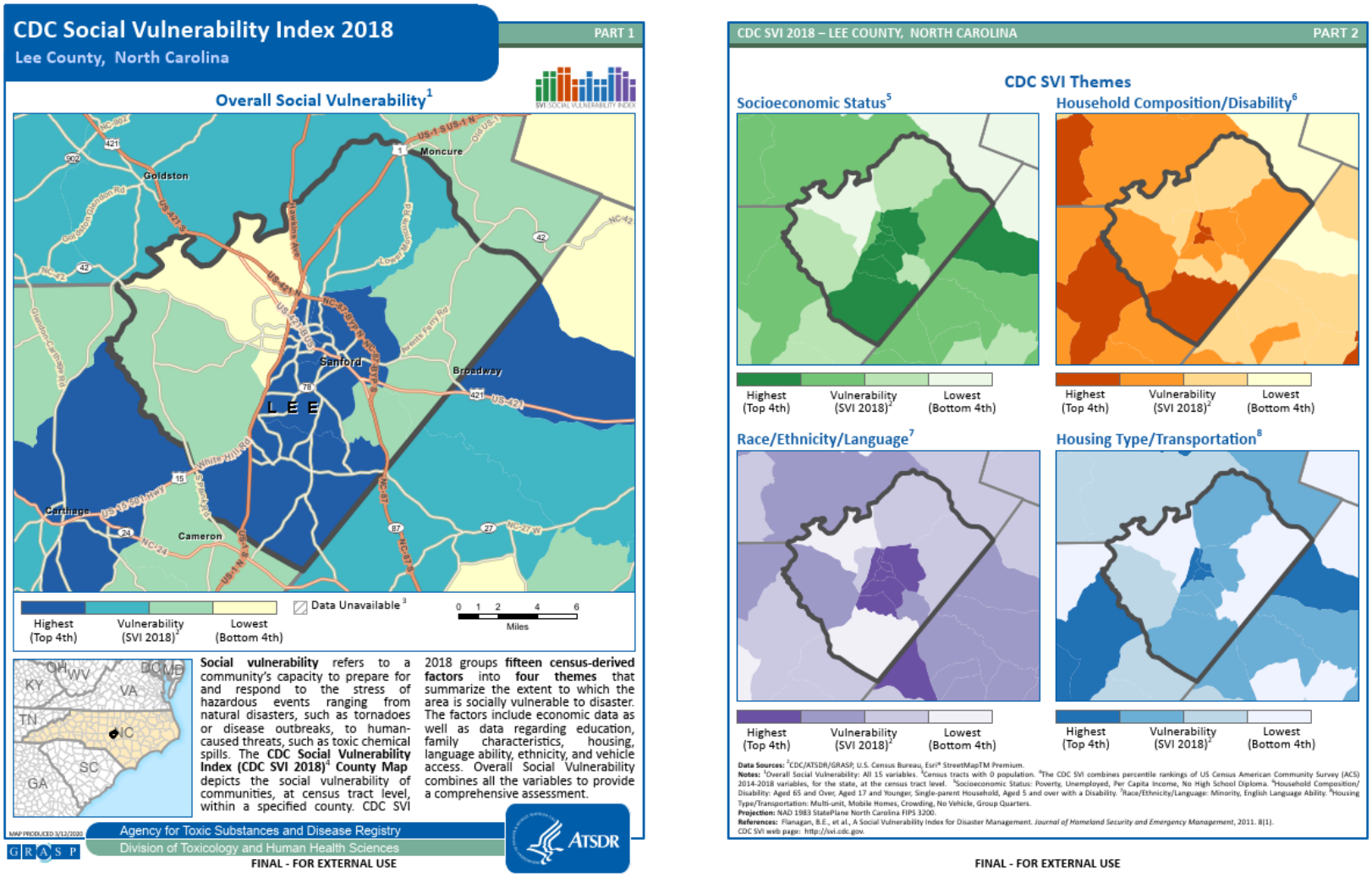
In Lee County, the areas of highest social vulnerability according to CDC SVI are seven census tracts located in and south of Sanford (**Figure 10** and **Table 13**). Sanford is the county seat and largest city in Lee County with a population of 29,456 people as of 2019. In the high vulnerability census tracts, socioeconomic status, minority status and language are the main drivers of the CDC SVI score (Table 14). The median household income in Sanford in 2019 was $46,915 and median property value was $142,200.[54] Lee County has the highest poverty rate of the counties in the region, at 12.6 percent of families.[55]

Table 13. CDC SVI Scores for Tracts with High Vulnerability in Lee County

Census Tract	Overall CDC SVI	Theme 1: Socioeconomic Status	Theme 2: Household Composition & Disability	Theme 3: Minority Status & Language	Theme 4: Housing Type & Transportation
Tract 302	0.9870	0.9783	0.8614	0.9770	0.9246
Tract 303	0.9838	0.9778	0.9363	0.9788	0.8442
Tract 304.02	0.8704	0.8806	0.6693	0.9419	0.7101
Tract 304.01	0.8404	0.7728	0.6485	0.9516	0.7217
Tract 301.01	0.8292	0.6941	0.6559	0.8581	0.8645
Tract 305.02	0.7793	0.8441	0.4319	0.8677	0.6070
Tract 305.03	0.7640	0.8454	0.9529	0.2323	0.5918

Source: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html (data download)
*Highlighted cells indicate high vulnerability tracts for CDC SVI themes

[54] (https://datausa.io/profile/geo/sanford-nc
[55] U.S. Department of Commerce. 2022. Census Bureau, American Community Survey Office, Washington, D.C., reported by Headwaters Economics' Populations at Risk, headwaterseconomics.org/par.



Source: https://svi.cdc.gov/map.html (interactive map)

Figure 10. Overall CDC SVI in Lee County

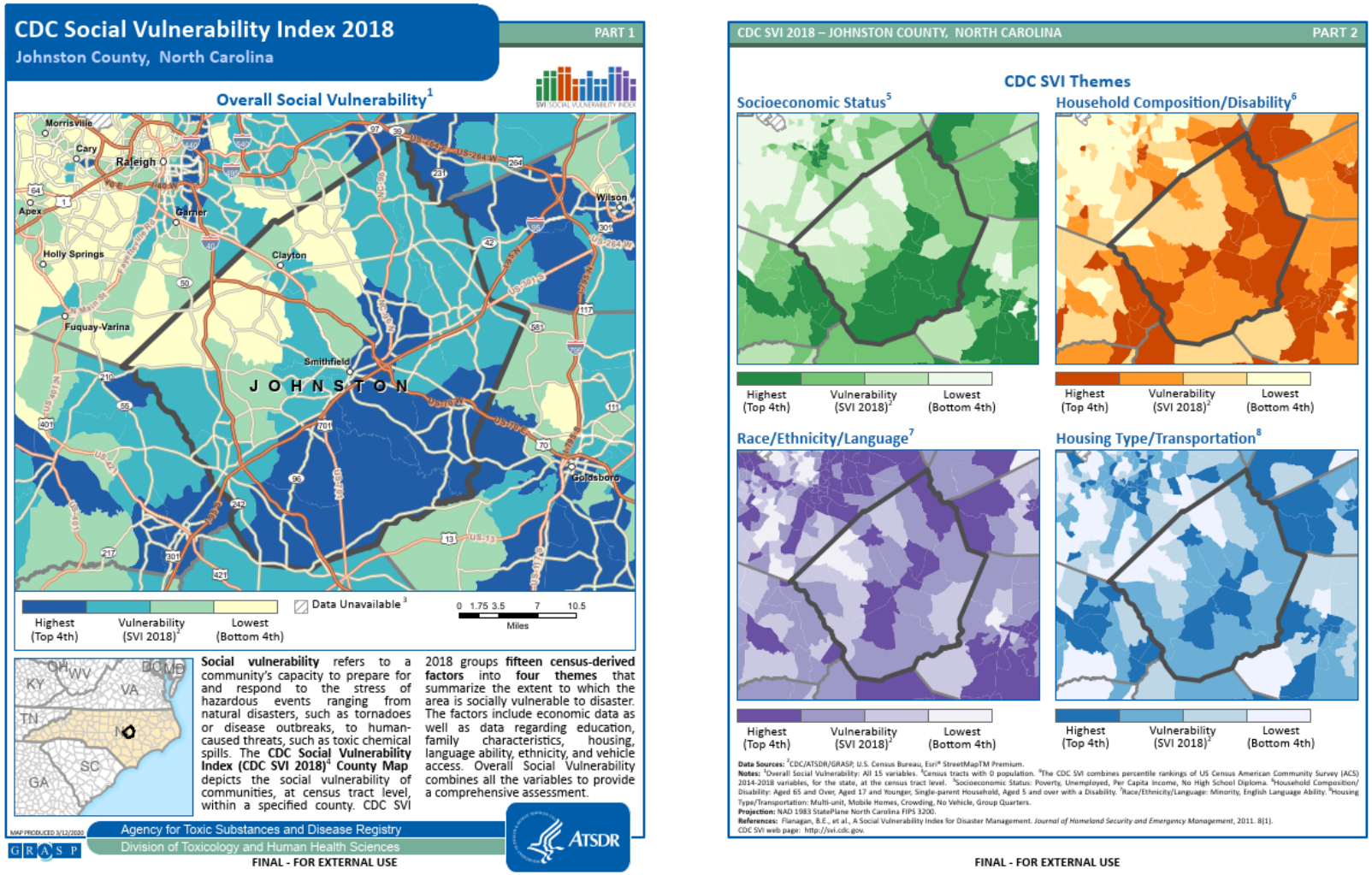
5.7.3 Johnston County

In Johnston County, the areas of highest social vulnerability according to CDC SVI are seven census tracts located in the southern part of the county, and include the jurisdictions of Benson, Four Oaks, Smithfield and Selma (**Figure 11** and **Table 14**). In all the high vulnerability census tracts, socioeconomic status is a primary driver. In the highest of the high vulnerability census tracts, household composition and disability are also drivers of high vulnerability (Table 15).

Table 14. CDC SVI Scores for Tracts with High Vulnerability in Johnston County

Census Tract	Overall CDC SVI	Theme 1: Socioeconomic Status	Theme 2: Household Composition & Disability	Theme 3: Minority Status & Language	Theme 4: Housing Type & Transportation
Tract 403.01	0.9621	0.8880	0.9598	0.9157	0.8706
Tract 406	0.9098	0.9468	0.8166	0.7470	0.8095
Tract 407	0.8834	0.7705	0.8836	0.8995	0.8026
Tract 403.02	0.8635	0.8339	0.8342	0.9304	0.6338
Tract 412.02	0.8598	0.7649	0.7469	0.7770	0.8946
Tract 413	0.8029	0.9361	0.5769	0.6475	0.6084
Tract 405	0.7783	0.7932	0.9335	0.4378	0.6251

Source: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html (data download)
*Highlighted cells indicate high vulnerability tracts for CDC SVI themes



Source: https://svi.cdc.gov/map.html (interactive map)'

Figure 11. Overall CDC SVI in Johnston County

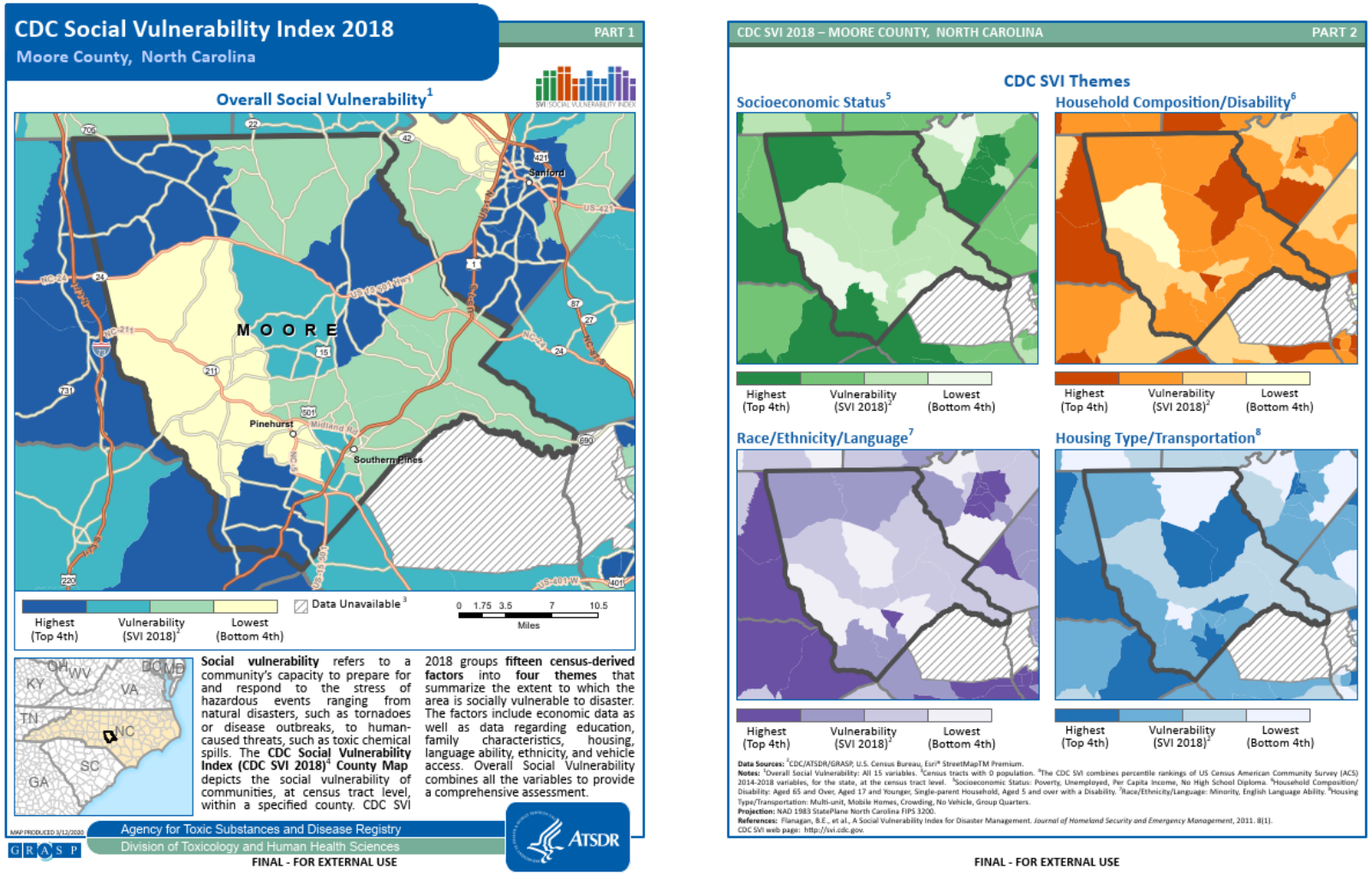
5.7.4 Moore County

In Moore County, the areas of highest social vulnerability according to CDC SVI are three non-contiguous census tracts dispersed throughout the county (**Figure 12 and Table 15**). Socioeconomic status is the primary driver for two of the high vulnerability tracts. Household composition and disability and housing type and transportation are the drivers for the third tract.

Table 15. CDC SVI Scores for Tracts with High Vulnerability in Moore County

Census Tract	Overall CDC SVI	Theme 1: Socioeconomic Status	Theme 2: Household Composition & Disability	Theme 3: Minority Status & Language	Theme 4: Housing Type & Transportation
Tract 9502	0.8006	0.8098	0.6864	0.7424	0.6967
Tract 9504.02	0.7733	0.5419	0.8998	0.4567	0.9182
Tract 9512	0.7598	0.7506	0.7150	0.7244	0.6445

Source: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html (data download)
*Highlighted cells indicate high vulnerability tracts for CDC SVI themes



Source: https://svi.cdc.gov/map.html (interactive map)

Figure 12. Overall CDC SVI in Moore County

5.8 Cascading Impacts

Cascading impacts are situations where an initial impact from a climate hazard causes or contributes to another impact, or a series of impacts. These could also be termed compound or cumulative impacts. Often, these cascading impacts may not have been anticipated which may make response and recovery more challenging.

For each hazard described in this assessment and its impact on the region's housing, critical infrastructure, major economic development, public health, historical and cultural resources, natural environmental systems and social vulnerability, it is worthwhile to imagine and examine possible cascading impacts and how projects and solutions may be developed that would address these.

For example, flooding impacts on housing may cause health and safety impacts if waters remain for many days and contribute to mold growth; costs for repair and rebuilding may increase due to the presence of mold. Health costs for the homeowner or renter may increase if there is sensitivity to mold that worsens other existing health conditions. Solutions to a set of cascading impacts should focus on solving the primary issue in a very timely manner to prevent subsequent issues.

Another example of a cascading impact is a hurricane that floods access to a road that leads to a communication tower in need of repair. Until the flooded road is cleared, communication in the area may be compromised, potentially increasing risk to region residents in the case of an injury or need for immediate medical assistance.

As the Regional Resilience Portfolio projects are identified, it would be very useful to consider potential cascading impacts and how those might be addressed by project modifications or additional steps in the project design process.

6. Vulnerability Hot Spots

This section includes identification of locations of greatest agglomeration of vulnerabilities within the Triangle J region. Stakeholder and public input during the initial project phases contributed to the identification of vulnerability hot spots. The Stakeholder Partnership meetings, the Public Survey, the interactive mapping tool and the Public Workshop all provided data and ground-truthing of data. The information gathered confirmed existing and ongoing issues and helped identify new and emerging problems to consider as the Regional Resilience Project Portfolios are created.

An Interactive Mapping tool was created and used throughout both the Stakeholder Partnership Meetings and the Public Workshops. The purpose was to map problem areas as identified by participants during the meetings in real time. Additionally, visualization aided in locating specific sites that have been exposed to natural hazards to facilitate understanding and in-depth discussion and analysis. As a problem area was identified, the tool prompt the user to select the hazard of concern, the event in which the impact occurred and the issue being addressed. The map was open to the stakeholders and public to add additional areas and information.

Table 16 and **Figures 13, 14 and 15** on the following pages provide summary information for areas of local vulnerability that were entered into the Interactive Mapping tool. Note that no users entered information about vulnerability problems in Lee County. Each issue in Table 17 was identified as a recurring event, further reinforcing the need to prioritize these issues as resilience strategies are developed.

Table 16. Hot Spots Identified by Stakeholder Partnership

ID	Hazard	Issue
1	Flooding	Upstream pollution from other counties.
4	Flooding	When the dam is holding back water there is flooding upstream because of the lack of release of water
5	Flooding	Flooding wells that need to be moved?
6	Flooding	Wells that get contaminated during flooding and need to be moved.
8	Flooding	When the dam is holding back water there is flooding upstream because of the lack of release of water
9	Flooding	Flooding wells that need to be moved?
10	Flooding	Wells that get contaminated during flooding and need to be moved.
11	Flooding	2nd and 4th street culverts are an issue. towns common park
2	Flooding	Raise the freeboard to consider environmentally sensitive areas.
12	Flooding	Flooding on the Princeton and Selma
13	Flooding	Flooding in prone areas in the west off Ennis Road off Camp Branch

ID	Hazard	Issue
7	Flooding	Area prone to flooding county has drone footage with flooding issues
14	Flooding	Flooding on 70 near Wilson's Mill
3	Flooding	Roadway overtopping, nighttime flooding, frequent rescue efforts needed
15	Flooding	Overtopping Bridges
16	Flooding	Overtopping Bridges
17	Flooding	Overtopping Bridges
18	Flooding	Water backs up from the confluence with Little River
19	Flooding	Aberdeen built in a floodplain, high risk from flooding
20	Flooding	No system in place to communicate gate opening and downstream impacts
21	Precipitation	Downtown area is subject to frequent flooding from stormwater runoff

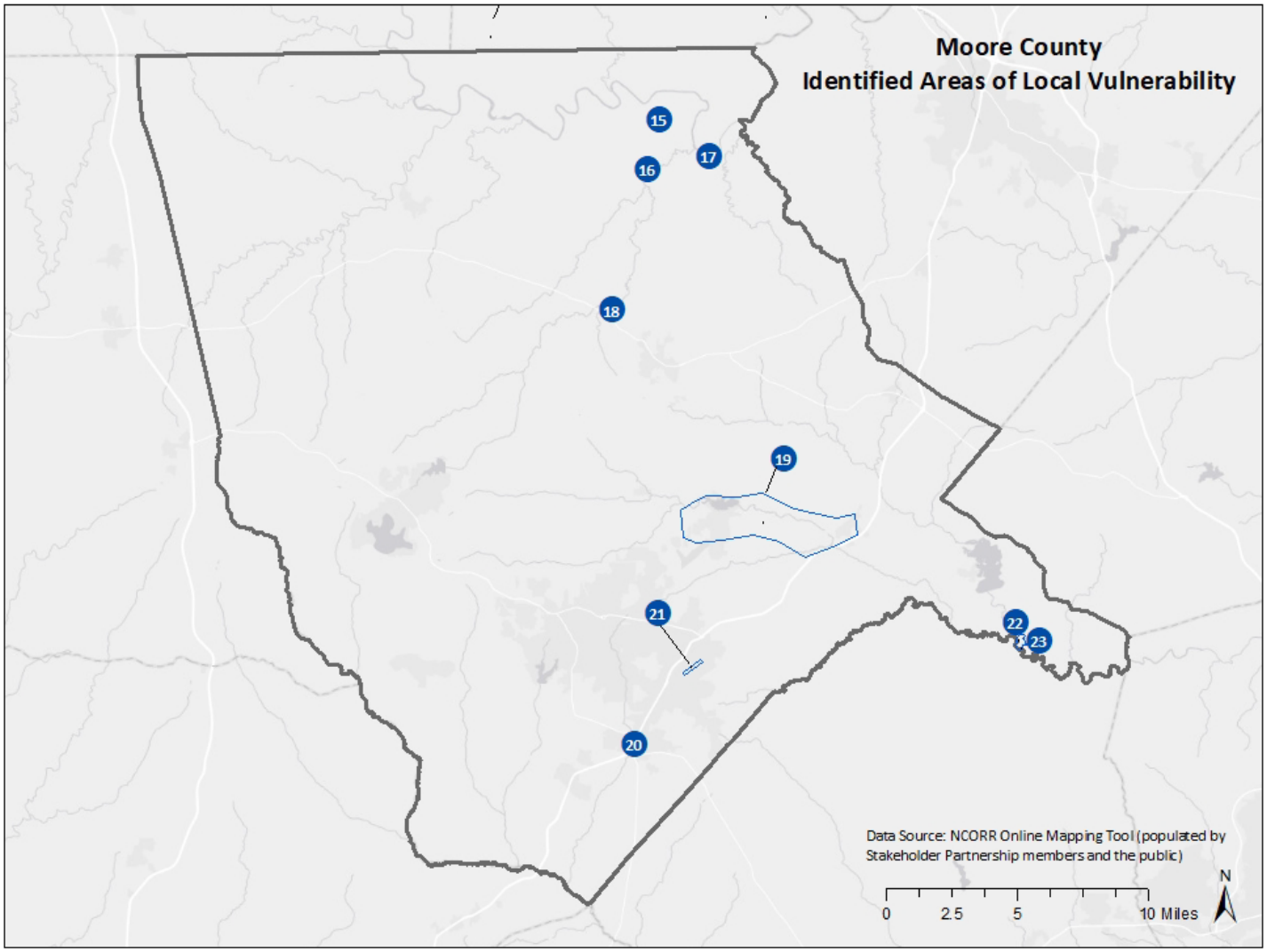


Figure 13. Moore County Local Vulnerabilities

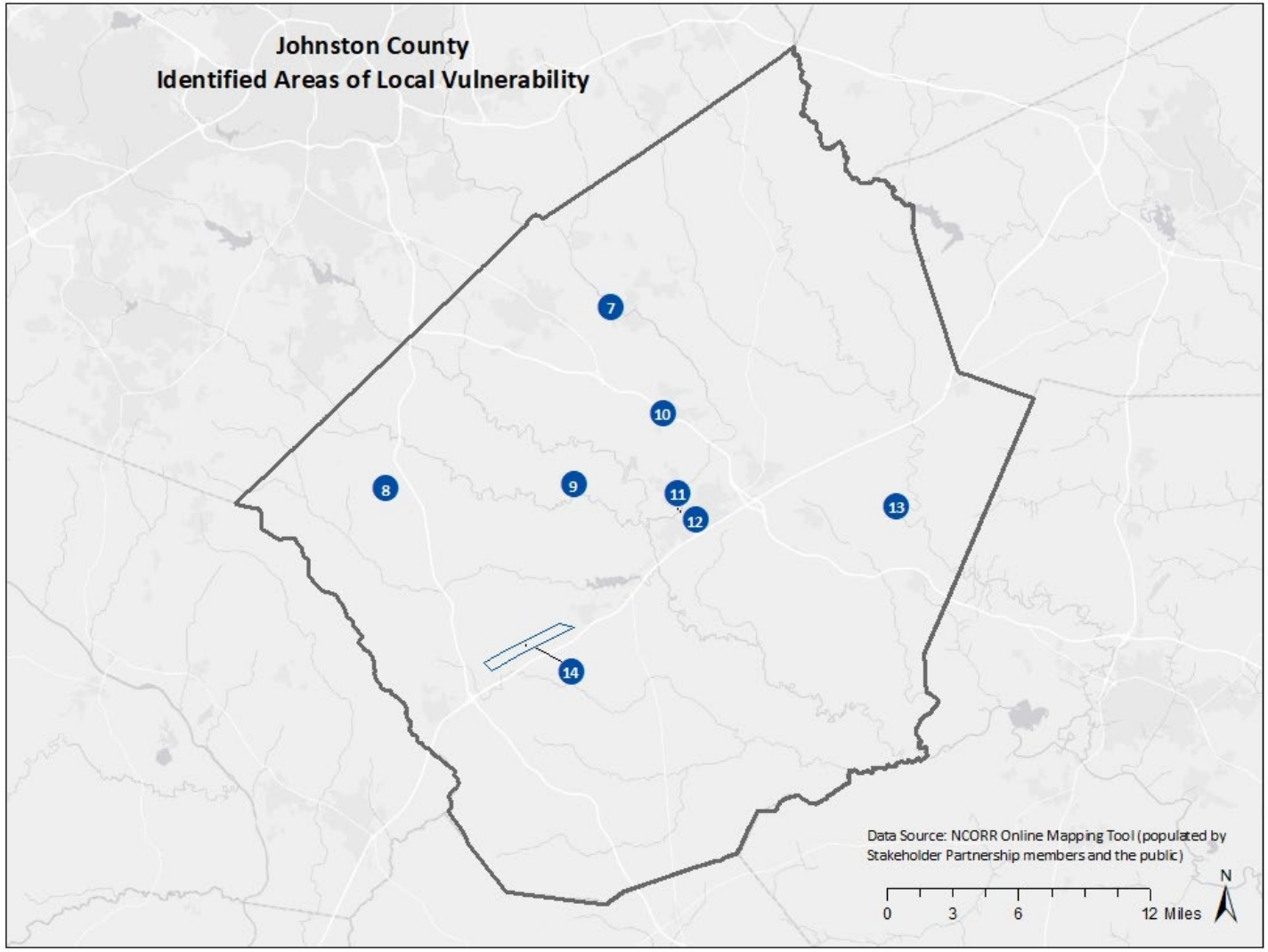


Figure 14. Johnston County Local Vulnerabilities

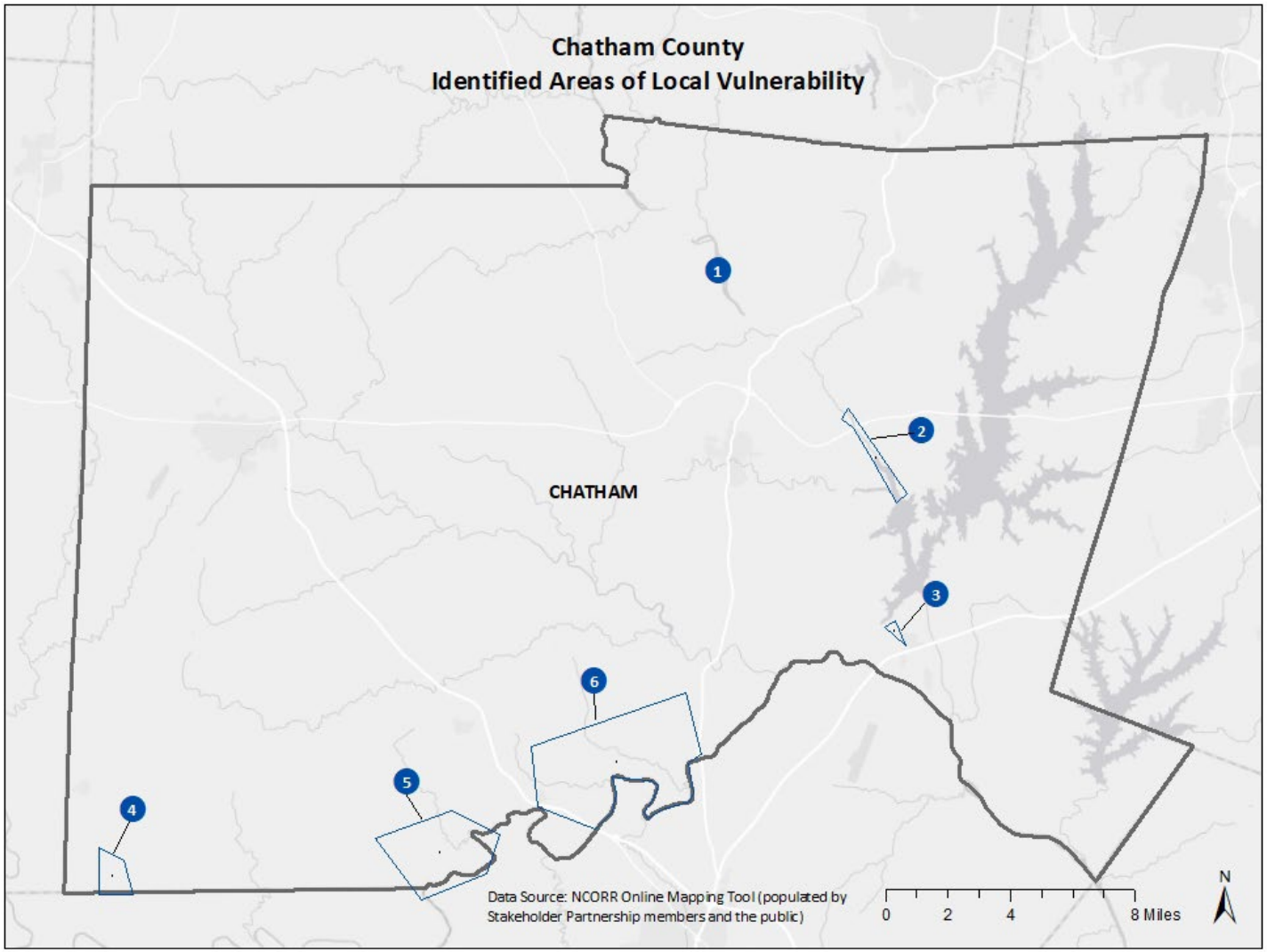


Figure 15. Chatham County Local Vulnerabilities

The RISE review to this point has provided information about areas in Triangle J that are prone to flooding from heavy precipitation or storms that are causing a significant impact in Moore, Chatham and Johnston counties. The project team analyzed these areas based on their proximity to locations in the region that have the greatest flood risk, built up areas (including areas with critical infrastructure) and areas that are the most socially vulnerable.

Moore County's vulnerability hot spots are focused in the eastern and central sections of the county. Flooding in Moore County is primarily attributed to proximity to streams/tributaries, overtopping of bridges and dams, and backup from confluences. Waterways that have a relatively high frequency of flooding include Deep River, McLendon's Creek, Little River and Mill Creek. These floods result in property damage including homes, roads and businesses. Many of the areas are repetitive flooding from heavy precipitation and locations where buildings have been constructed in the floodplain.

The downtown area of Southern Pines Downtown is subject to frequent flooding from stormwater runoff. Whispering Pines has an issue where no system to communicate is in place to warn communities when the floodgate is opening. This causes significant downstream impacts along the little River east of Highway 1 North. In the North of the county along Deep River and McLendon's Creek there are bridges that are in danger of overtopping.

Vulnerability hot spot areas within Johnston County are in the northern portion of the county from Smithfield to just north of Clayton and to the Wake County boundary. Flooding is a primary concern for Johnston County, which is attributed to proximity to streams/tributaries, ditch maintenance and low-lying areas. Waterways that have a relatively high frequency of flooding include the Neuse River, Middle Creek, Poplar Creek and Steep Hill Branch. Johnston County Emergency Management has done a comprehensive review and documented the major areas of potential hazard within the county. Significant challenges in the county are water release information to inform downstream homes and businesses of the potential impact. There is a need for a better communication method for warning.

Another significant issue brought up was the blockage of culverts and pipes by either debris or sediment. There is a current and future need for coordination between the state, county and local governments to successfully clear debris, drainage pipes and culverts. The communication is necessary to ensure the correct updates are happening in the correct order. Coordination is key to fixing stormwater and drainage issues as different owners and stakeholders must work in tandem for fixes to work. Dams overtopping is another issue. This is often private landowner or homeowners' associations.

Several of the counties brought up the need for Markers along the rivers to assist emergency rescue operations. Often if people are injured during recreational activities, it is difficult for EM to find them because there is no way to know where you are along the river.

Hazards in Chatham County include flooding from storms and precipitation. Similarly, the other counties in Triangle J, flooding is a major concern for the county. These events occur due to proximity to streams/tributaries, run-off, low-lying areas, ditch maintenance and debris build up. Waterways that have a relatively high frequency of flooding include Cedar Creek, George's Creek and the Deep River. Municipalities that are significantly impacted during flood events

include, but are not limited to, Farmville, Bynum and Carbonton. Other areas of high impact are to the northeast where the Haw River enters the Chatham County on the way to Jordan Lake.

Chatham County has experienced repeated flooding which impacts residents and transportation. This is due to the debris and culvert constriction. This causes large scale road overtopping and areas of flooding in the Southeast of the county.

Conducting this vulnerability assessment for the Triangle J region allows the stakeholders within the region to have a better understanding of the challenges to resilience that these communities face. Understanding the challenges will allow stakeholders to develop strategies to address these challenges and increase community resilience.

7. Appendix A – Stakeholder Partnership Membership

Table A-1. Triangle J Region Stakeholder Partnership Members

Name		Organization
Anantha	Aiyyer	North Carolina State University, Marine earth and atmospheric sciences
Scott	Brooks	Moore County
Donald	Campbell	North Carolina Emergency Management
Henry	Crews	Green Rural Redevelopment Organization (GRRO)
Matt	Day	Triangle J COG/Triangle Area RPO
Heather	Deck	Sound Rivers
Jason	Epley	RLUAC
Robert	Fleming	Fort Bragg
Dennis	Hancock	NCEM
Barry	Hull	Fort Bragg
Wesley	Johnson	Wetland Solutions
Daniela	Jones	North Carolina State University
Keith	Larick	NC Farm Bureau Federation
Anne	Lowry	Chatham County Public Health Department
Brooke	Massa	NC Wildlife Resources Commission
Kim	Matthews	Carolina Wetlands Association and Research Triangle Institute (RTI)
Lacee	Monte	Chatham County Council on Aging
Steve	Newton	Chatham County Emergency Management
James	Salmons	Upper Coastal Plain Rural Planning Organization
Rick	Savage	Carolina Wetlands Association
Colby	Sawyer	Chatham County Emergency Management
Mark	Schell	NCEM
Jan	Sherwin	Friends of the Lower Haw River

Name		Organization
Gretchen	Smith	Friends of Lower Haw River State Natural Area
Shane	Underwood	North Carolina State University
Stephen	Wensman	Town of Smithfield
Kevin	Hubbard	Johnston County Emergency Services
Joshua	Holloman	Johnston County Emergency Services
Mark	Helmer	Town of Smithfield
Vagn	Hansen	Regional Land Use Advisory Commission
Matt	Britt	Lee County Emergency Services
Jan	Goodson	Dr. J. H. Carter & Associates, Inc.
Matthew	Stillwagon	NC Department of Public Safety Emergency Management Risk Management Section
Debra	Ensminger	Moore County

8. Appendix B – Critical Infrastructure Maps, By County

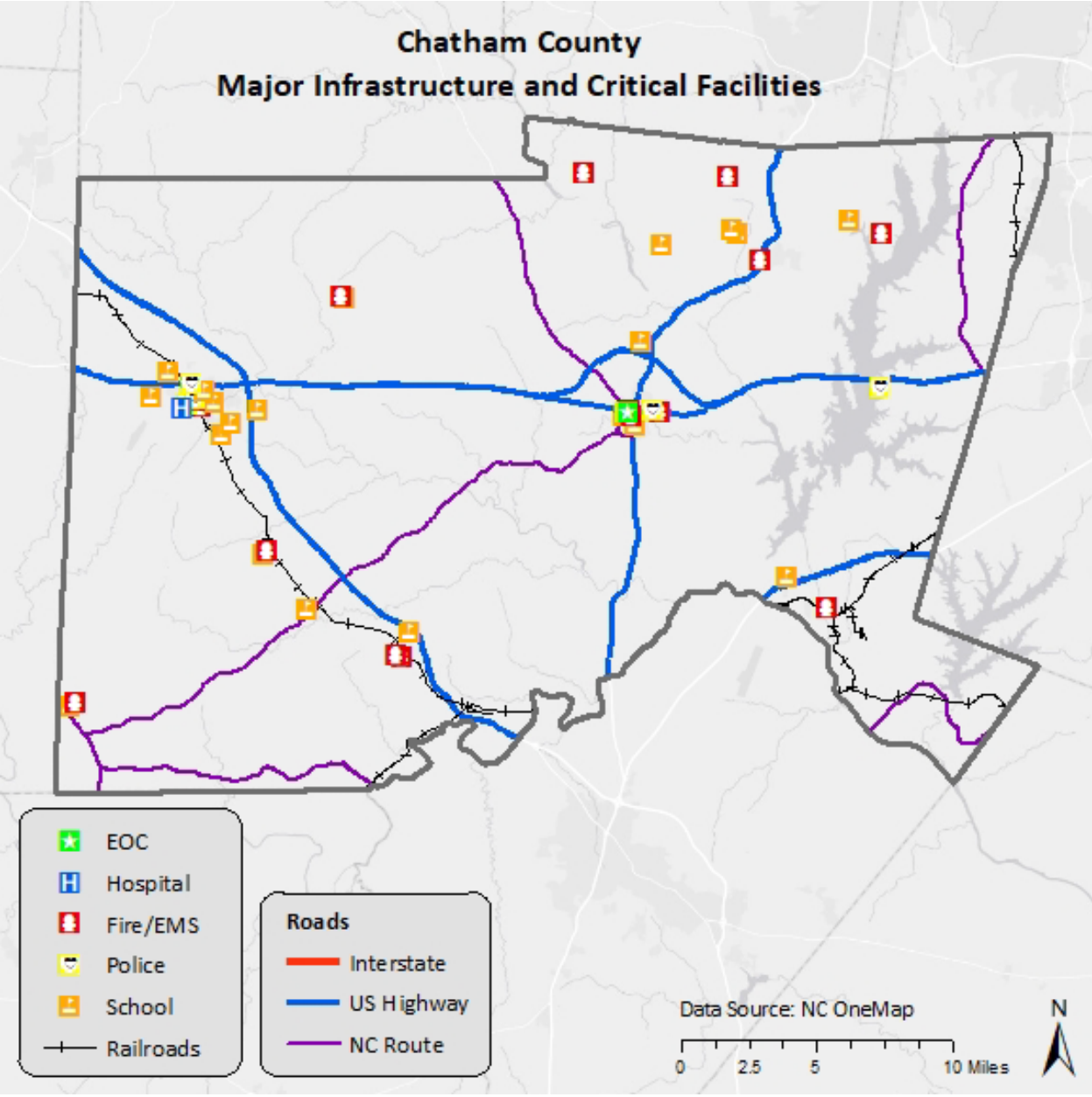


Figure B-1. Chatham County Critical Infrastructure

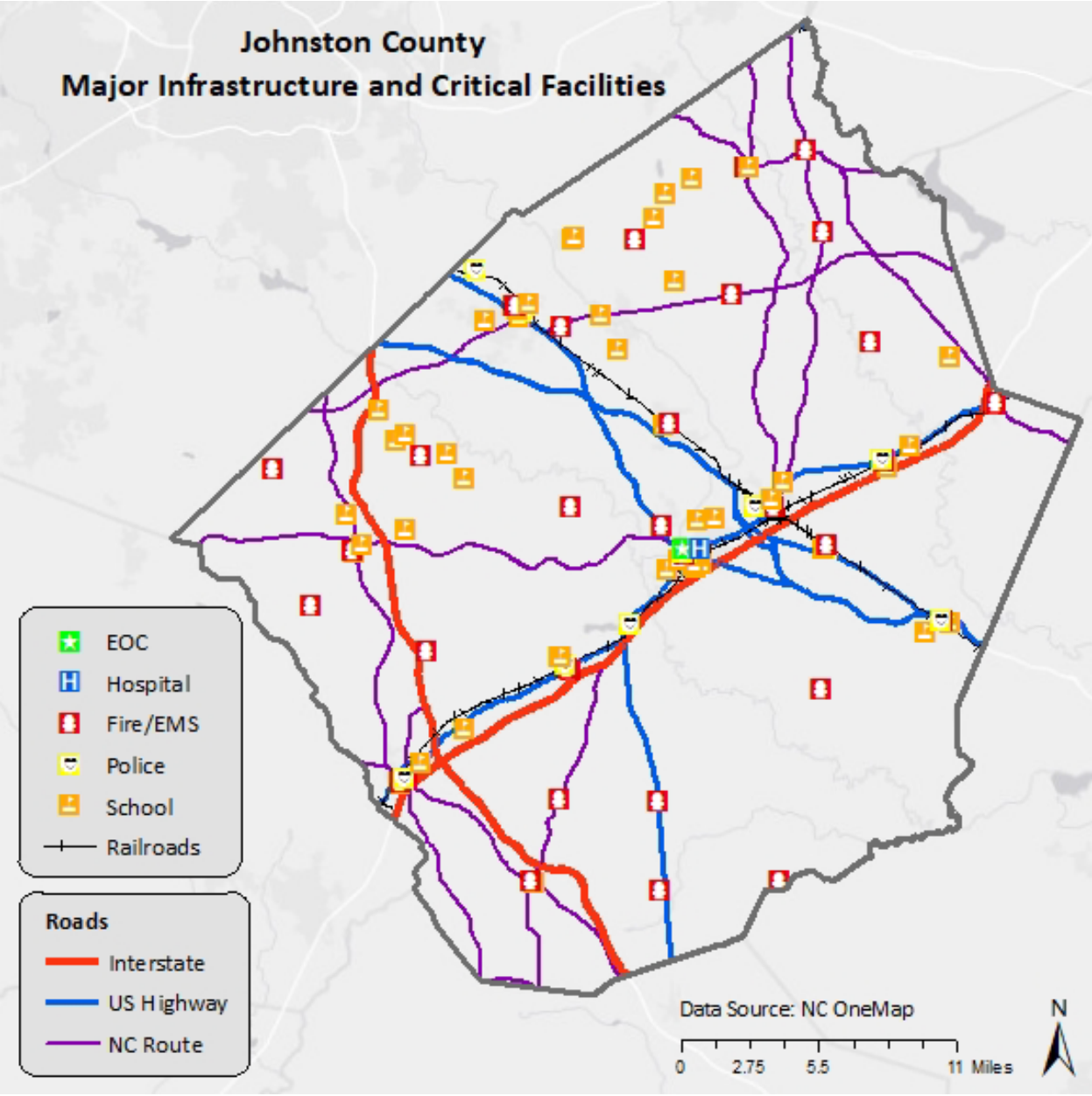


Figure B-2. Johnston County Critical Infrastructure

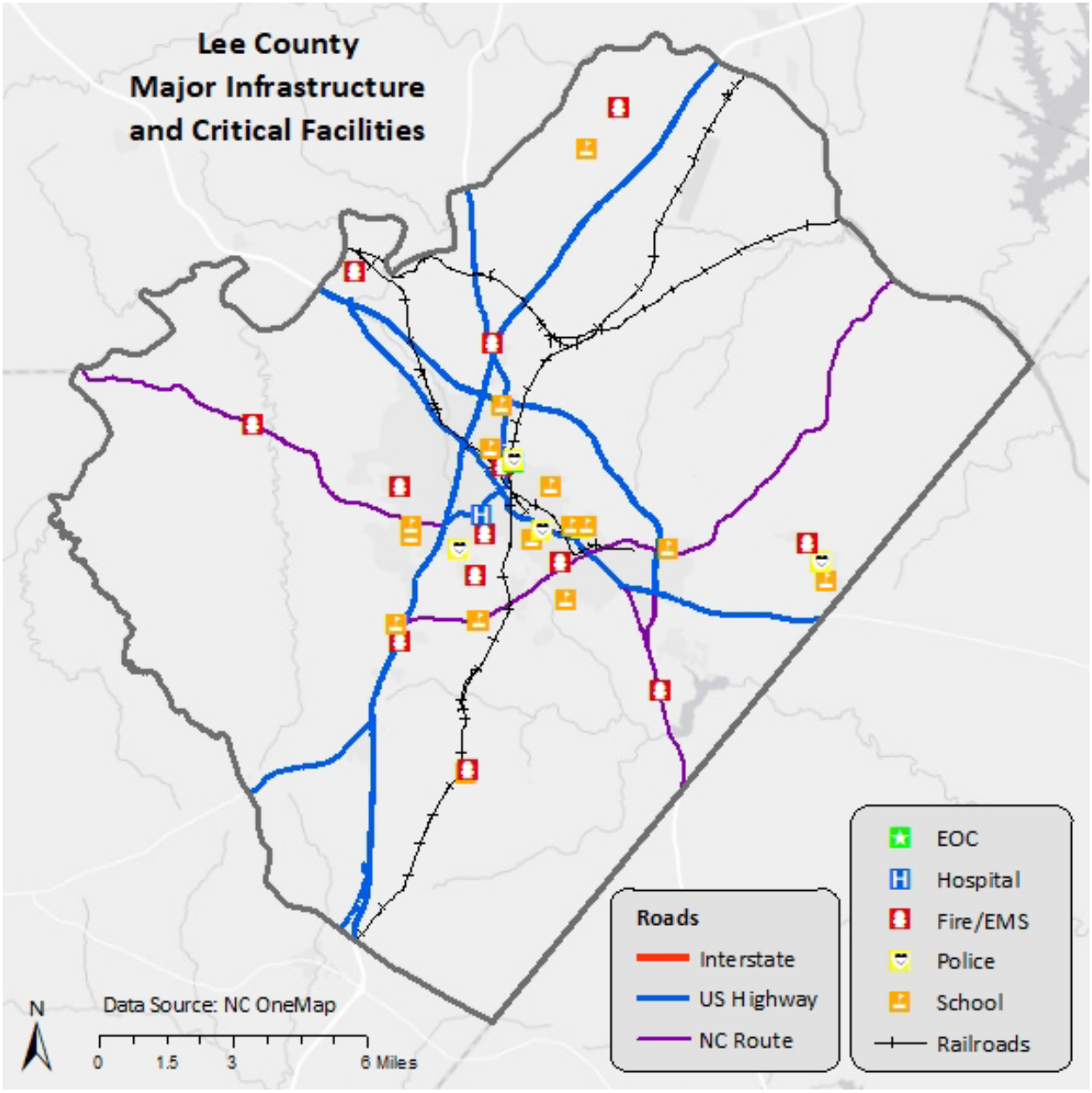


Figure B-3. Lee County Critical Infrastructure

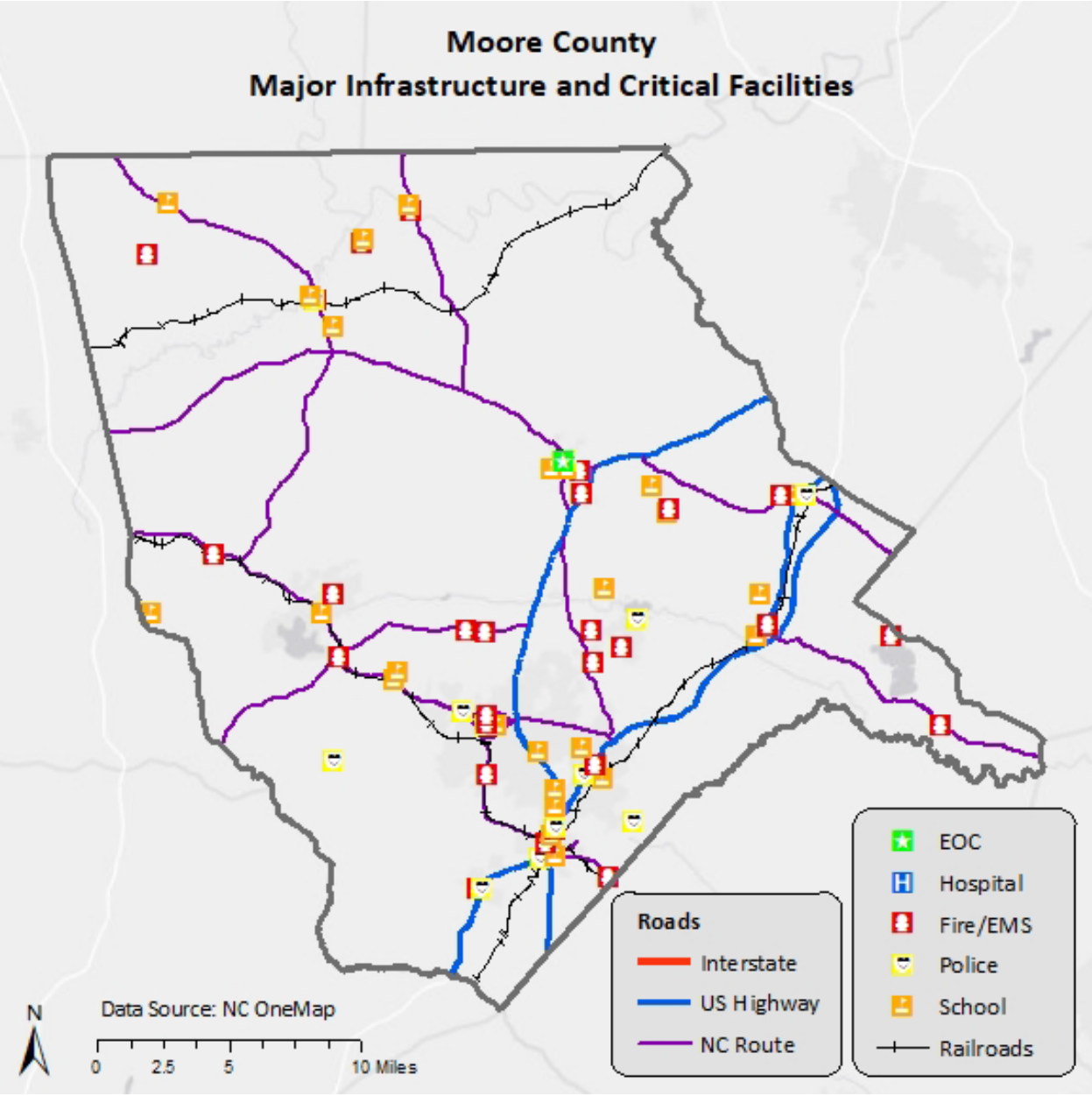


Figure B-4. Moore County Critical Infrastructure

9. Appendix C – Largest Employers Maps, By County

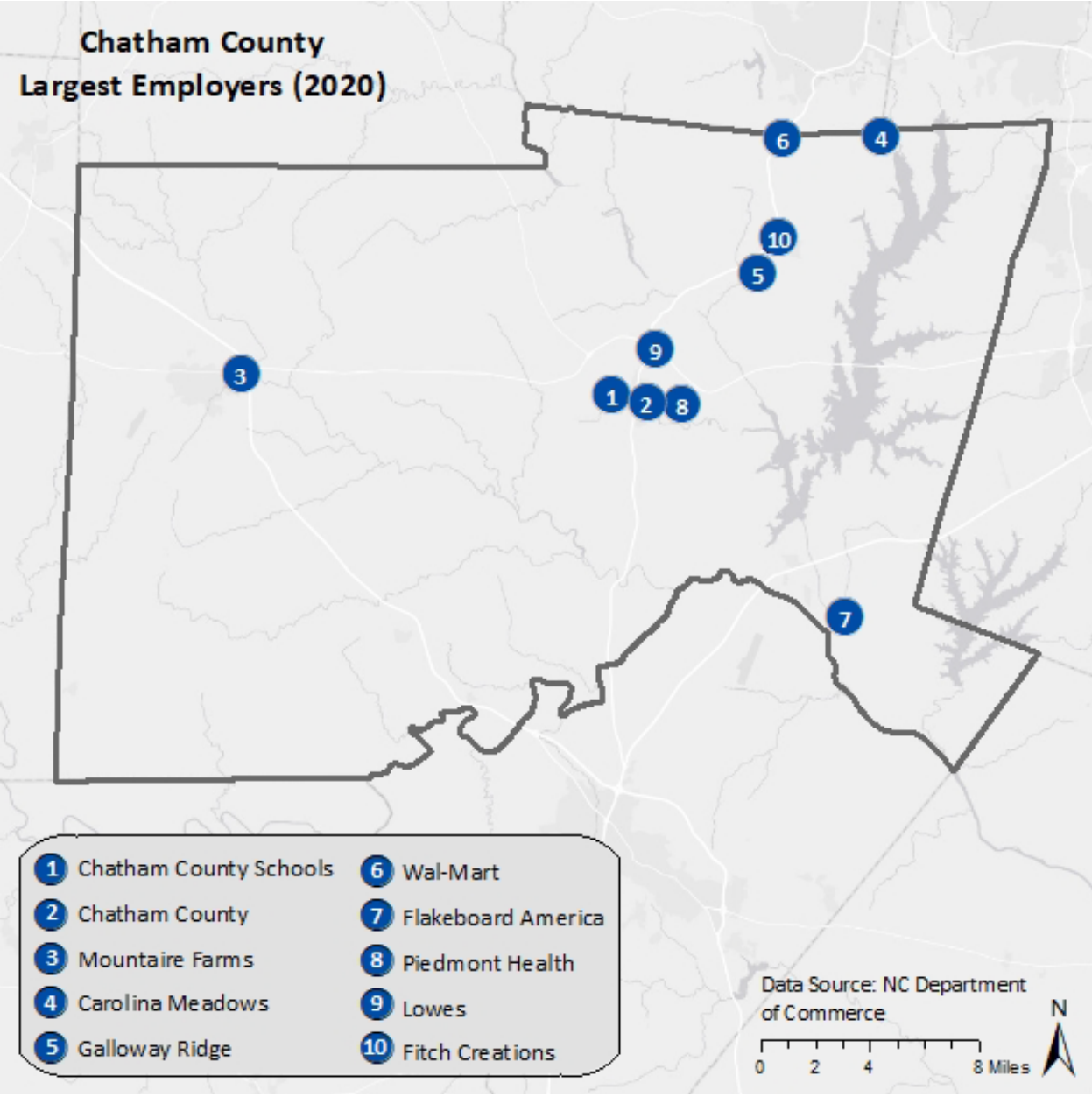


Figure C-1. Chatham County Largest Employers

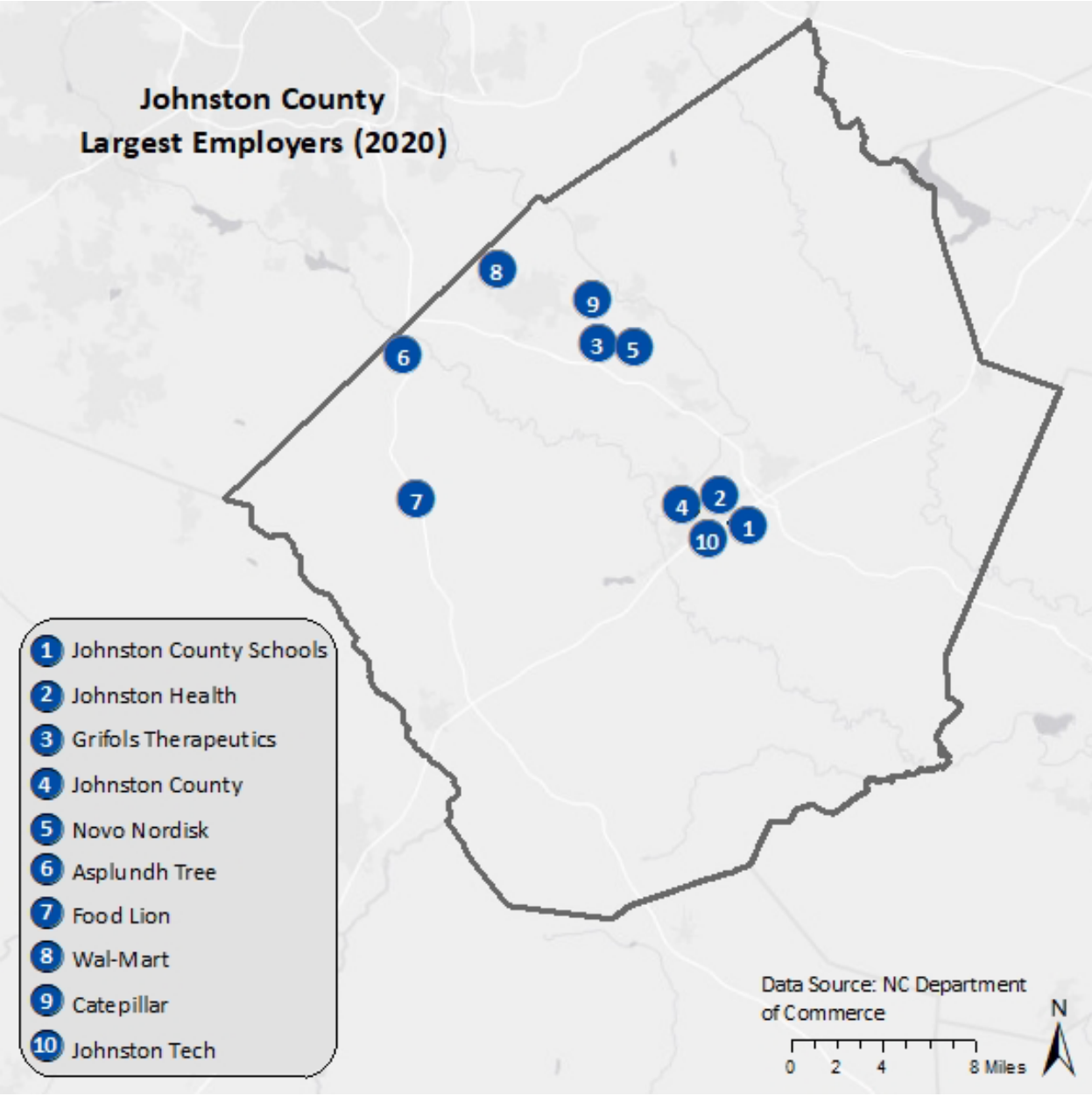


Figure C-2. Johnston County Largest Employers

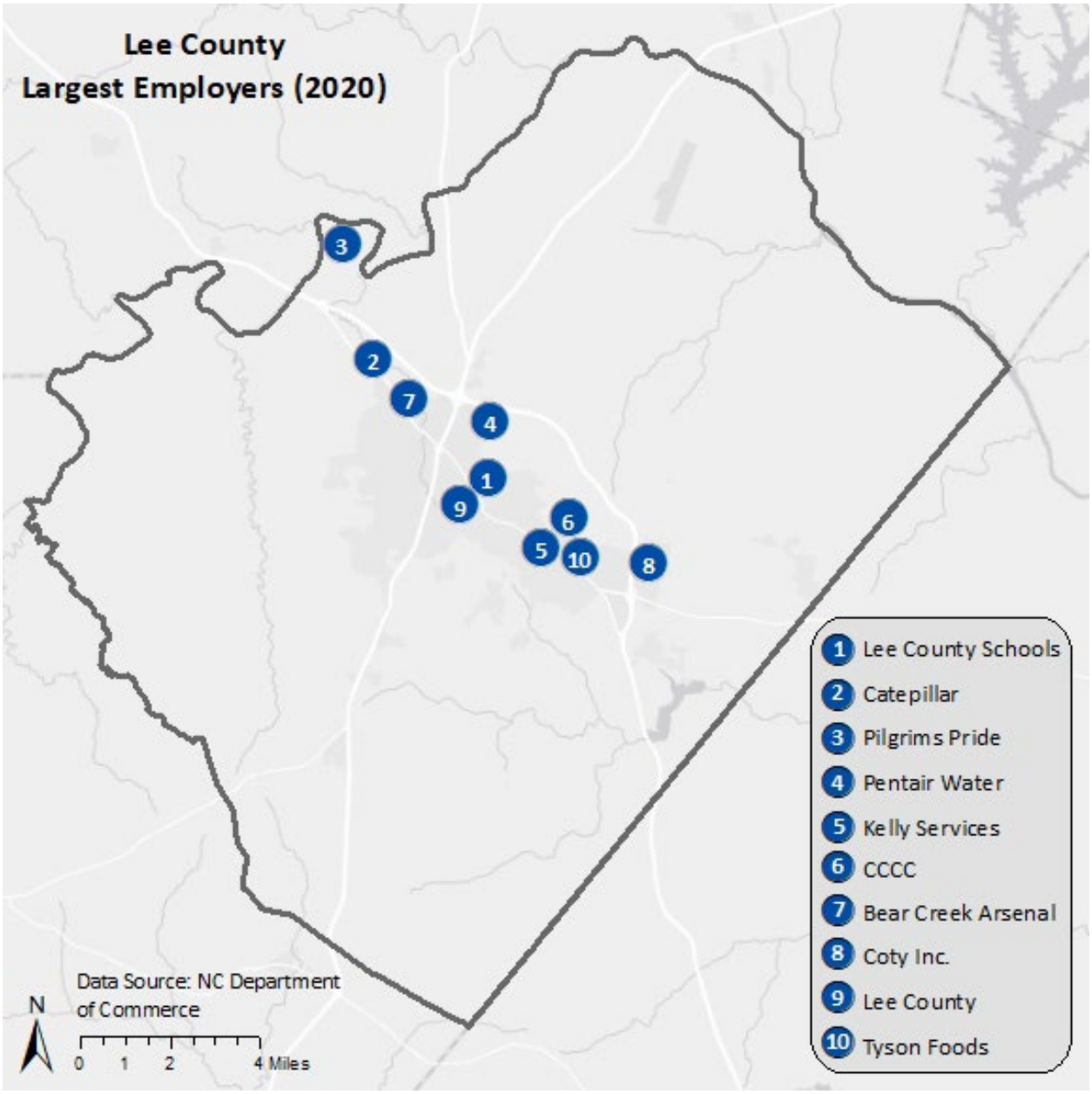


Figure C-3. Lee County Largest Employers

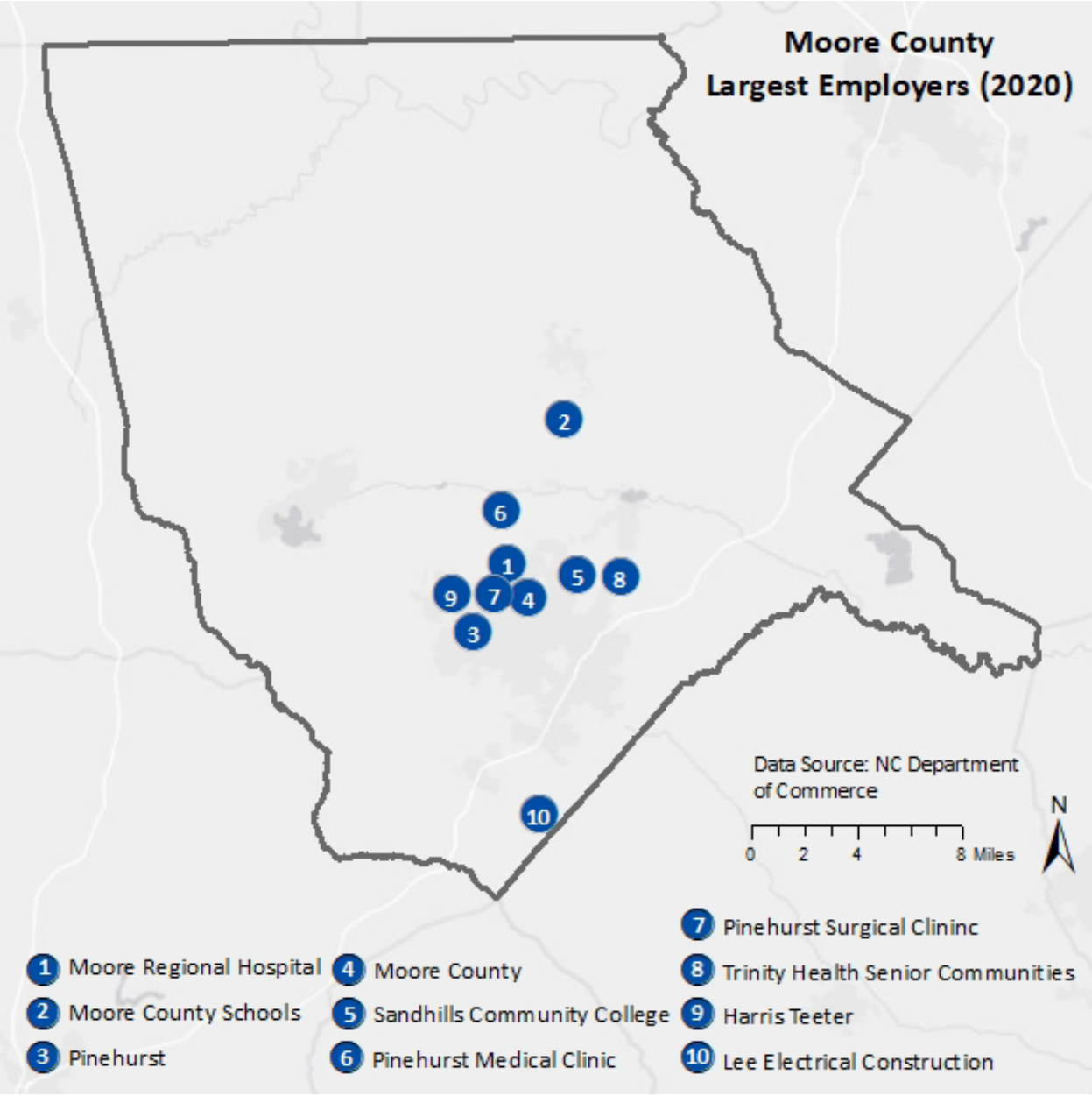


Figure C-4. Moore County Largest Employers

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