Strategic Statewide Resilience and Risk Reduction Plan

# 6 | OTHER HAZARDS

# OVERVIEW

This chapter furthers the ability of organizations across the state to anticipate by identifying wildfire, drought, heat, seismic, severe thunderstorms, wind, and winter weather hazards. While the initial version of this plan focuses on flooding, S.C. Code Ann. § 48-62-10 *et seq.*, also directs SCOR to identify potential losses that could occur as a result of severe weather events and other natural catastrophes that impact South Carolina. This chapter is a brief overview of these hazards utilizing a few key resources. South Carolina's vulnerability to other hazards will be analyzed in future iterations of this plan, as appropriate datasets are identified or developed.

A historical analysis of the various hazards that impact South Carolina is one part of the SCEMD State Hazard Mitigation Plan that was last published in 2018; an updated iteration of that plan is scheduled to be published in 2023. These plans include a comprehensive discussion of historic events' geographic extent, and economic and human impacts.

## CONTENTS

## KEY FINDINGS

- There is a risk for increased impacts as more people and property are located in the path of hazards.

### WILDFIRE

- Wildfires are common occurrences in South Carolina and are defined by the South Carolina Forestry Commission as any forest fire, brush fire, grassfire, or any outdoor fire that is not controlled or supervised.
- On average, approximately 1,400 wildfires burn nearly 11,000 acres in South Carolina each year (SC Forestry Commission (SCFC), 2021).

### DROUGHT

- In the last 21 years, South Carolina has experienced three major droughts.
- The State Water Plan under development at SCDNR aims to understand water supply versus water demand, including the impacts of drought on the water resources in the State.

### HEAT

- Heat is the most dangerous of the weather related hazards in recent decades (National Weather Service, 2022).
- Historic analysis documents maximum summer temperature increases across the State.
- Portions of the state are projected to experience up to 50 more days a year with temperatures above 95 °F by the end of the century.
- Future temperature increases and more frequent and intense heat waves will likely cause the Southeast to experience a disproportionate health burden.

### SEVERE THUNDERSTORMS

- Thunderstorms occur frequently in South Carolina, and severe storms have the potential to produce damage-causing hail, lightning, and high winds.
- Tornadoes are a facet of severe thunderstorms as well.
- In South Carolina, extreme winds are the most reported hazard to the National Centers for Environmental Information (NCEI).

### TROPICAL SYSTEMS AND HURRICANES

- While hurricanes are considered low frequency but high consequence events.
- South Carolina ranks 5th (fifth) among states that experience hurricanes, behind Florida, Texas, Louisiana, and North Carolina.

### TORNADOES

- There is no significant trend in tornadoes occurring in the State.
- Current climate projections predict that tornado alleys are shifting east.

## WINTER WEATHER

- Damage from winter weather events has increased in the last few decades.
- These events can disrupt communications and power by trees or branches falling on suspended lines, disrupt travel plans by impairing roadways, and damage plants both for residential and agricultural purposes.

## SEISMIC EVENTS

- According to the USGS, South Carolina has experienced 229 earthquakes since 2001, with 46 events larger than a magnitude 2.5. The largest event since 2001 reached a magnitude 4.1 in Parksville, SC, on November 11, 2014.
- The largest earthquake recorded in the State was the Charleston Earthquake of 1886 with an estimated magnitude of 7 to 7.6.
- Tsunamis are rare on the east coast of the U.S. and there is insufficient data to make reasonable decisions or recommendations to mitigate or plan for the impacts of a tsunami.

## INFORMATION USED IN THIS CHAPTER

This chapter uses state, federal, and local data sources to give a brief overview of the State's vulnerabilities to hazards other than flood, which is described in its own chapter. Local and state specific data are prioritized when available, and they are supplemented by FEMA's National Risk Index (NRI), which gives a brief overview of nationwide vulnerabilities to various hazards. The NRI interactive map database allows users to identify potential impacts that may occur to populations and economies at the Census tract level. The Index provides a Risk Index Rating for each hazard based on previous hazard specific economic losses to represent a community's relative risk from "Very High" to "Very Low" when compared with communities across the United States, and is calculated using Equation 6.1. The equation includes the variables for Expected Annual Loss, the average economic loss in dollars resulting from each hazard each year, Social Vulnerability using based around the Social Vulnerability Index (SVI), and Community Resilience based on HVRI's BRIC indicators (Zuzak, et al., 2023).

**Equation 6.1 FEMA Risk Index Equation (Zuzak, et al., 2023)**

$$Risk\ Index = Expected\ Annual\ Loss\ x\ \frac{Social\ Vulnerability}{Community\ Resilience}$$

**Table 6.1 FEMA Risk Index nomenclature breaks by percentiles (Zuzak, et al., 2023)**

| Risk Index | Percentile |
|---|---|
| **Very High** | 80th to 100th percentiles |
| **Relatively High** | 60th to 80th percentiles |
| **Relatively Moderate** | 40th to 60th percentiles |
| **Relatively Low** | 20th to 40th percentiles |
| **Very Low** | 0th to 20th percentiles |

## WILDFIRE

Wildfires are common occurrences in South Carolina and are defined by the South Carolina Forestry Commission as any forest fire, brush fire, grassfire, or outdoor fire that is not controlled or supervised. On average, approximately 1,400 wildfires burn nearly 11,000 acres in South Carolina each year (SC Forestry Commission (SCFC), 2021).

Common ignitors of wildfires are debris burning (35-45%), woods arson (25-30%), equipment use (5%), smoking (3-4%), lightning (2%), campfires (1-3%), intentional fires, railroad (1-2%), children (3-5%), and miscellaneous (4-6%). In November 2016, a large wildfire started in Table Rock State Park from an escaped campfire. This fire occurred during an ongoing drought and grew to 10,623 acres before it became under control (SC Forestry Commission (SCFC), 2022).

Although wildfires can start any time there is a spark and enough fuel to drive it, they are exacerbated by periods of drought and excessive heat that can increase the amount of fire prone brush within an area. The South Carolina Forestry Commission, along with the other 12 states in USDA Forest Service Region 8, have used the LANDFIRE model, funded by the U.S. Department of Agriculture Forest Service, to develop the Southern Wildfire Risk Assessment Portal (SouthWRAP). South Carolina's vulnerability to wildfires can be estimated using SouthWRAP for regional scale assessments.

### WILDFIRE BURN PROBABILITY

SouthWRAP provides access to the LANDFIRE model with layers used by decision makers, including the Burn Probability and Wildland Urban Interface Risk Index.

Burn Probability represents how communities are interspersed with wildfire fuels, and the expected human structural impacts if a fire occurs. Wildfire Burn Probability, displayed in Figure 6.1, is interpreted as the actuarial likelihood that an area will burn in a wildfire and is the result of analysis of landscape conditions, weather patterns, ignition patterns, and regional fire management practices. This analysis does not incorporate the built environment or assess the impact of wildfire.

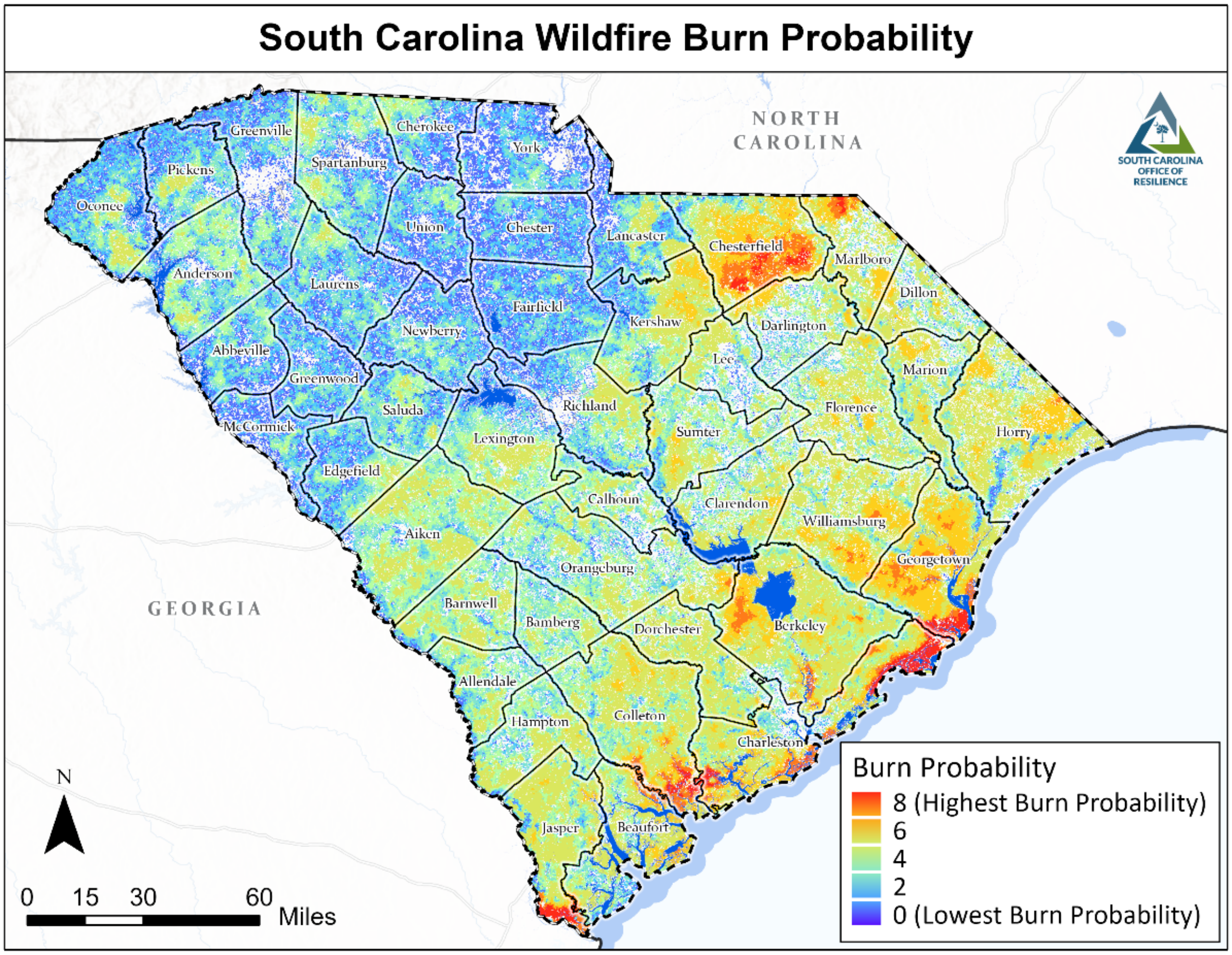


Figure 6.1 South Carolina Wildfire Burn Probability

## WILDFIRE VULNERABILITY BY SECTOR

### SECTOR DATASETS

The data identification and collection for this chapter was completed in coordination with the subcommittees of the Strategy Statewide Risk Reduction and Resilience Plan Advisory Committee. Identified and collected point datasets were overlaid with hazard risk data below to determine the physical vulnerability of each sector/facility type. While many of the facilities are point locations (such as storage tanks or individual buildings such as fire stations), a point analysis is limited in that it simplifies the full extent of an asset or facility at a location. The point analysis is overlayed with the SouthWRAP Burn Probability to assess the potential impacts. This analysis's simplicity enables a broad view of how wildfire puts South Carolina at risk. It is a starting point, but more specific analysis would be needed to assess risk levels more comprehensively at a particular facility, building, or campus.

#### BUSINESSES

Businesses identified in the ESRI Business Analyst database are used for the wildfire point analysis. Most of the business are outside of the Estimated Burn Probability (Figure 6.2).

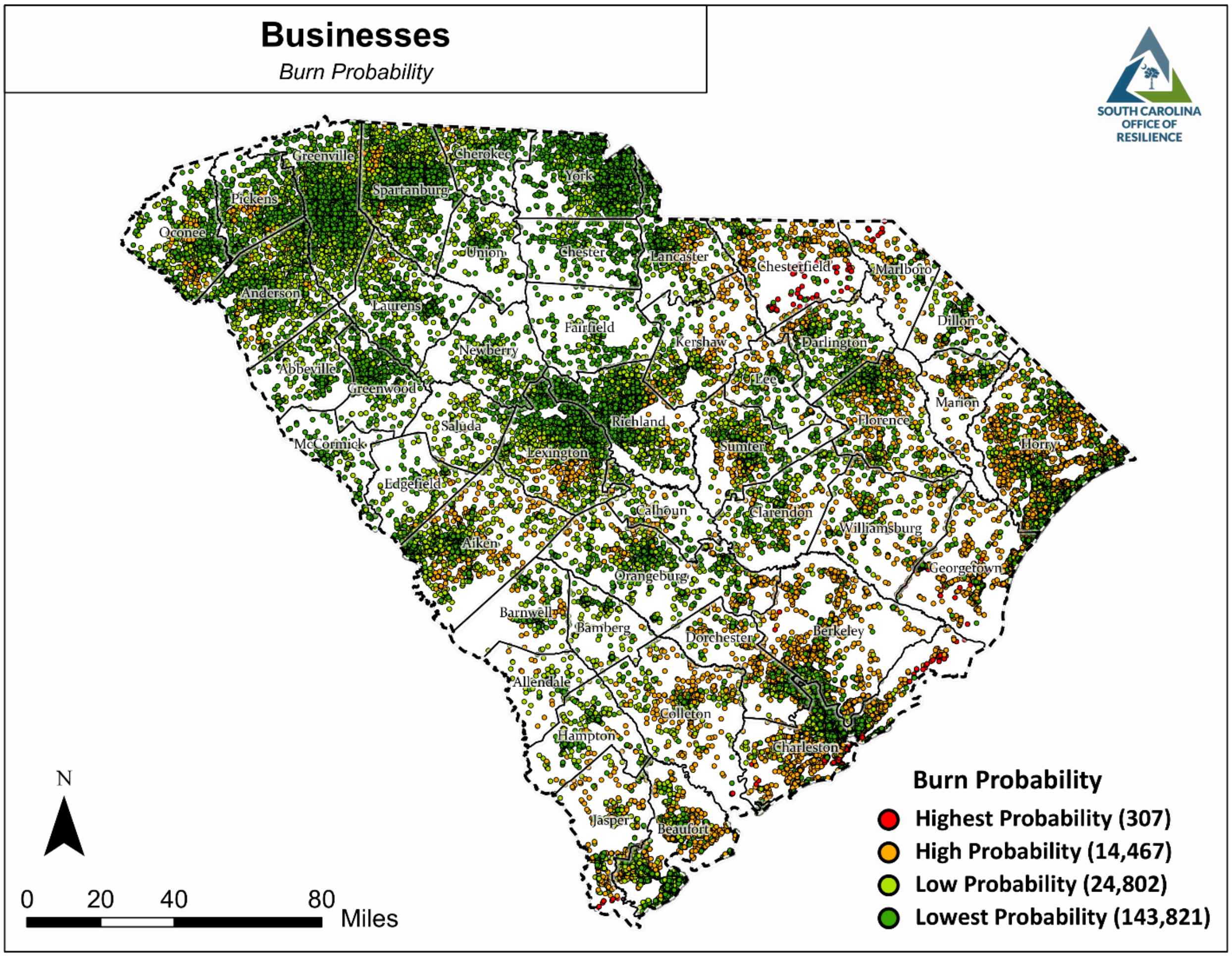


Figure 6.2: Estimated Burn Probability on businesses (ESRI). Wildfire data provided by SouthWRAP

## HAZARDOUS WASTE LOCATIONS

### DRY CLEANERS

Dry cleaners are included in the South Carolina Hazardous Waste Management Act, which defines a dry cleaning facility as a professional commercial establishment for the purpose of cleaning clothing or other fabrics utilizing a process that involves the use of dry cleaning solvent, which can cause additional impacts during hazard events. Figure 6.3 identifies dry cleaners that fall within the burn probability areas.

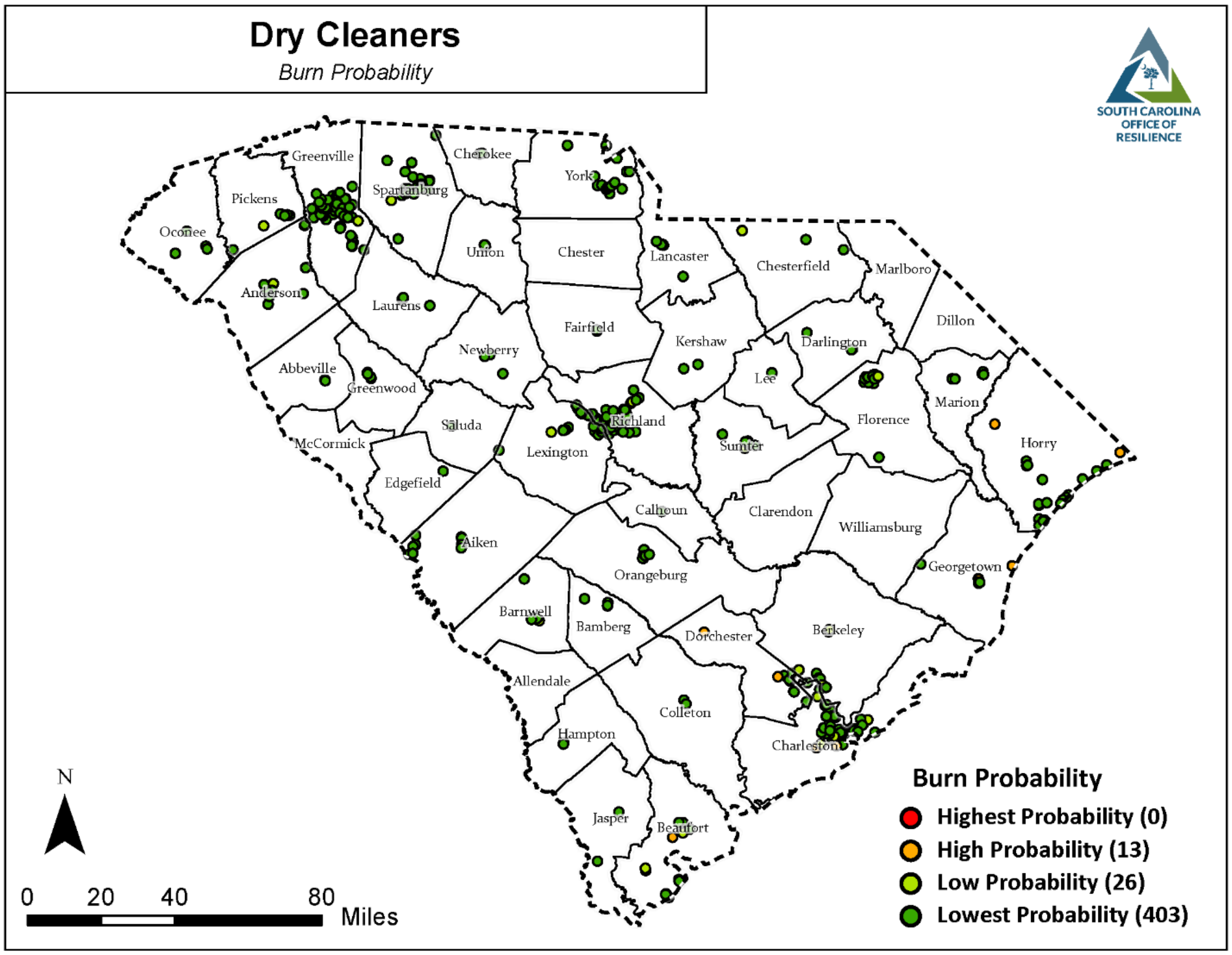


Figure 6.3: Estimated Burn Probability on dry cleaners (DHEC). Wildfire data provided by SouthWRAP.

## MINES

About 500 mines are actively operating, with permits through DHEC, following the SC Mining Act (1974). Several types of surface mining are done in the state, including open pit mining of granite, strip mines for sand, clay and gravel, and sand dredging from river bottoms (South Carolina Department of Health and Environmental Control, n.d.). Figure 6.4 shows the mines in relation to burn probability areas.

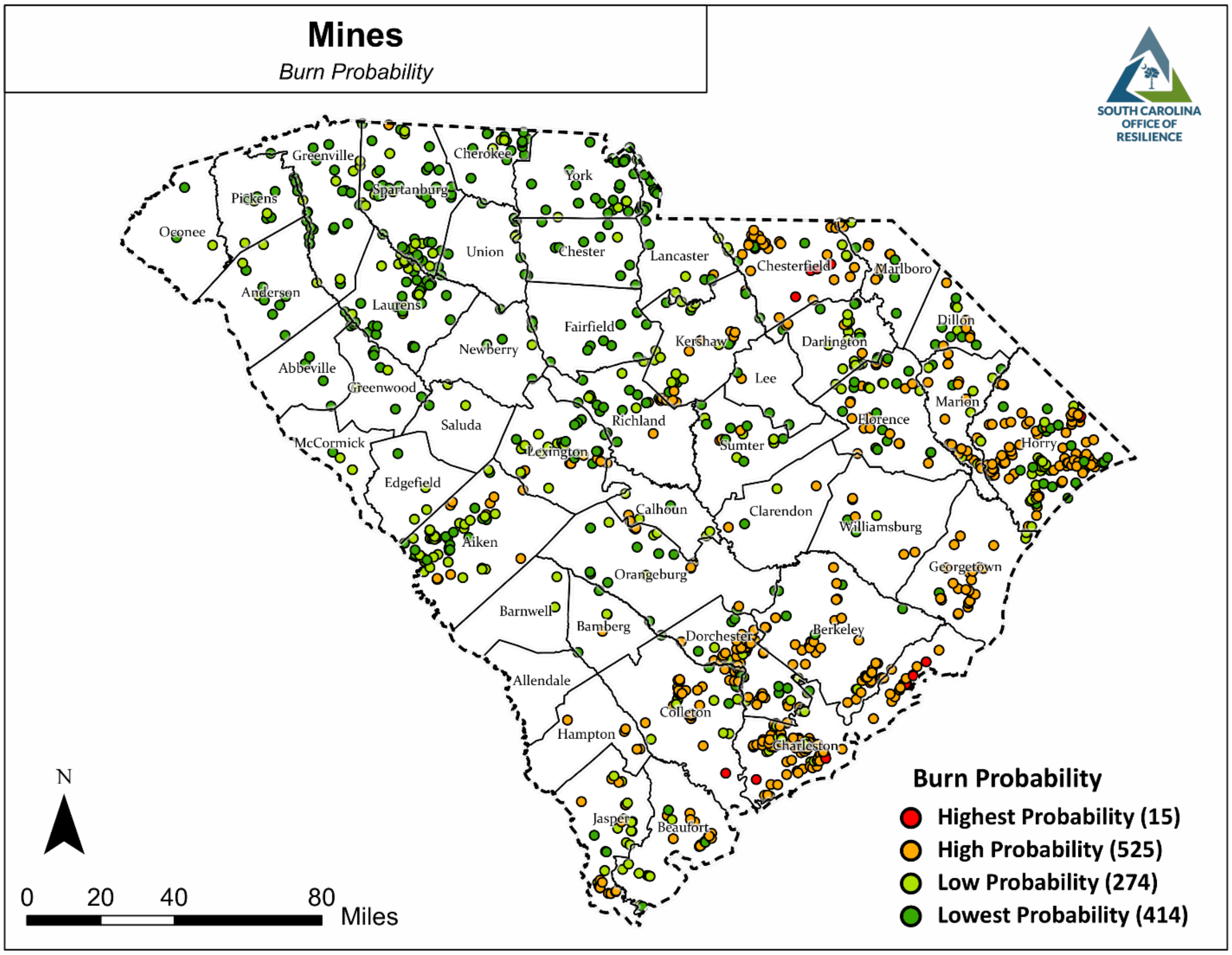


Figure 6.4: Estimated Burn Probability on mines (DHEC). Wildfire data provided by SouthWRAP.

## SOLID WASTE

The [South Carolina Solid Waste Policy and Management Act](#) defines a solid waste facility as all contiguous land, structures, other appurtenances, and improvements on the land used for treating, storing, or disposing of solid waste. A facility may consist of several treatment, storage, or disposal operational units such as landfills, surface impoundments, or a combination. Figure 6.5 shows landfills in relation to burn probability areas, where Figure 6.6 is all solid waste facilities in relation to burn probability areas.

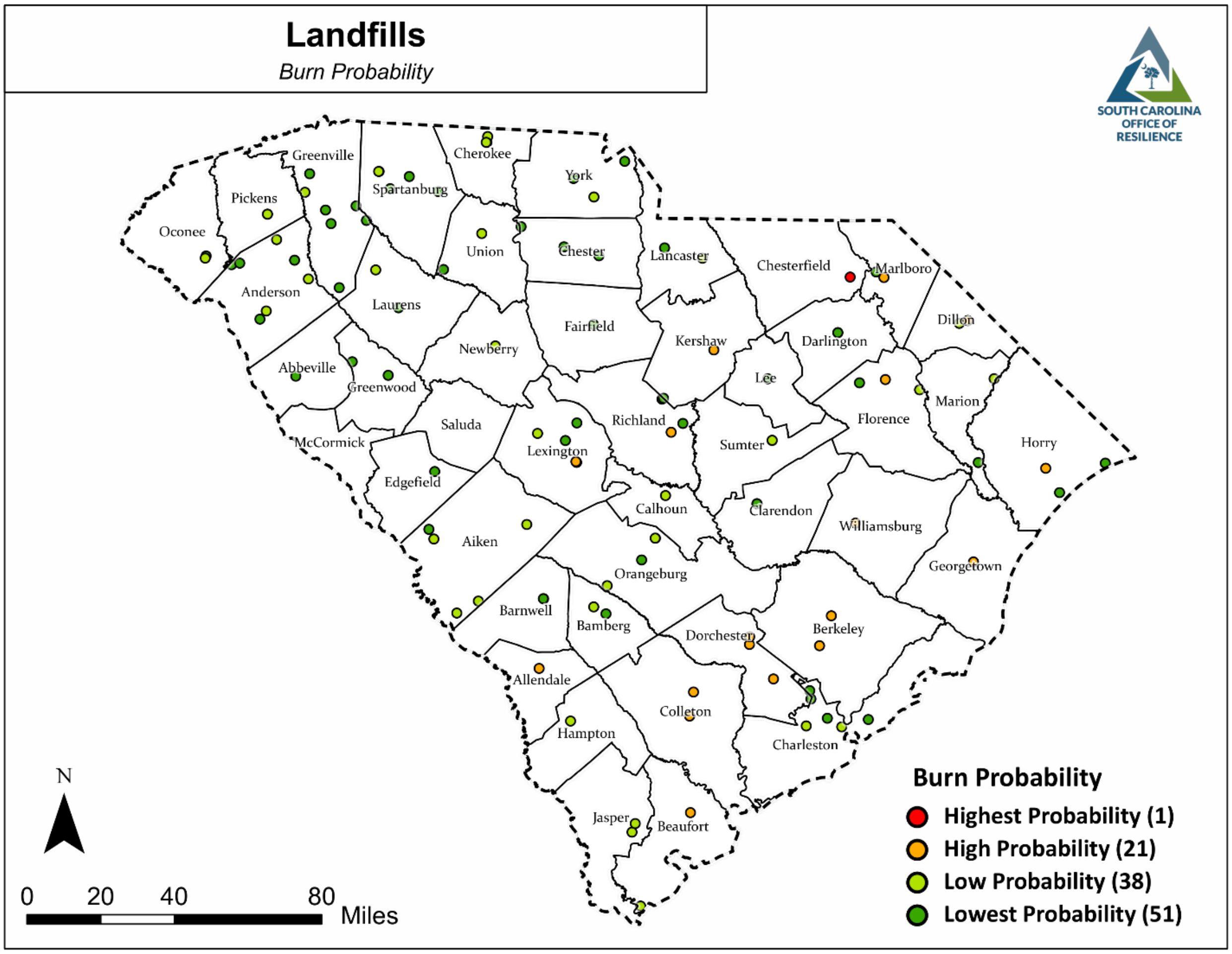


**Figure 6.5: Estimated Burn Probability of solid waste facilities (Department of Homeland Security). Wildfire data provided by SouthWRAP**

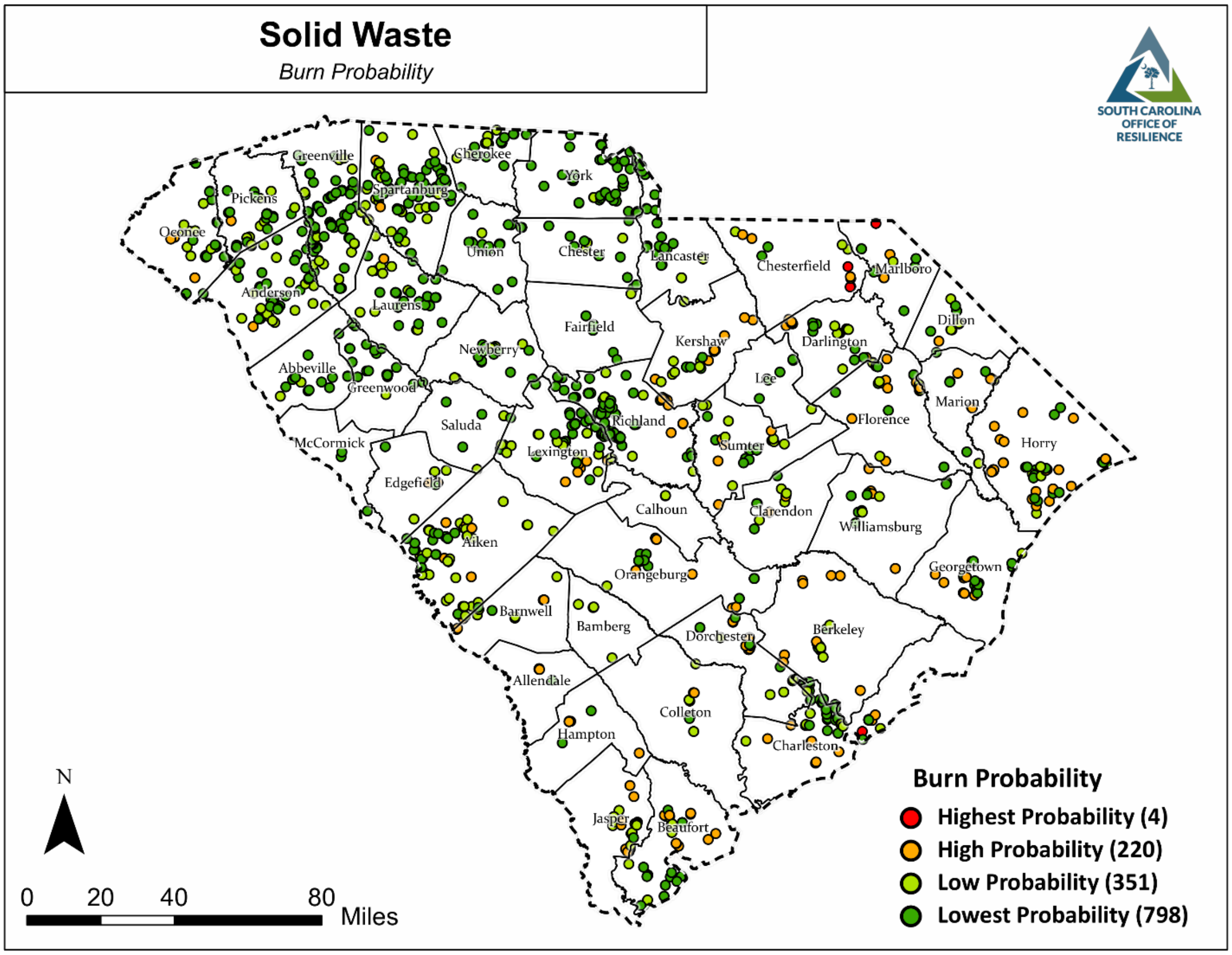


Figure 6.6: Estimated Burn Probability of solid waste facilities (DHEC). Wildfire data provided by SouthWRAP

## HAZARDOUS MATERIALS TREATMENT, STORAGE AND DISPOSAL

DHEC permits active hazardous materials treatment, storage and disposal facilities as authorized by the Federal Resource Conservation and Recovery Act, which established a process for treating, transporting, storing and disposing of hazardous waste (SC Department of Health and Environmental Control, n.d.). Figure 6.7 shows the burn probability risk to hazardous materials treatment, storage, and disposal facilities in South Carolina.

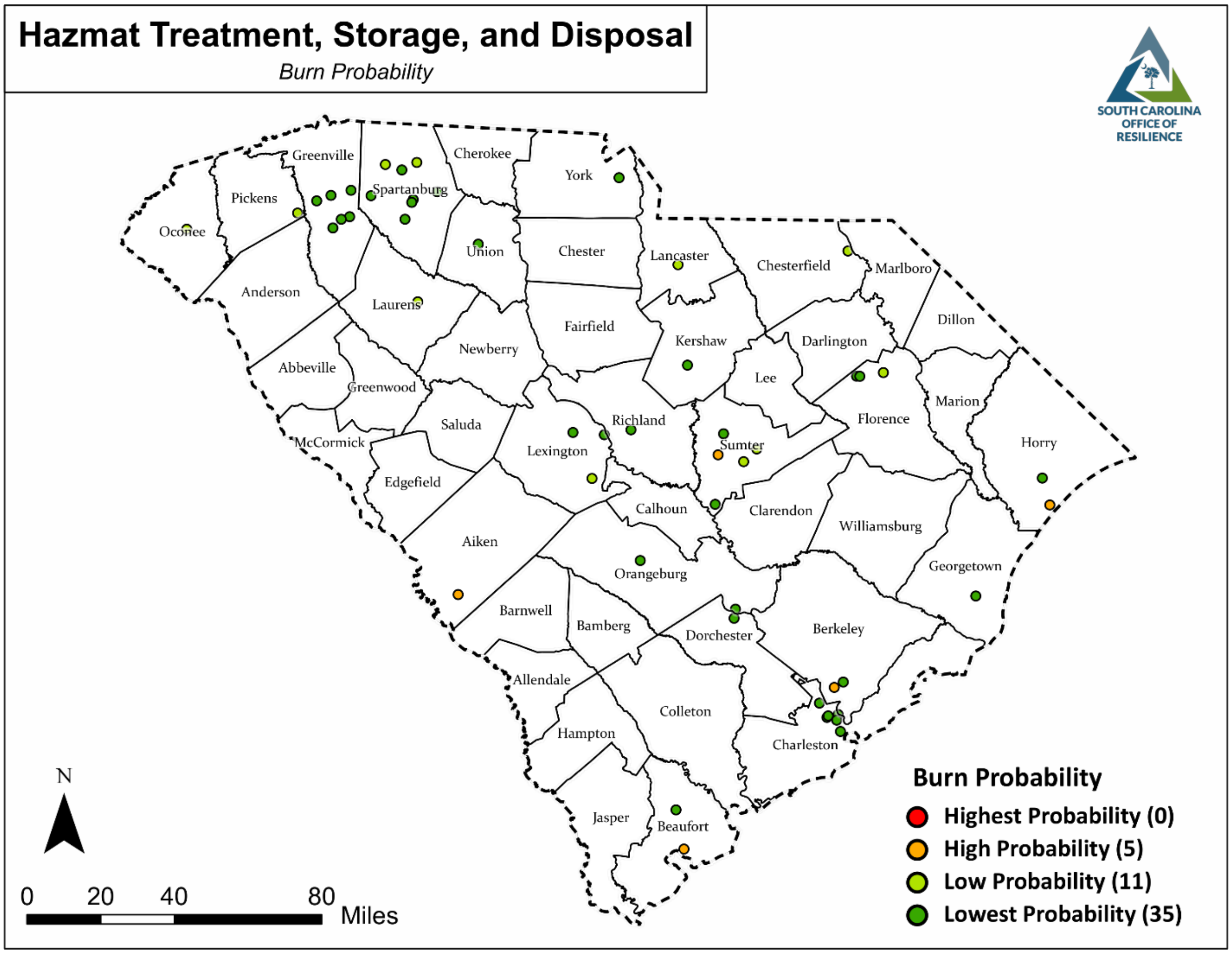


**Figure 6.7: Estimated Burn Probability of Hazmat Treatment, Storage and Disposal Facilities (DHEC). Wildfire data provided by SouthWRAP**

## CULTURAL RESOURCES

South Carolina's history is rich with the diversity of traditional communities that trace their roots to the landscape.

Figure 6.8 represents the number of points from National Register Locations with a Burn Probability of 5 or higher by census tract. South Carolina has over 1,600 listings in the National Register of Historic Places including 199 historic districts. Since one listing can include multiple buildings and sites, it is estimated that 12,000 to 15,000 properties are included in the National Register.

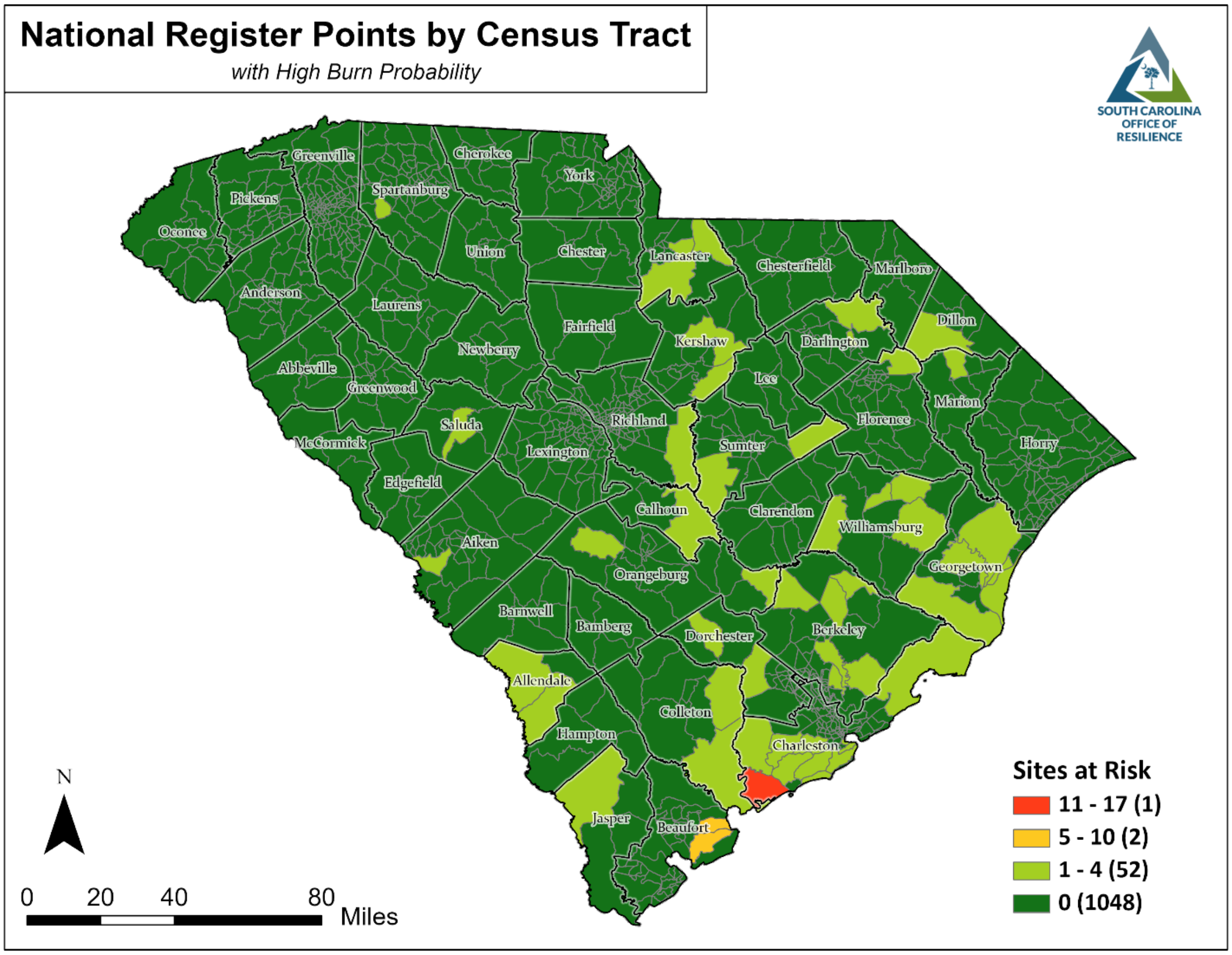


**Figure 6.8: National Register Locations with a Burn Probability of 5 or higher by census tract (ArchSite). Wildfire data provided by SouthWRAP**

Figure 6.9 shows the historic structures in the National Register with a Burn Probability of 5 or higher by census tract. Over 83,000 properties have been recorded by surveys of historic properties since the early 1970s. Over the past decade an average of 1,800 properties were added annually to the Statewide Survey collection that is maintained by the SC Department of Archives and History (SCDAH).

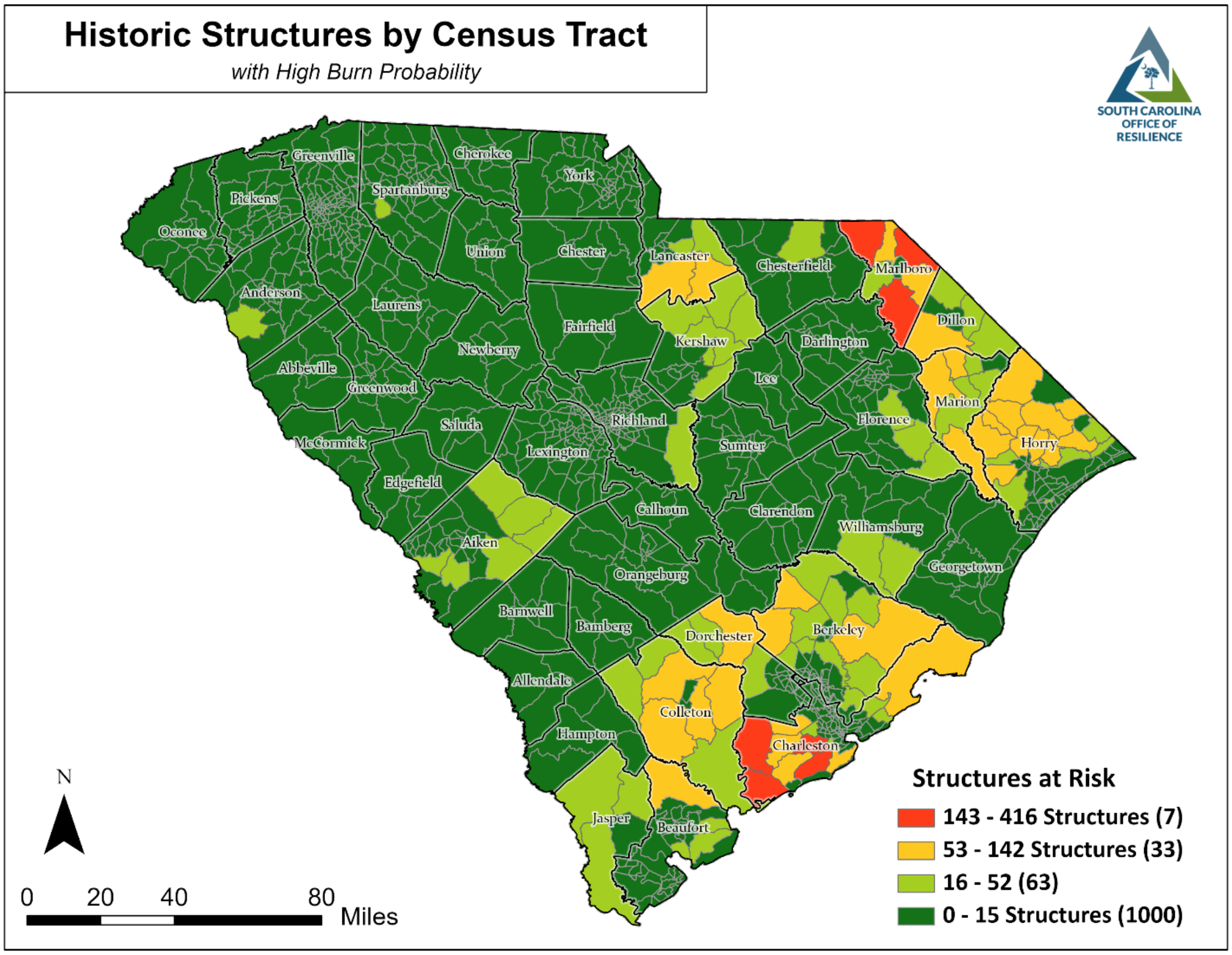


**Figure 6.9: Historic Structures with a Burn Probability of 5 or Higher by census tract (ArchSite). Wildfire data provided by SouthWRAP**

## COMMUNITY SERVICES

Community services are essential to maintaining the health, safety and welfare of people, economies and ecosystems through environmental changes and natural hazards.

### MILITARY

South Carolina's military community provides critical strategic value to our nation's defense. Our location on the East Coast is advantageous for deployment to the Middle East, South and Central America, Africa, and Europe, as well as to Military Operating Areas (MOAs) offshore. Each base (Figure 6.10) supports multiple defense missions that contribute to defense readiness, training, and homeland security (SC Department of Veterans' Affairs, n.d.). Figures 6.11 to Figure 6.14 identify the burn probability of many of the military installations across South Carolina.

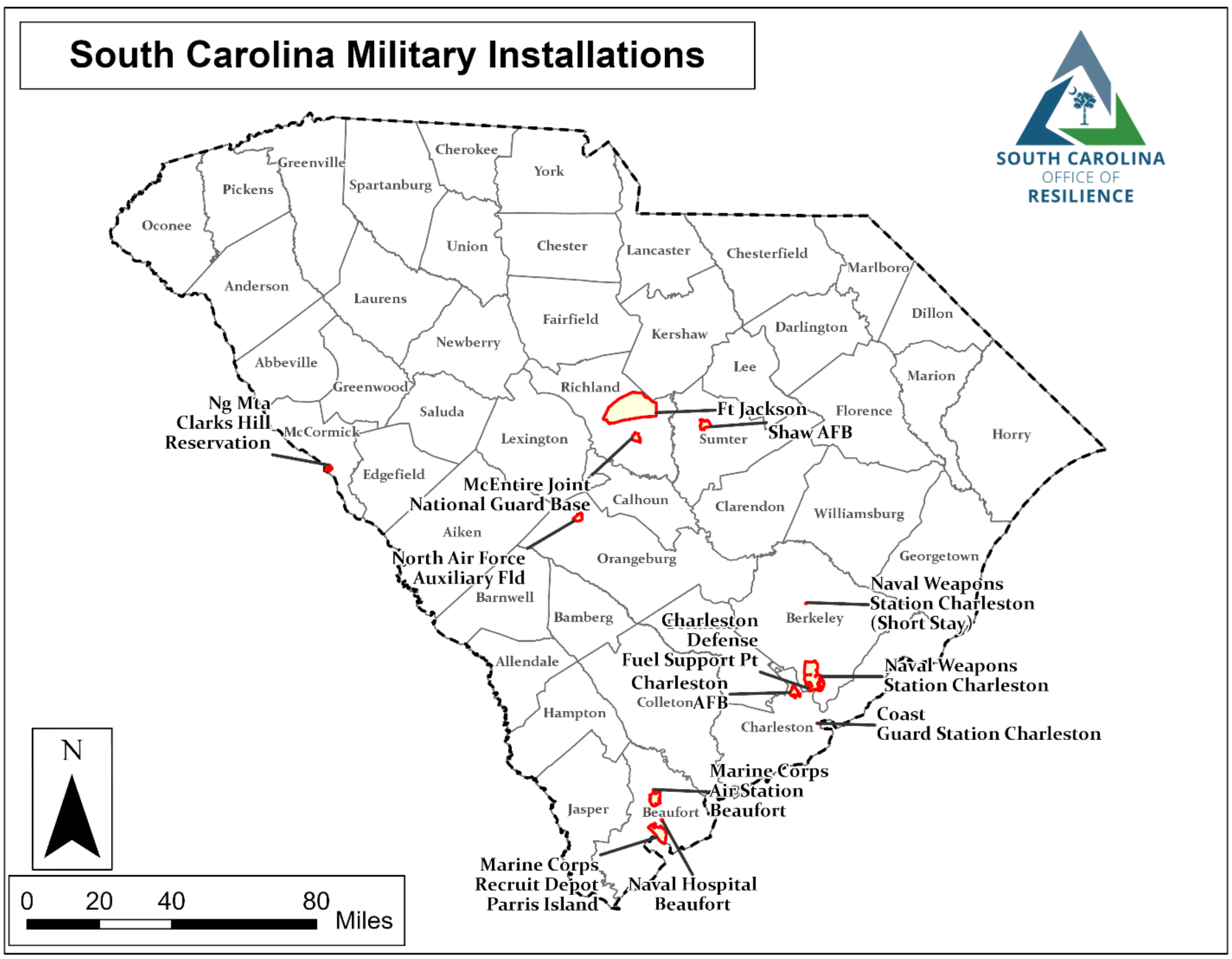


Figure 6.10: South Carolina Military Installations

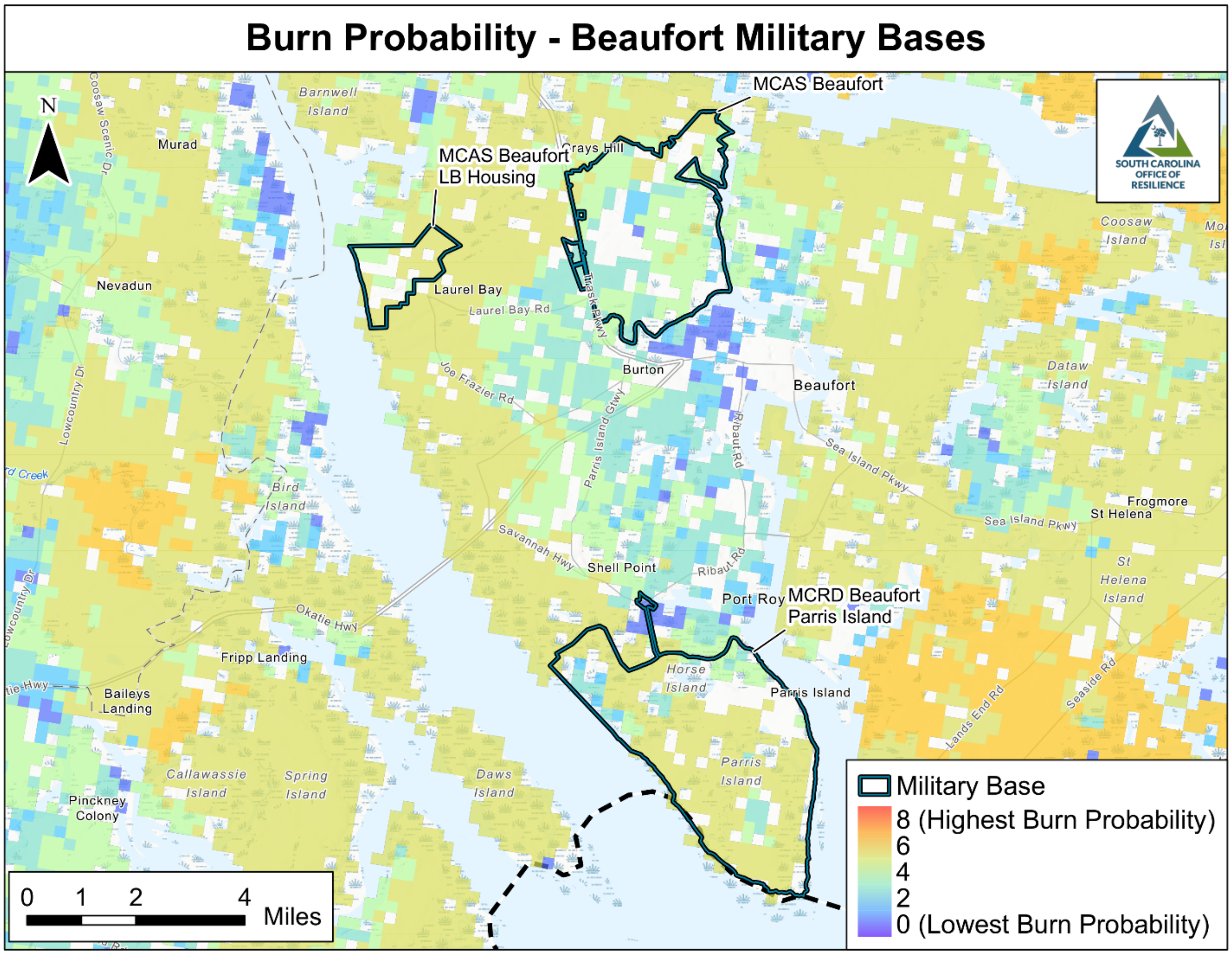


**Figure 6.11: Estimated Burn Probability of Military Installations in the Beaufort County: MCAS Beaufort, MCAS Beaufort LB Housing, and MCRD Beaufort Parris Island. Wildfire data provided by SouthWRAP**

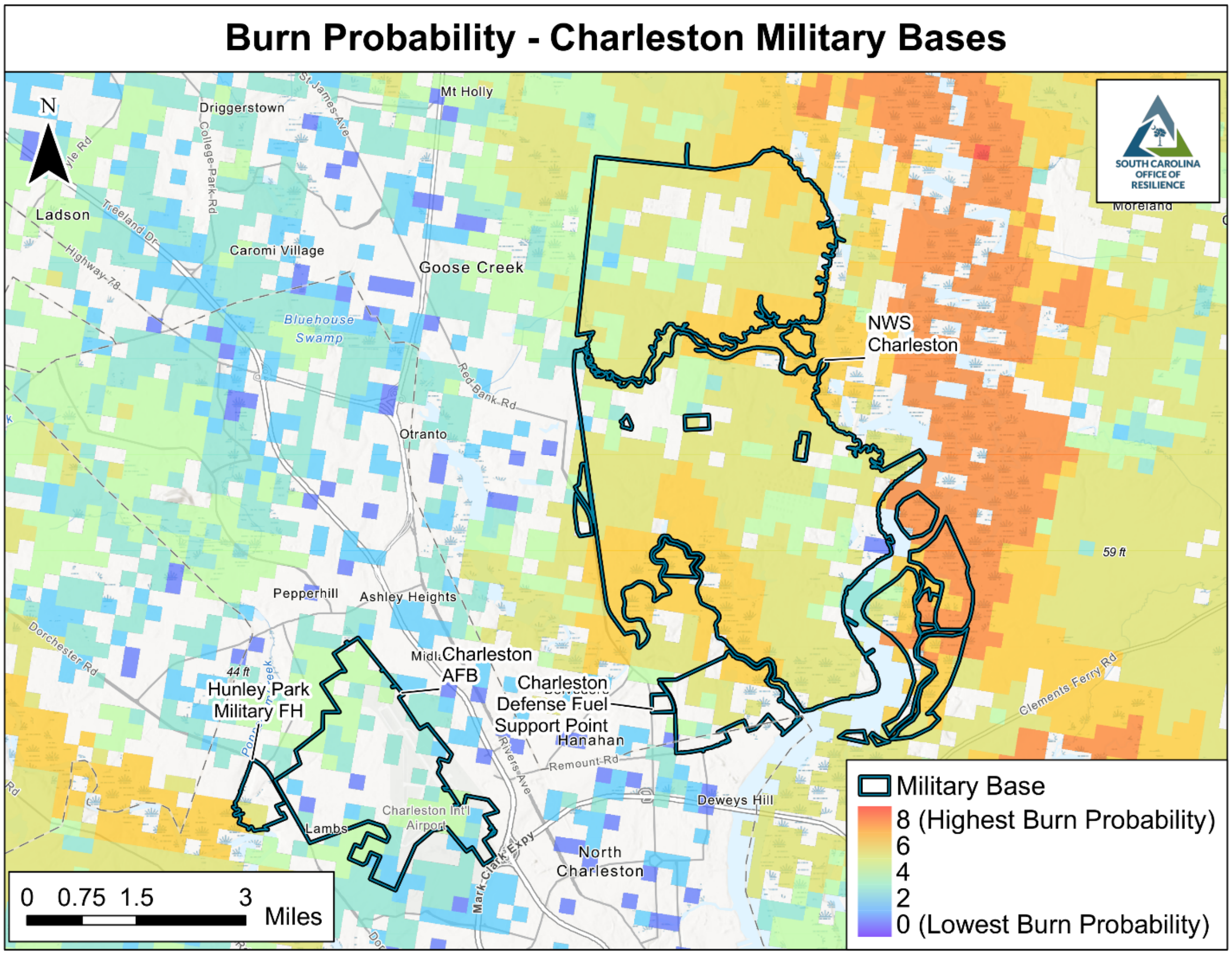


**Figure 6.12: Estimated Burn Probability of Military Installations in the Charleston County: NWS Charleston, Charleston Defense Fuel Support Point, Charleston AFB, and Hunley Park Military FH. Wildfire data provided by SouthWRAP**

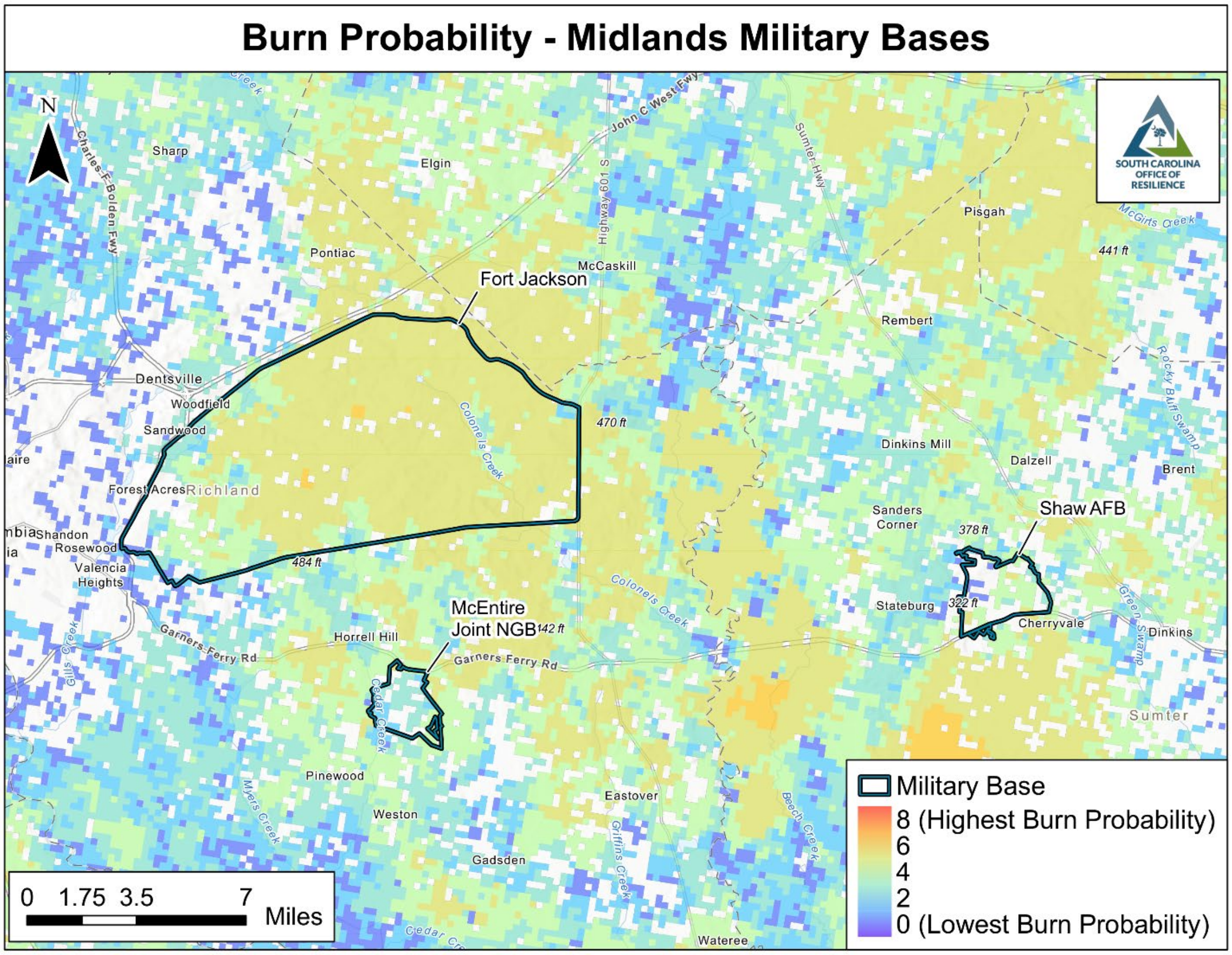


**Figure 6.13: Estimated Burn Probability of Military Installations in the Midlands, Fort Jackson, Shaw AFB, and McEntire Joint NGB. Wildfire data provided by SouthWRAP**

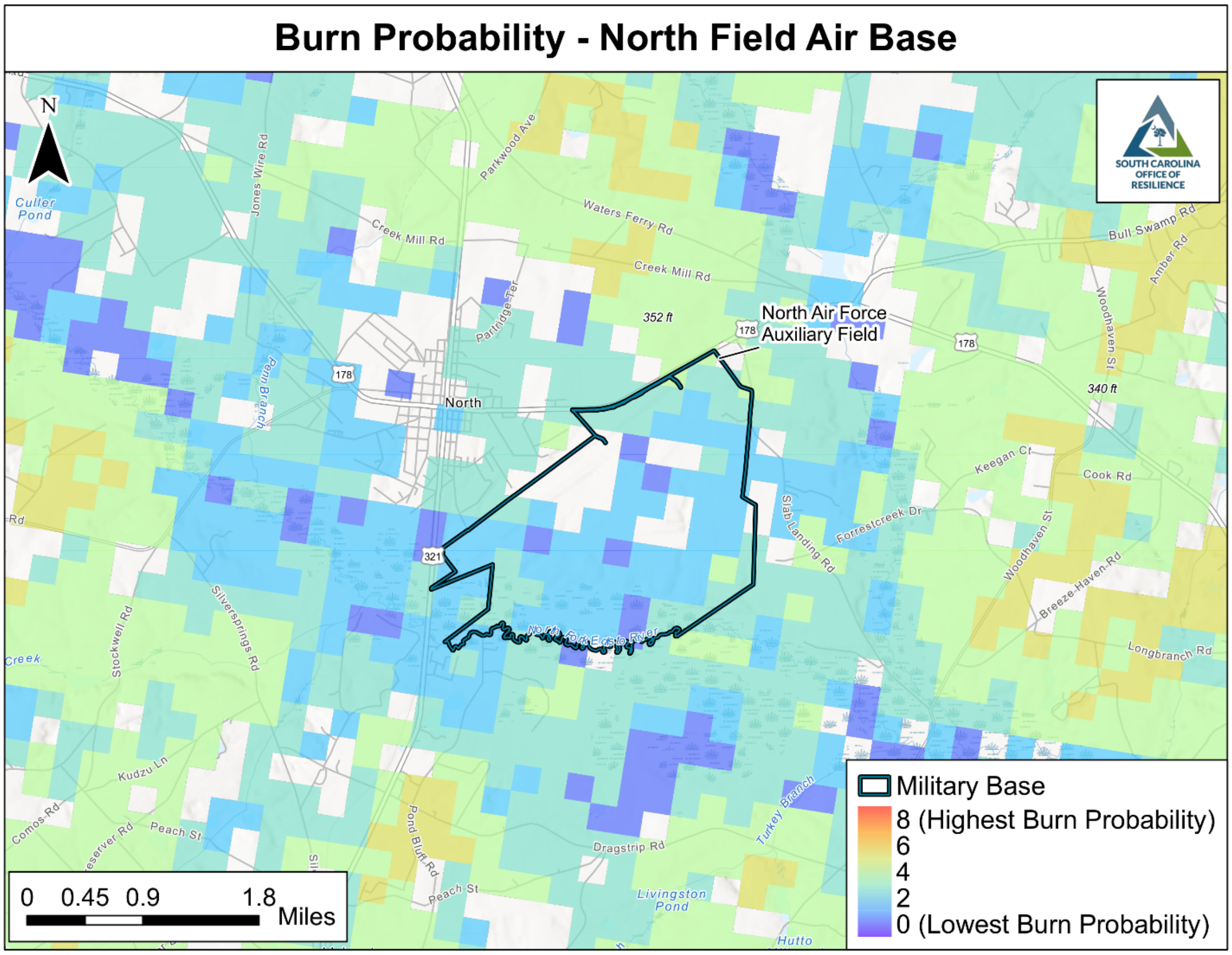


Figure 6.14: Estimated Burn Probability of North Field Air Base in Orangeburg County. Wildfire data provided by SouthWRAP

## PUBLIC SAFETY

### STATE LEVEL

State level law enforcement in South Carolina is split across several agencies. The Department of Public Safety and the State Law Enforcement Division (SLED) act in coordination with local and federal entities. Services provided include crime investigation, emergency response, intelligence gathering, protective services, and highway patrol. In times of emergency, personnel and resources are deployed preemptively to provide support functions to the afflicted areas.

The South Carolina Forestry Commission has 48 commissioned, class 1 law enforcement officers that conduct origin and cause investigations on every wildfire the SCFC responds to and assists other state and local agencies with origin and cause needs. SCFC has 4 full-time investigators that focus on complex arson causes and other issues, like timber theft.

### LOCAL LAW ENFORCEMENT

While the above state agencies support local law enforcement agencies, the initial response depends on county, city, and town law enforcement agencies. Figure 6.15 shows the potential risk to law enforcement offices across the state.

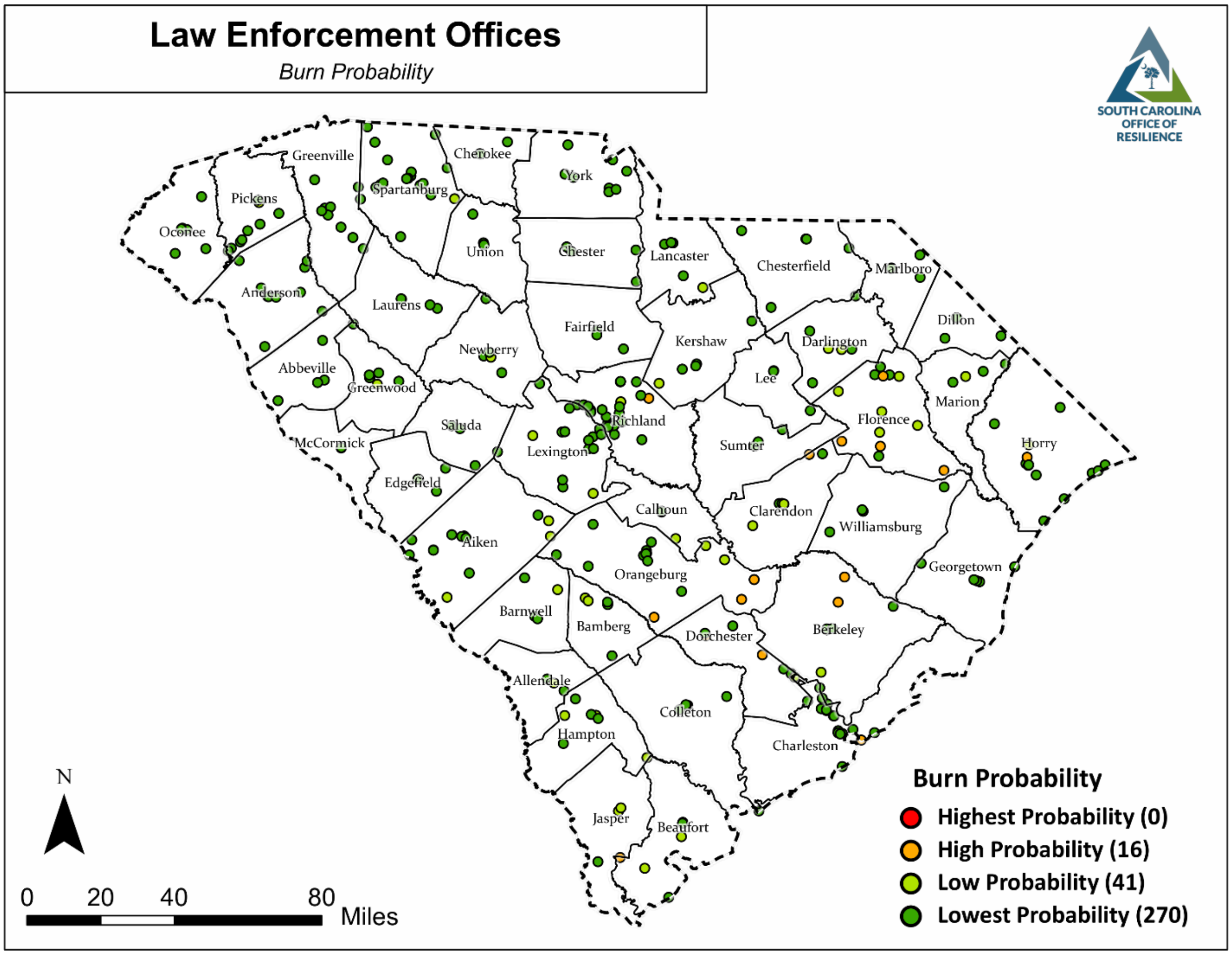


**Figure 6.15: Estimated Burn Probability of local law enforcement agencies (SLED). Wildfire data provided by SouthWRAP**

## DETENTION CENTERS

SLED identifies 84 detention centers across the state, which includes county, state, federal, and juvenile facilities. Figure 6.16 shows the potential risk to detention centers across the state.

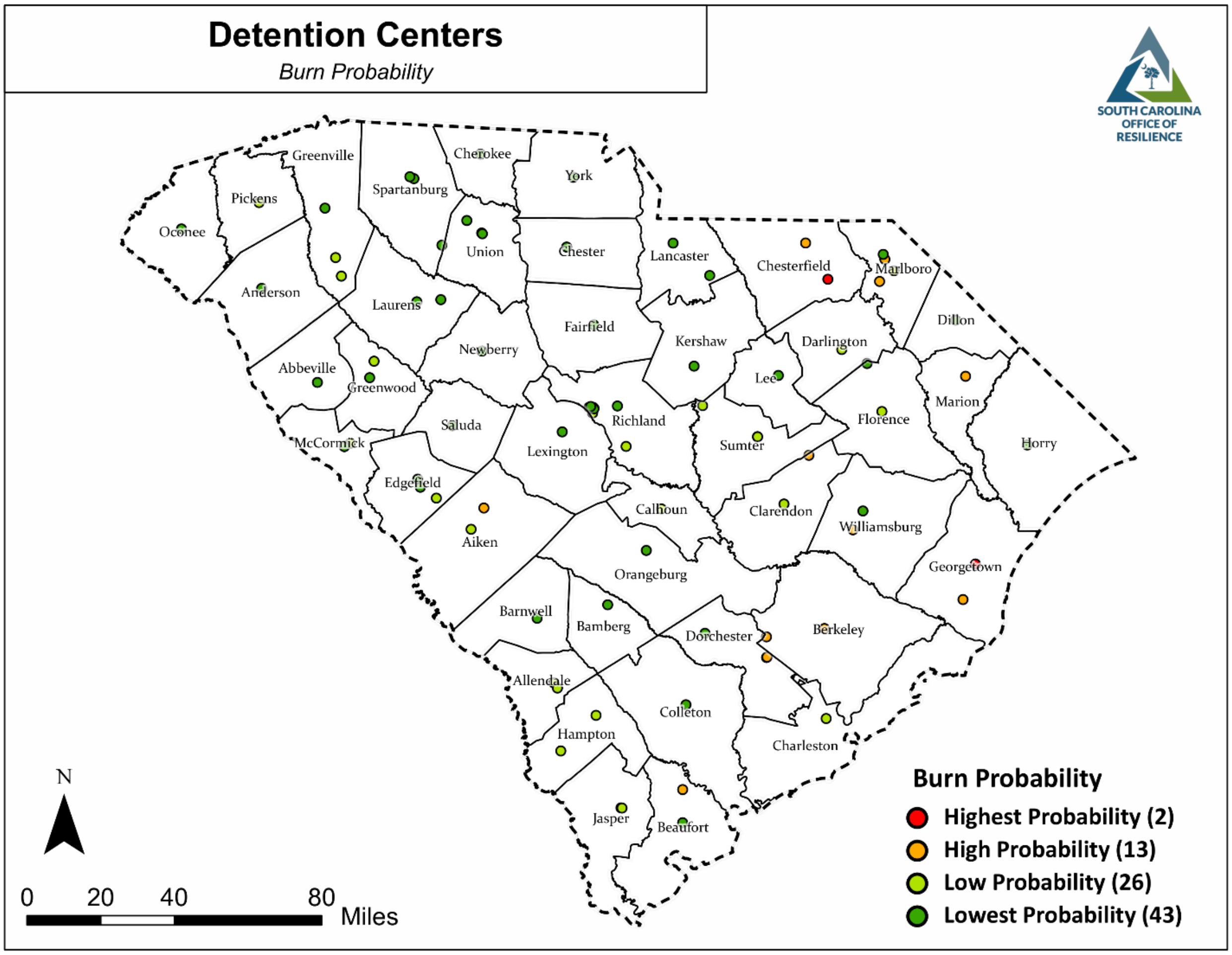


**Figure 6.16: Estimated Burn Probability of detention centers (SLED). Wildfire data provided by SouthWRAP**

## FIRE STATIONS

Fire stations provide response to a variety of incidents, disasters, and situations. The public relies heavily on first responders during daily emergencies, and even more during disasters when there is a greater need for assistance. Figure 6.17 shows the burn probability for fire stations across the state. The data points include manned fire stations and buildings from which a fire response occurs, such as volunteer fire department buildings, and includes both private and governmental entities.

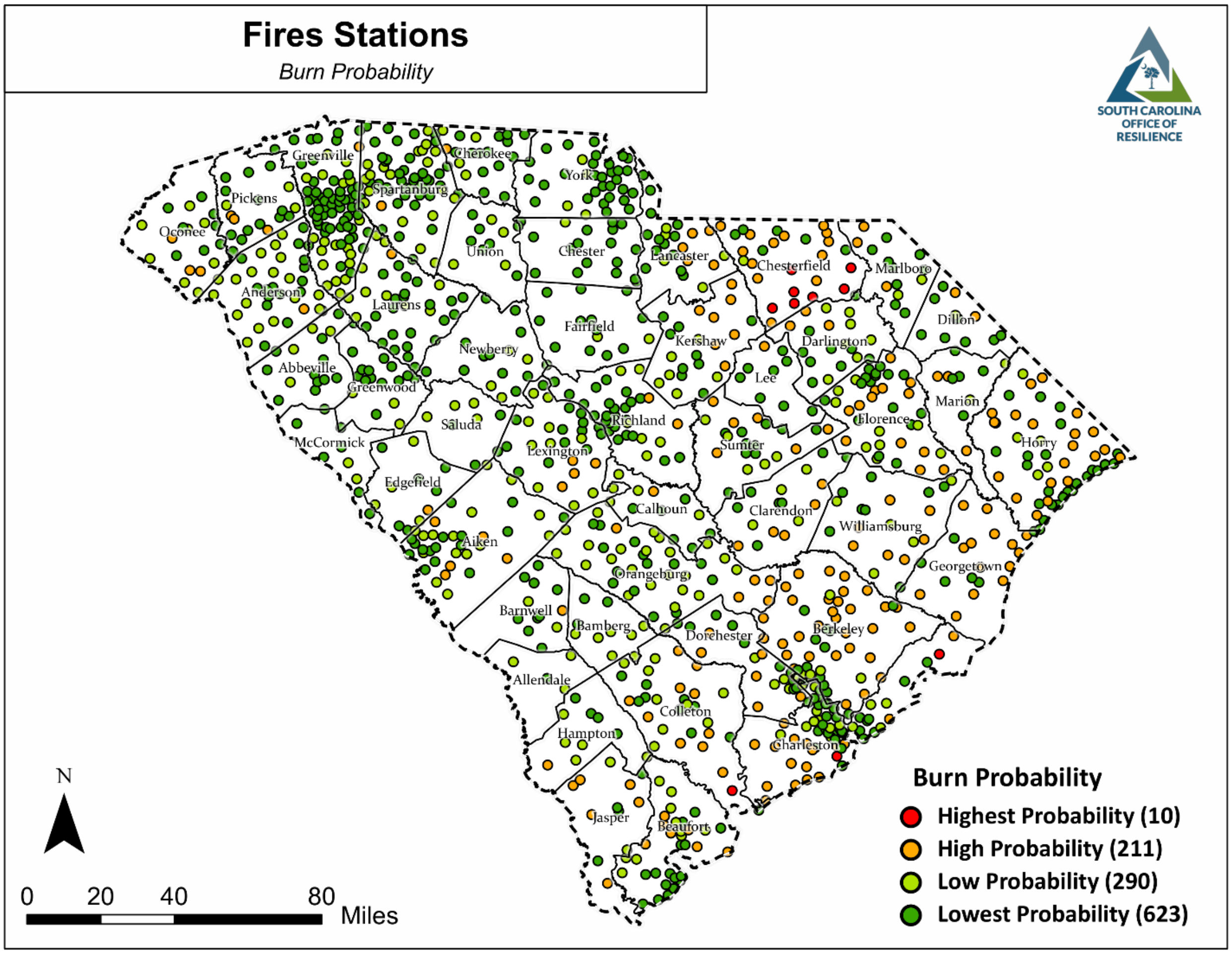


Figure 6.17: Estimated Burn Probability of fire stations (Department of Homeland Security). Wildfire data provided by SouthWRAP

## EMS

Like fire stations, EMS stations and personnel are needed daily, but are in increased demand leading up to, during, and after a disaster. There are an increased number of calls to respond to and more barriers to arriving on the scene. Similar to fire stations, EMS stations are placed where they can service the most people and as the population grows, new staging sites are added. Figure 6.18 shows the burn probability for EMS stations across the State.

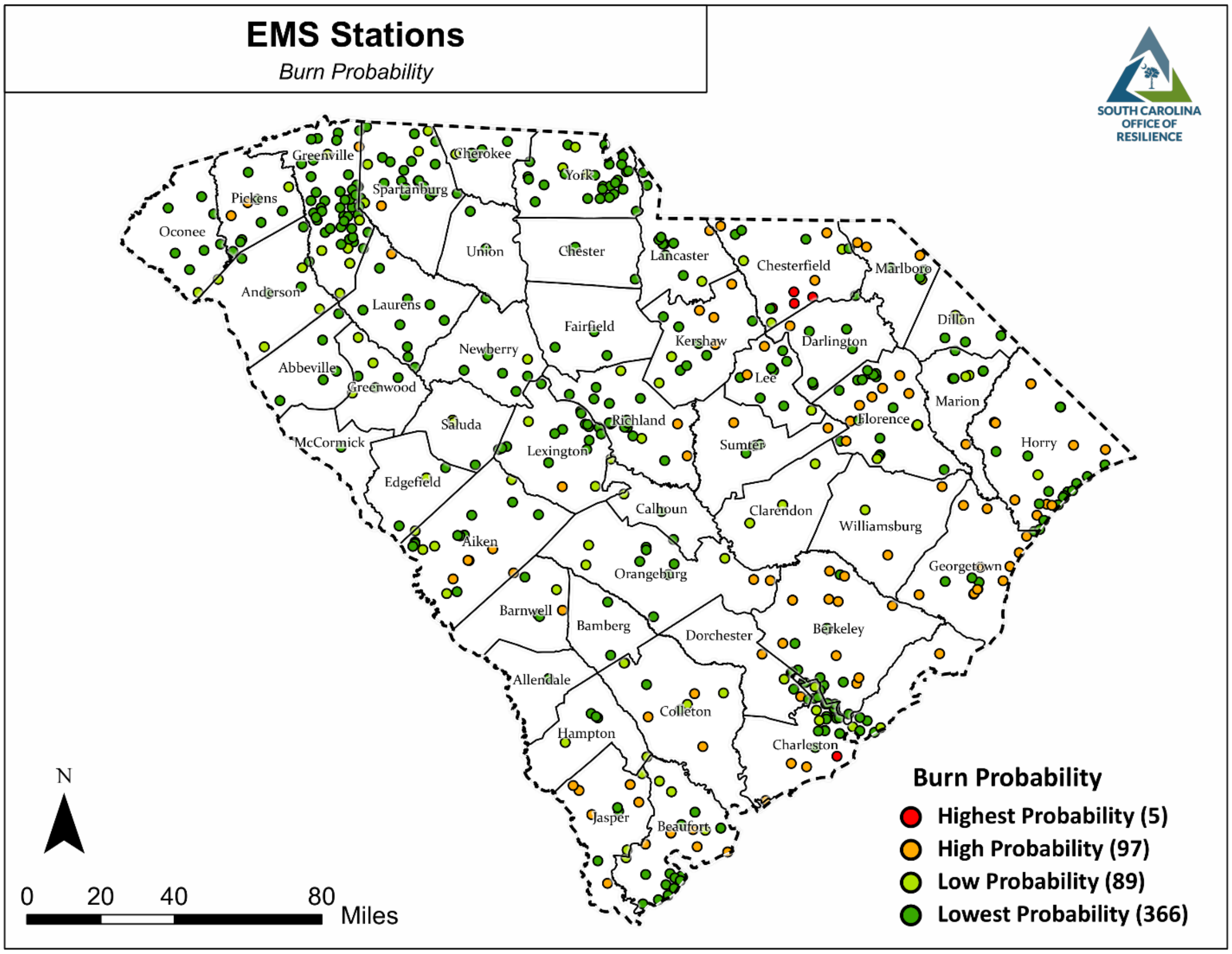


Figure 6.18: Estimated Burn Probability of EMS stations (Department of Homeland Security). Wildfire data provided by SouthWRAP

## EDUCATION

In addition to the initial impact of an event on schools, hazard events have the potential to force schools to close for long periods of time, disrupting student learning.

### K-12 EDUCATION

According to the South Carolina Department of Education's Active Student Headcounts, there are 777,111 students enrolled in South Carolina public schools (SC Department of Education, 2022). It has been found that the damage public schools face due to natural hazards is compounded by their age and condition (The Pew Charitable Trusts, 2017). These factors are not variables in the assessment for burn probability used to identify the public schools at potential risk in Figure 6.19 and the private schools in Figure 6.20.

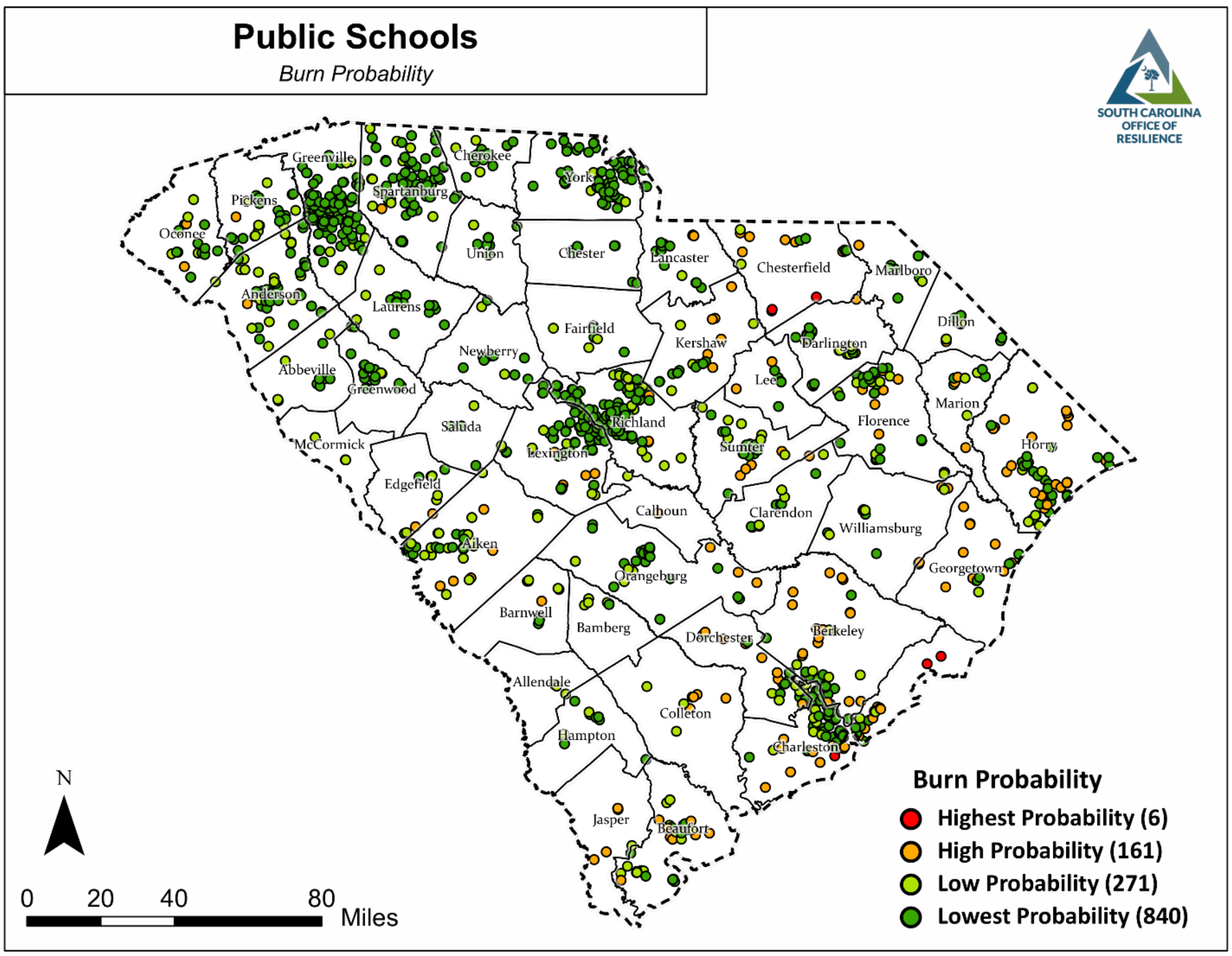


Figure 6.19: Estimated Burn Probability of public schools (Department of Homeland Security). Wildfire data provided by SouthWRAP.

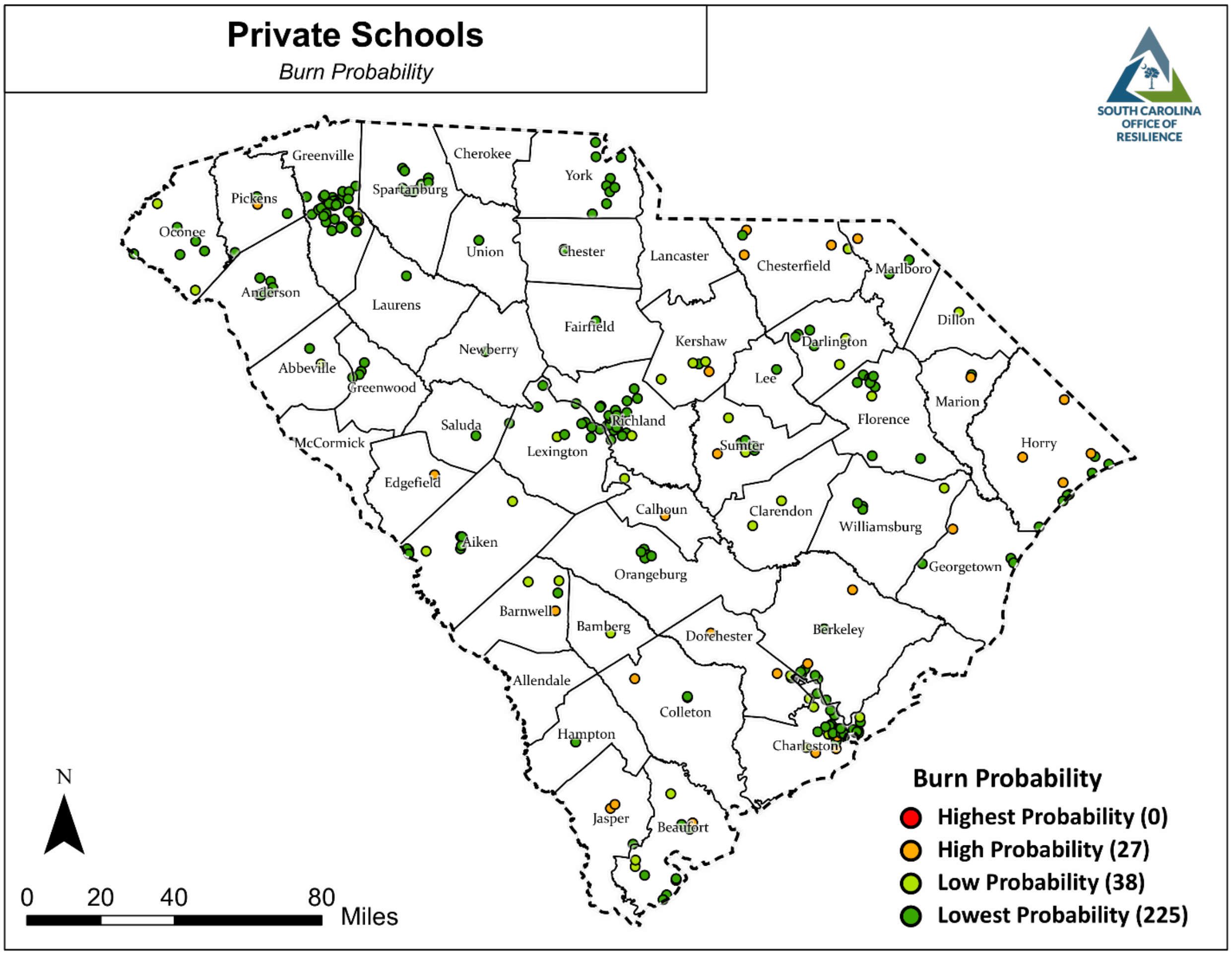


**Figure 6.20: Estimated Burn Probability of private schools (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

## HIGHER EDUCATION

There are 33 public colleges and universities as well as 25 independent institutions in South Carolina. In the Fall of 2020, these institutions enrolled 229,781 students, 69.8% of which were full-time students. In the previous school year (2019-2020), these institutions awarded 52,670 degrees, 49.4% of which were bachelor's degrees. This is a 14.5% increase over the total degrees awarded in the 2010-2011 school year. From an economic perspective, public and private institutions employ nearly 16,000 faculty members, and 48% are full-time (SC Commission on Higher Education, 2021).

In terms of physical vulnerability, public institutions alone have a building footprint of over 36 million square feet of usable space across the state, 28% of which is instructional space. 40% of buildings are over 50 years old while 10% of all public campus buildings are over 99 years old.

Figure 6.21 shows the burn probability of the post-secondary education schools. Higher education tends to have large campuses that can be distributed across towns and satellite campuses. The point analysis does not represent the total wildfire risk to a whole campus and just a single point at the campus.

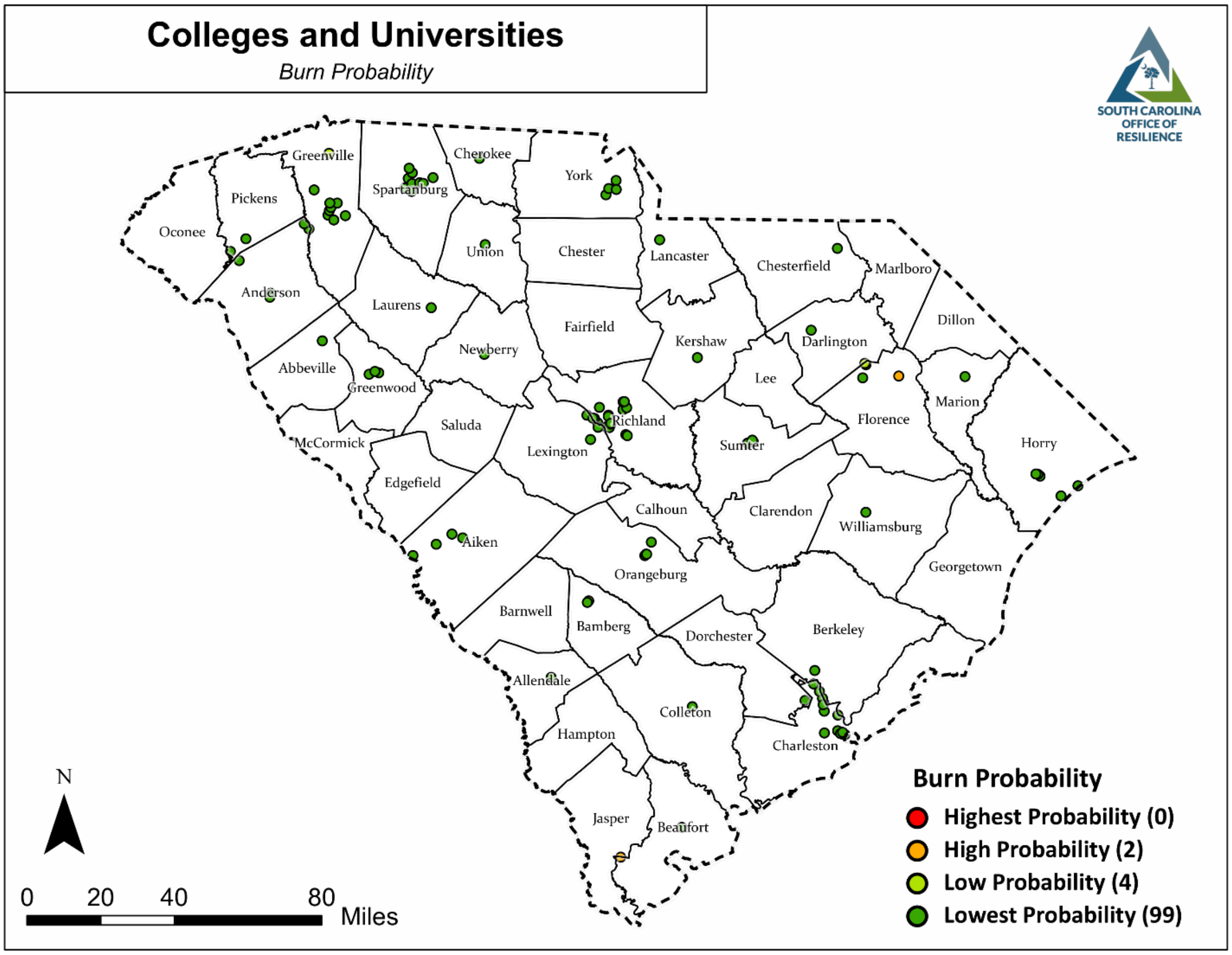


**Figure 6.21: Estimated Burn Probability of colleges and universities (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

## PUBLIC HEALTH

Wildfires can have large impacts on public health. The maps below show the physical burn probability of public health facilities. In addition to the risk of facilities burning, smoke associated with fire is of particular concern to public health. Wildfires can occur at any time, and the worst air quality impacts often happen when atmospheric conditions keep smoke low and blow it into developed areas or over roadways, creating hazardous air quality for public health or unsafe driving conditions where accidents may occur. Wildfire smoke can travel very long distances and cause impacts to sensitive populations. As more wildfires occur in the wildland urban interface, there have been increased smoke impacts on the population. These impacts can even be seen with controlled, prescribed fires, like those conducted by the SCFC. SCFC works with DHEC to implement South Carolina's Smoke Management Guidelines to encourage prescribed burns for forestry, wildlife, and agriculture purposes to be conducted on days when the atmospheric conditions allow smoke to dissipate and minimize smoke impacts, thereby allowing land managers to choose to burn when smoke will not create avoidable public health issues.

### PUBLIC HEALTH FACILITIES

DHEC's Bureau of Health Facility Licensing (BHFL) regulates health care facilities and providers, enforcing standards, inspections, and licenses for nursing homes, hospices, home health agencies, ambulatory surgical centers, adult day cares, and renal dialysis centers that provide essential health services. Figure 6.22 shows the burn probability for health facilities.

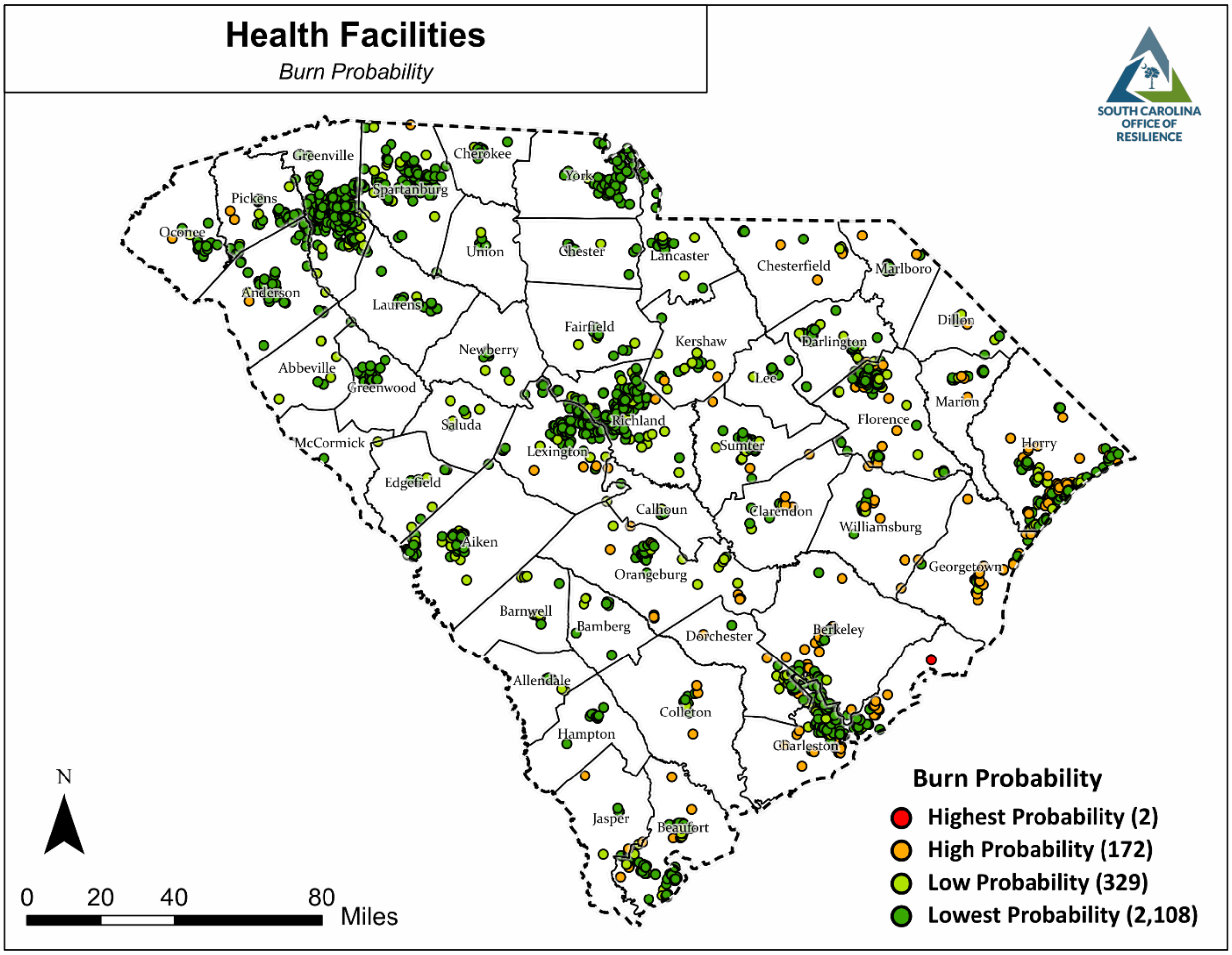


Figure 6.22: Estimated Burn Probability of health facilities (DHEC). Wildfire data provided by SouthWRAP.

## HOSPITALS

The State has over 100 hospitals. In addition to the physical vulnerabilities of these facilities, environmental changes and natural hazards can increase the demand for medical care. Hospitals can experience increased demand and continue to be essential leading up to, during, and in the short and long term after an event. In the time leading up to an event, especially in the case of evacuations, there can be increased traffic accidents. During and immediately after an event, those who cannot or do not leave may be trapped and in need of medical care. Road detours and closures before and during an event can limit hospital access for patients and staff. Figure 6.23 shows the burn probability for hospitals.

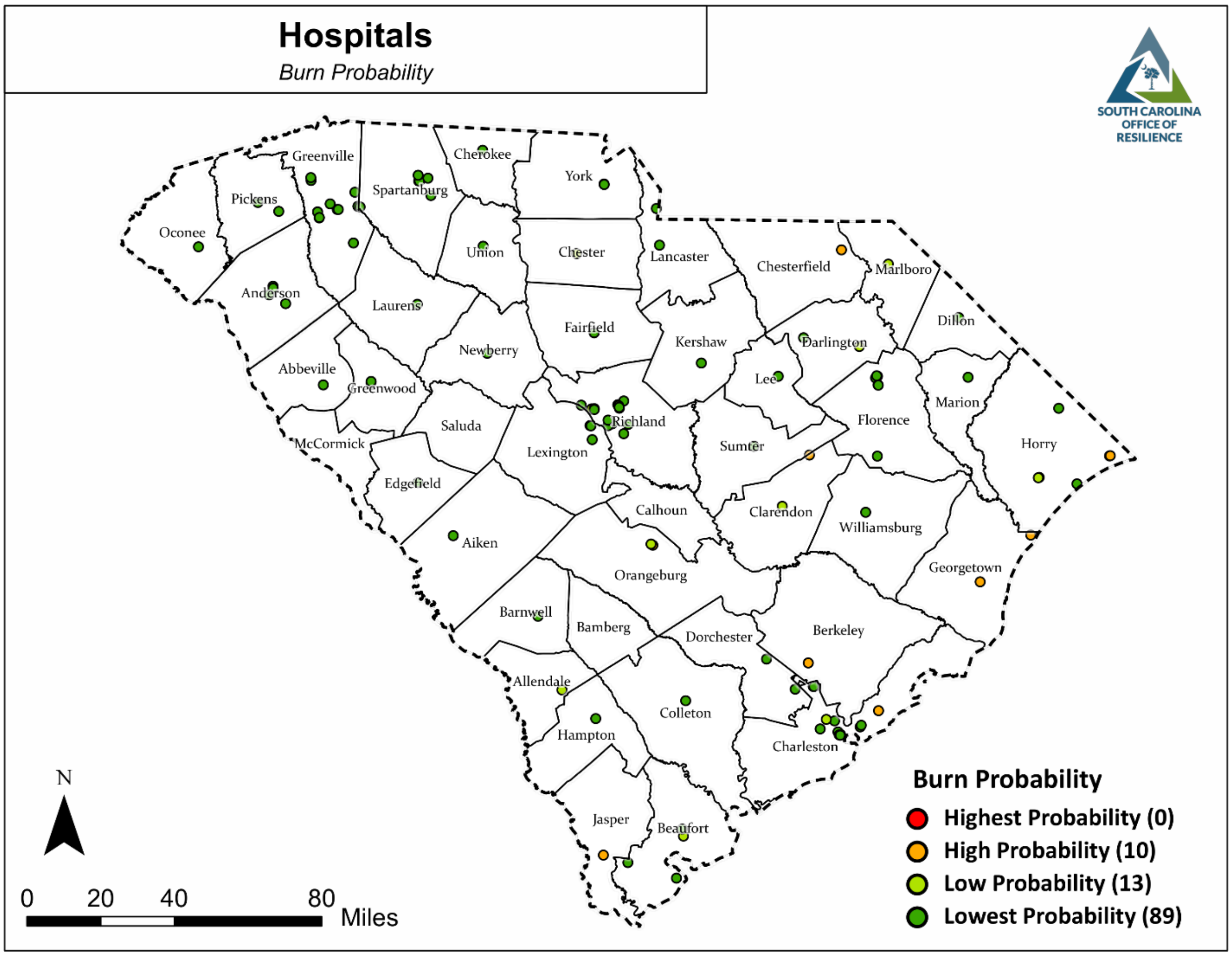


Figure 6.23: Estimated Burn Probability of hospitals (Department of Homeland Security). Wildfire data provided by SouthWRAP.

## NURSING HOMES

Nursing homes have similar vulnerabilities to hospitals when it comes to providing medical care. The residential nature of these facilities has the potential to impact their residents in the long term, requiring them to find other homes to live in and the loss of personal belongings. Figure 6.24 shows the burn probability for nursing homes.

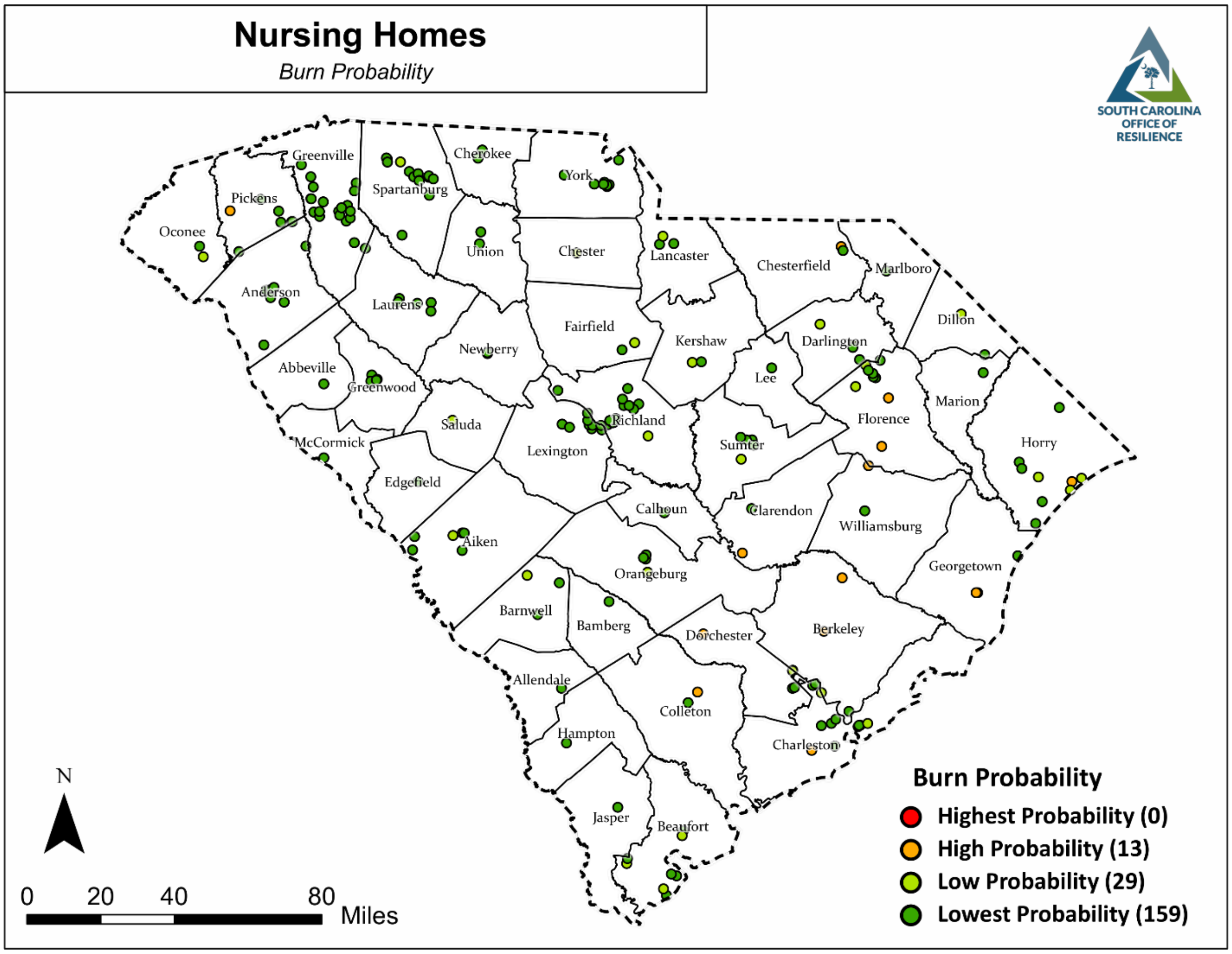


**Figure 6.24: Estimated Burn Probability of nursing homes (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

## MENTAL HEALTH FACILITIES

Experiencing environmental change and natural hazards can be stressful, and for some people, they may result in serious mental health consequences and make access to care for ongoing conditions more difficult. According to the South Carolina Behavioral Health 2021 Progress Report, nearly a fifth of South Carolinians live with mental illness, with 18.3% reporting a diagnosable mental, behavioral, or mental disorder in 2018 as reported by Mental Health America (South Carolina Institute of Medicine & Public Health, 2021).

There are 79 facilities operated by the South Carolina Department of Mental Health (DMH), helping individuals with addiction, Anxiety, Attention Deficit Disorder (ADD), behavioral problems, Bipolar Disorder, Depression, Oppositional Defiant Disorder (ODD), suicide risk, thought disorders, and trauma. This includes three hospitals, four nursing homes, 16 Community Mental Health Centers, and 43 Mental Health Clinics. The vulnerability of these programs is not isolated to the physical facilities but incorporates the mental health professionals' and the patients' access to these locations. Events may create accessibility issues and serve as traumatic events, spurring the need for more mental healthcare in its wake. Figure 6.25 shows the burn probability for DMH offices.

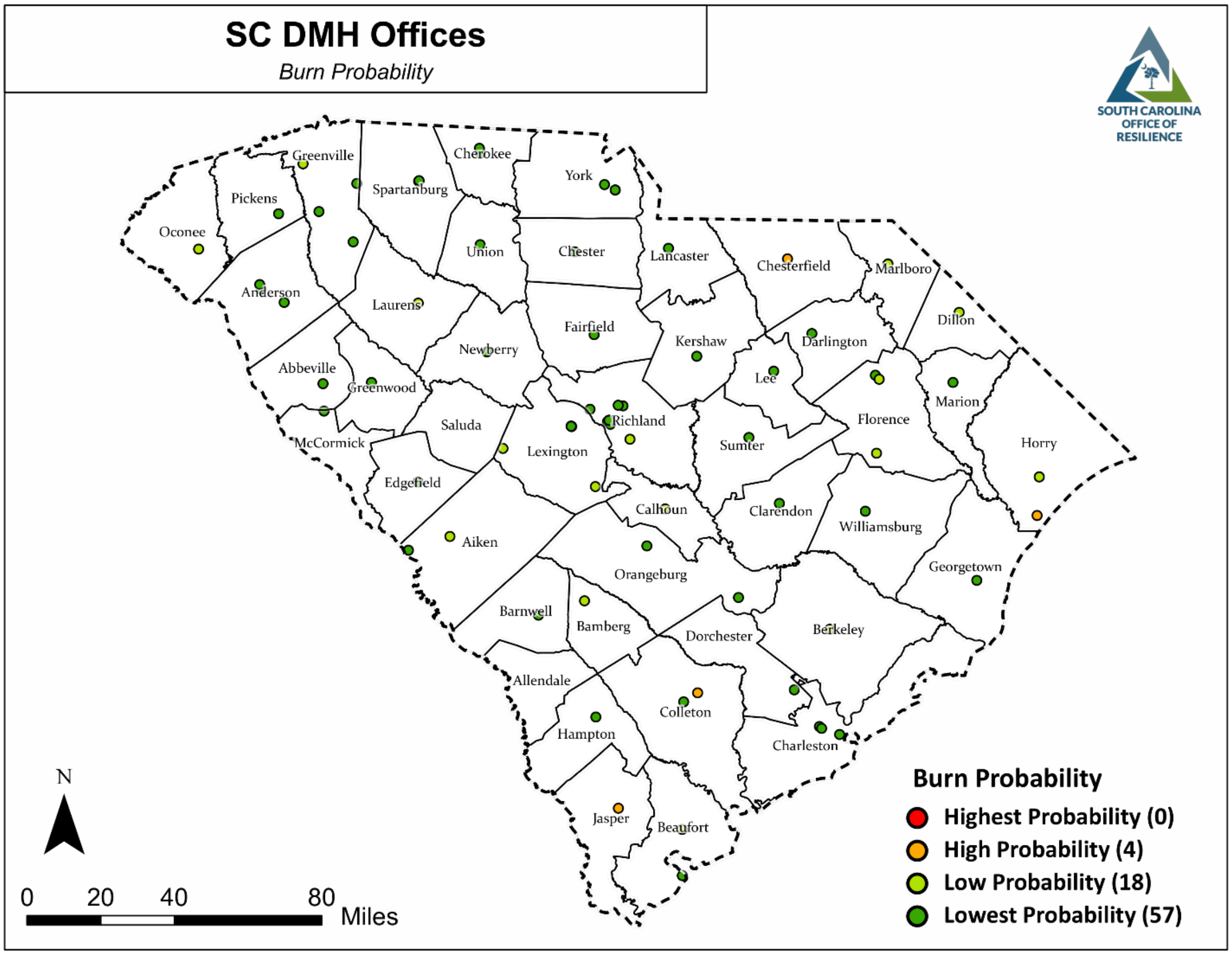


**Figure 6.25: Estimated Burn Probability of the South Carolina Department of Mental Health (DHM). Wildfire data provided by SouthWRAP.**

## DIALYSIS CLINICS

Wildfire can place large numbers of patients treated with maintenance dialysis or individuals with a recent onset of acute kidney injury at risk due to lack of access to dialysis care. Dialysis treatment requires specialized equipment, power, and high-quality water, which may be compromised during a hazardous event. Dialysis clinics may close ahead of or in response to an event. Even if clinics are able to operate, access can be limited after an event, leading to increased demand for accessible clinics (Lempert & Kopp, 2013). Figure 6.26 shows the burn probability for dialysis centers.

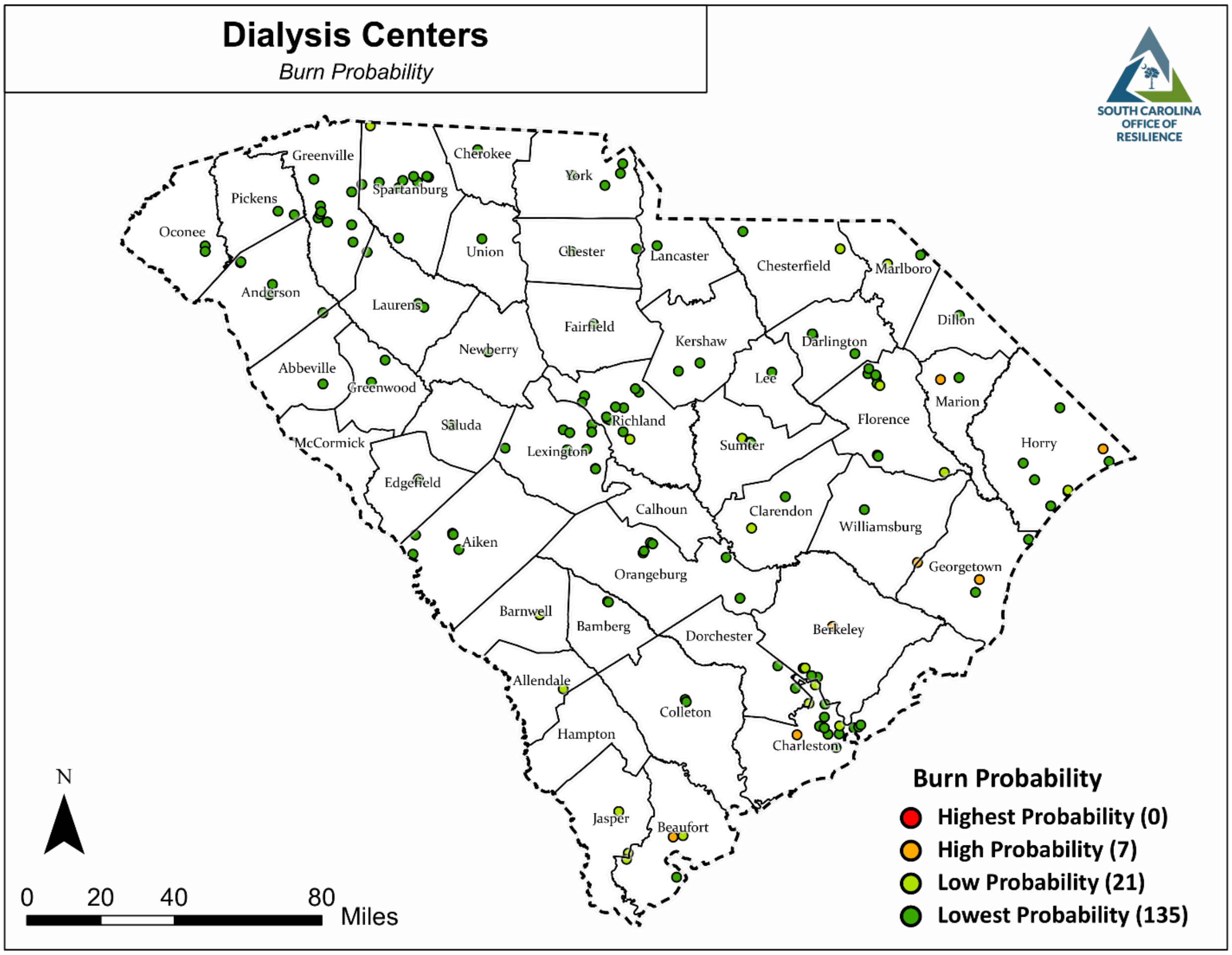


Figure 6.26: Estimated Burn Probability of dialysis centers (Department of Homeland Security). Wildfire data provided by SouthWRAP.

## PHARMACIES

People need access to their prescription medication to maintain continuity of care leading up to, during, and after an event. Approximately half of all Americans live with a chronic disease that requires prescription medications. Evacuations and preparation can increase demand for pharmacy services and medication doses. After an event, pharmacies may be closed for extended periods of time or have supply chain issues. Figure 6.27 shows the burn probability for pharmacies.

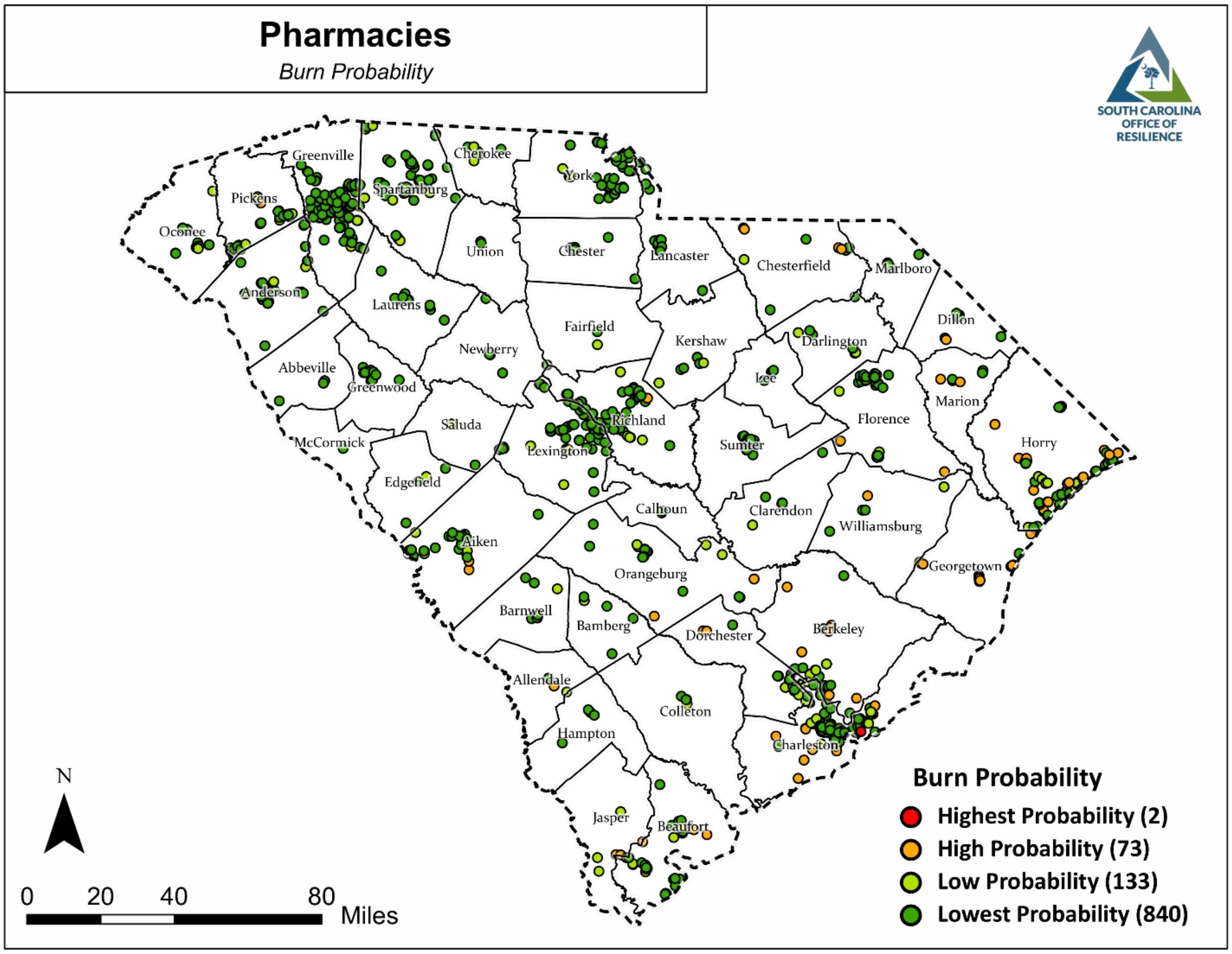


Figure 6.27: Estimated Burn Probability of pharmacies (Department of Homeland Security). Wildfire data provided by SouthWRAP.

## HEALTH AND HUMAN SERVICES

The SC Department of Health and Human Services administers a variety of programs related to health-related services. The largest of which is Medicaid, but also includes Community Long Term Care, Telehealth, and BabyNet. The Department maintains offices in counties across the state to administer these programs. Figure 6.28 shows the burn probability for DHHS offices in South Carolina.

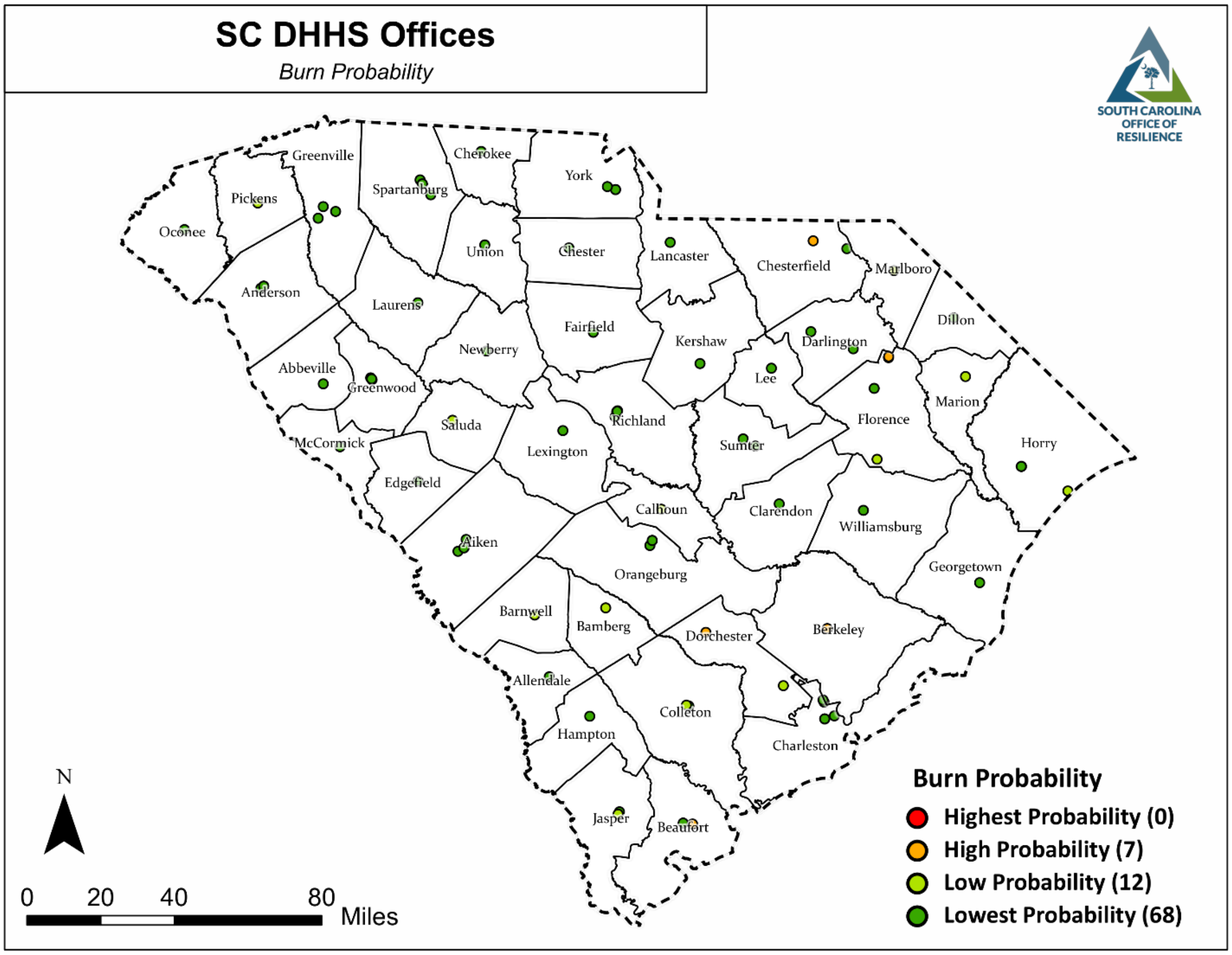


**Figure 6.28: Estimated Burn Probability of South Carolina Department of Health and Human Services offices (DHHS). Wildfire data provided by SouthWRAP.**

## SOCIAL SERVICES

The South Carolina Department of Social Services (DSS) hosts an array of programs including Child Protective Services (CPS), foster care / adoption, Temporary Assistance for Needy Families (TANF), Supplemental Nutrition Assistance Program (SNAP), work programs, early care and education, adult advocacy, and child support services. These programs directly impact 1 in 6 South Carolinians. DSS operates Disaster Supplemental Nutritional Program (D-SNAP) and maintains evacuation plans for its licensed facilities. Similar to other community services the vulnerability is not held completely by the physical locations; it lies with the access of providers and constituents to the services they rely on. Figure 6.29 shows the burn probability for childcare facilities.

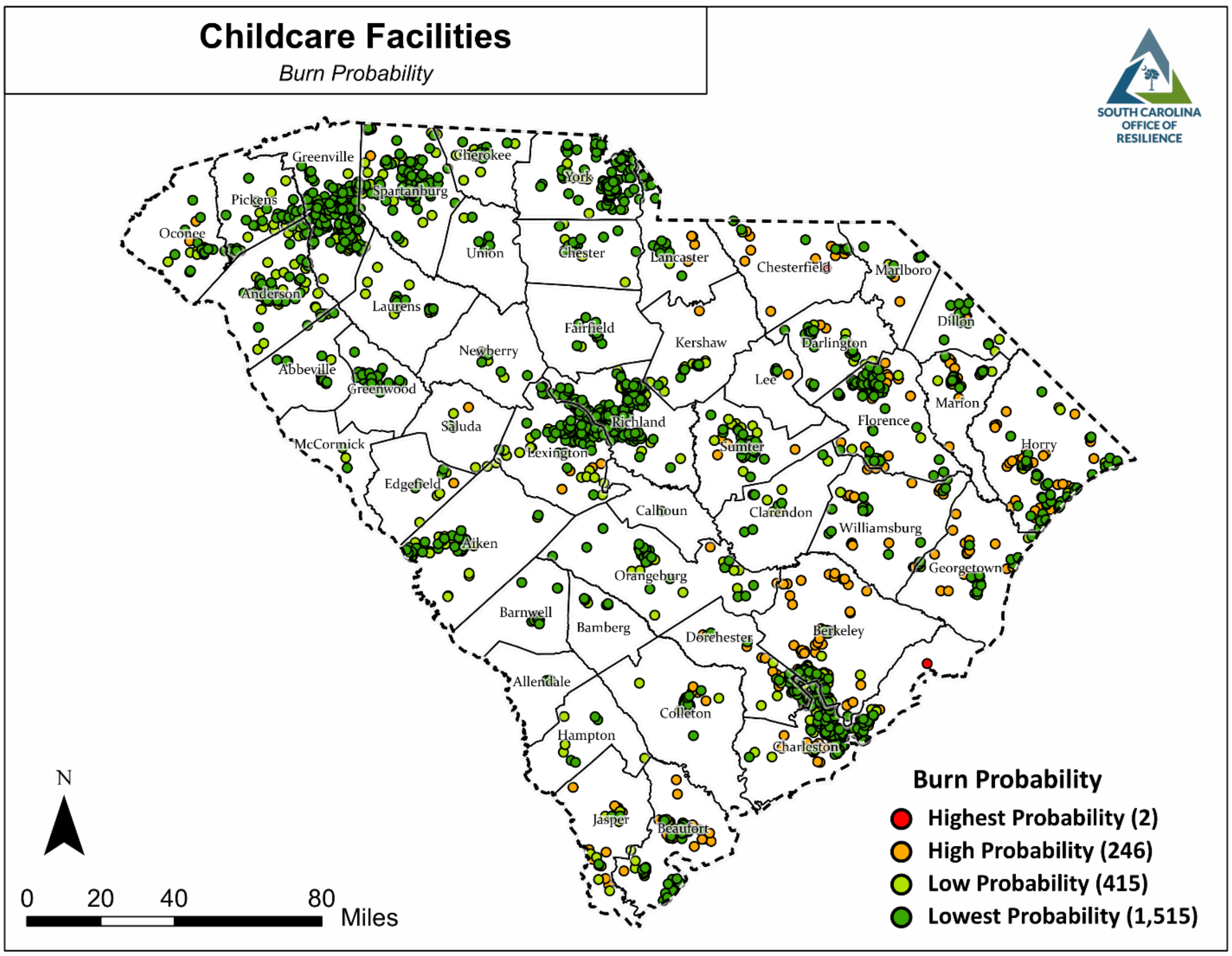


Figure 6.29: Estimated Burn Probability of childcare facilities (DSS). Wildfire data provided by SouthWRAP.

## VETERANS' AFFAIRS

The South Carolina Department of Veterans' Affairs (DVA) coordinates county level offices and places in the community where veterans can access benefits. The DVA assists veterans with employment, healthcare, suicide prevention, and education. Figure 6.30 shows the burn probability for DVA offices.

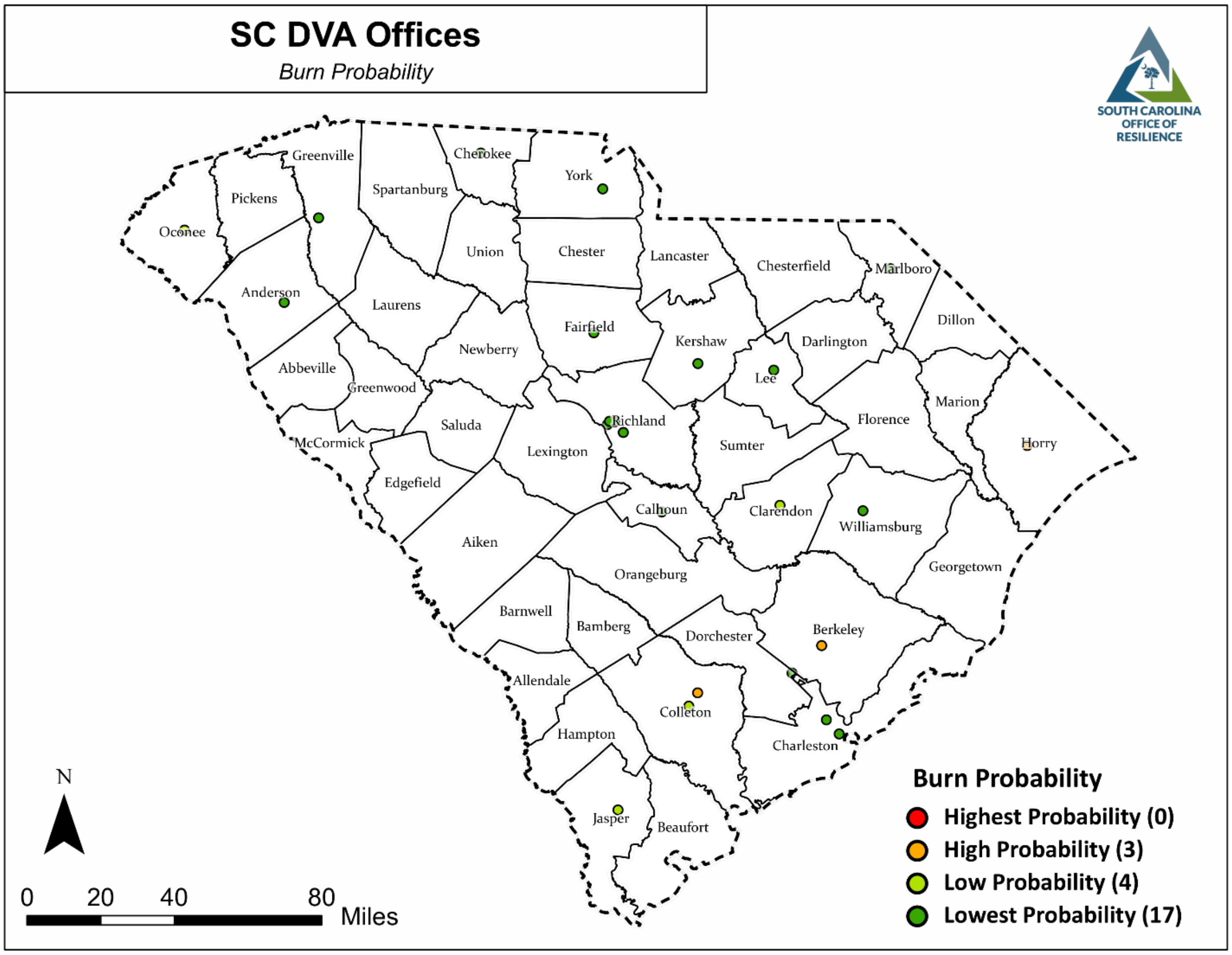


**Figure 6.30: Estimated Burn Probability of South Carolina Department of Veteran's Affairs offices (DVA). Wildfire data provided by SouthWRAP.**

## PLACES OF WORSHIP

There are nearly 6,000 places of worship across the State. After a disaster, these places and their communities provide essential support such as collecting, storing, and distributing supplies, acting as a shelter, and supporting other community needs. Figure 6.31 shows the burn probability for places of worship.

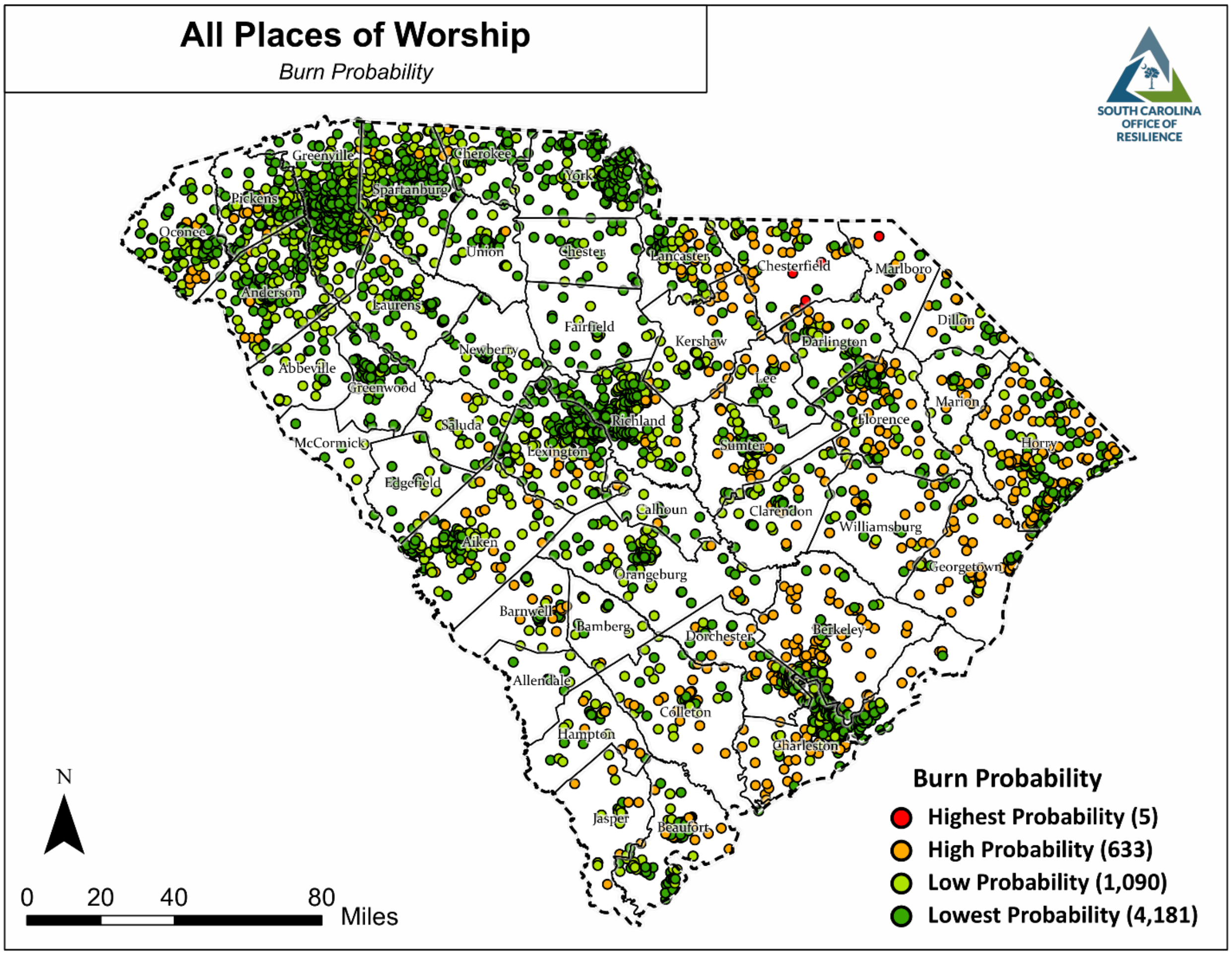


Figure 6.31: Estimated Burn Probability of places of worship (Department of Homeland Security). Wildfire data provided by SouthWRAP.

## INFRASTRUCTURE

### ROADS & BRIDGES

In South Carolina there are over 60,000 public road miles. SCDOT maintains over 41,000 miles of those roadways as well as more than 8,400 bridges, with the fourth largest state-maintained highway system in the nation (SC Department of Transportation, 2022). Impacts from wildfires could shut down roads and bridges. In many ways, the vulnerability of roads and bridges determines much of the vulnerability of all sectors listed in this chapter. All the facilities listed here require access. Additionally, roads and bridges are essential to evacuation and response, and for delivering longer term recovery resources. Figure 6.32 illustrates the burn probability of the State's highways.

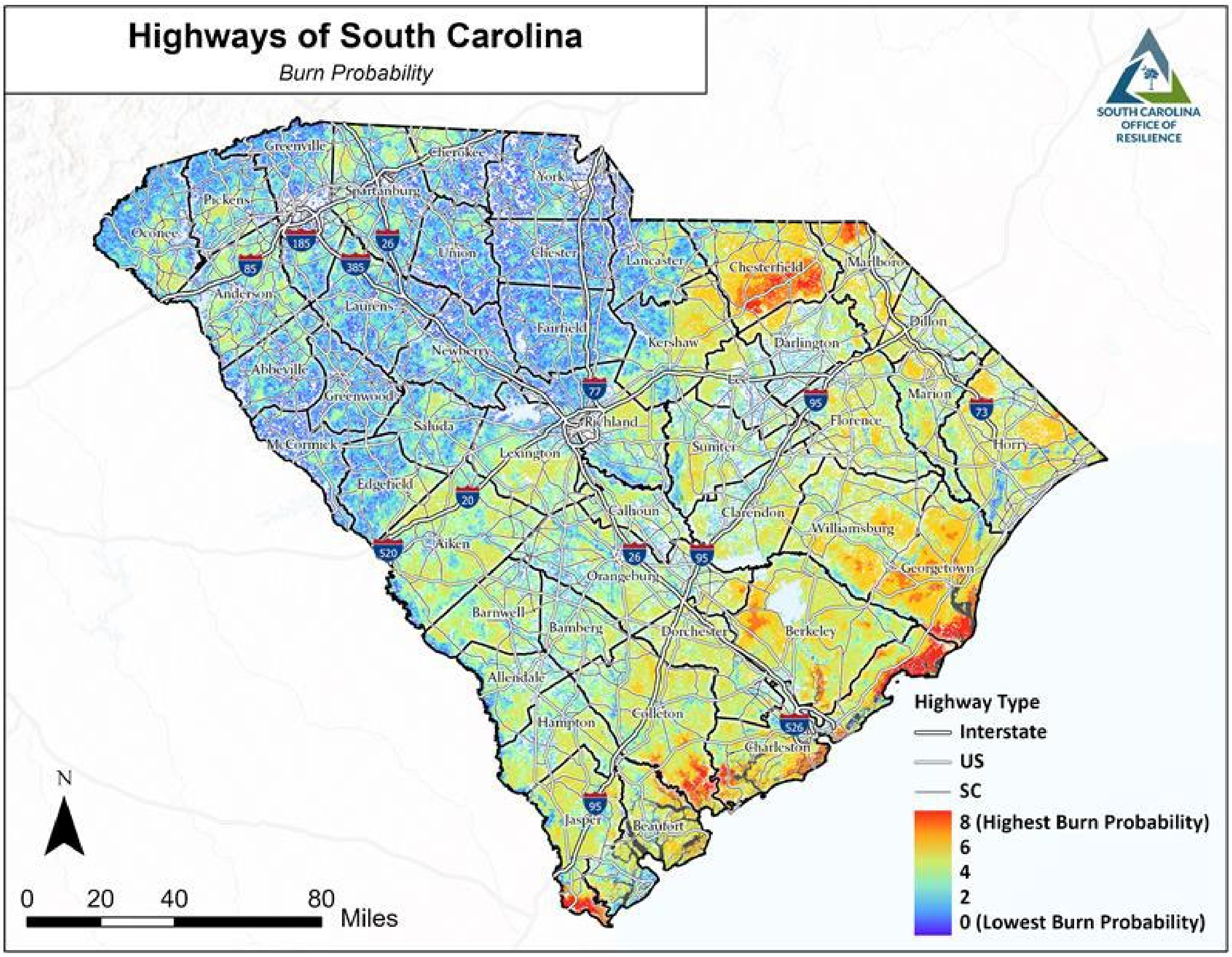


**Figure 6.32: Estimated Burn Probability of highways**

## AIR FACILITIES

There are 51 public general aviation and six commercial airports across the state. These airports employ 122,759 people, with an annual payroll of $4.8 billion. Additionally, they generate $16.3 billion in annual economic activity. This includes the economic impact of Boeing, which has a large presence in Charleston, and the location of the final assembly for the Boeing 787 Dreamliner (South Carolina Aeronautics Commission, 2018). Figure 6.32 shows the burn probability for airports and aviation facilities.

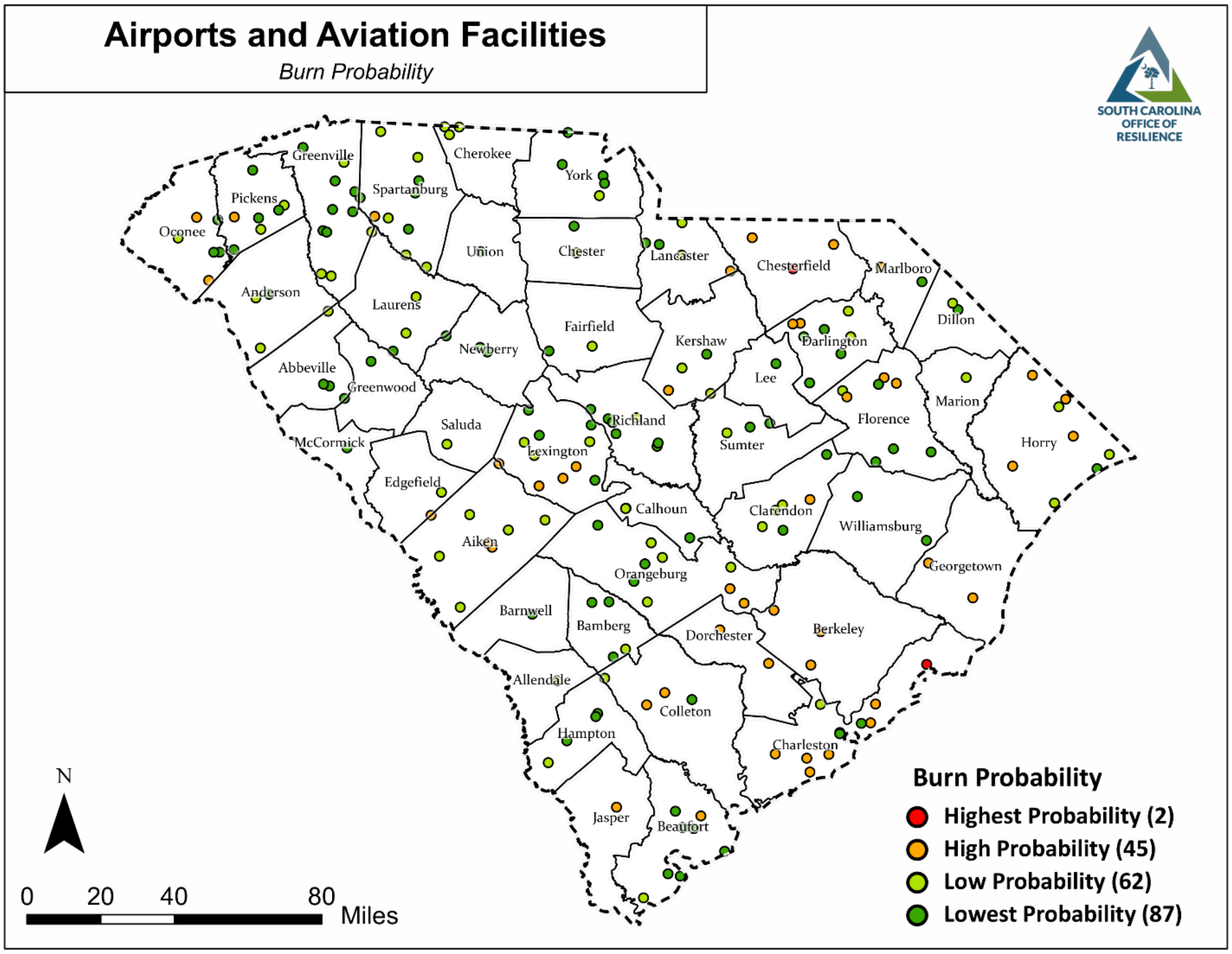


**Figure 6.33: Estimated Burn Probability of airports and aviation facilities (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

## ELECTRIC POWER GENERATION AND DISTRIBUTION

Electric generation and distribution require a complex system of power plants, substations, transmission lines, and other critical infrastructure that comprise the power grid (Kern & Miranda, 2021). This section considers the impacts of hazards through mapping electric generation (power plants) and distribution (substations) facilities.

Power generation includes hydroelectric dams, fossil fuel, nuclear, solar, wind, geothermal, and biomass (Department of Homeland Security). Electric power substation facilities and equipment allow for export onto the wider state grid and for distribution into homes and businesses (Department of Homeland Security). Figure 6.34 shows the burn probability for power plants and Figure 6.35 shows the burn probability for substations.

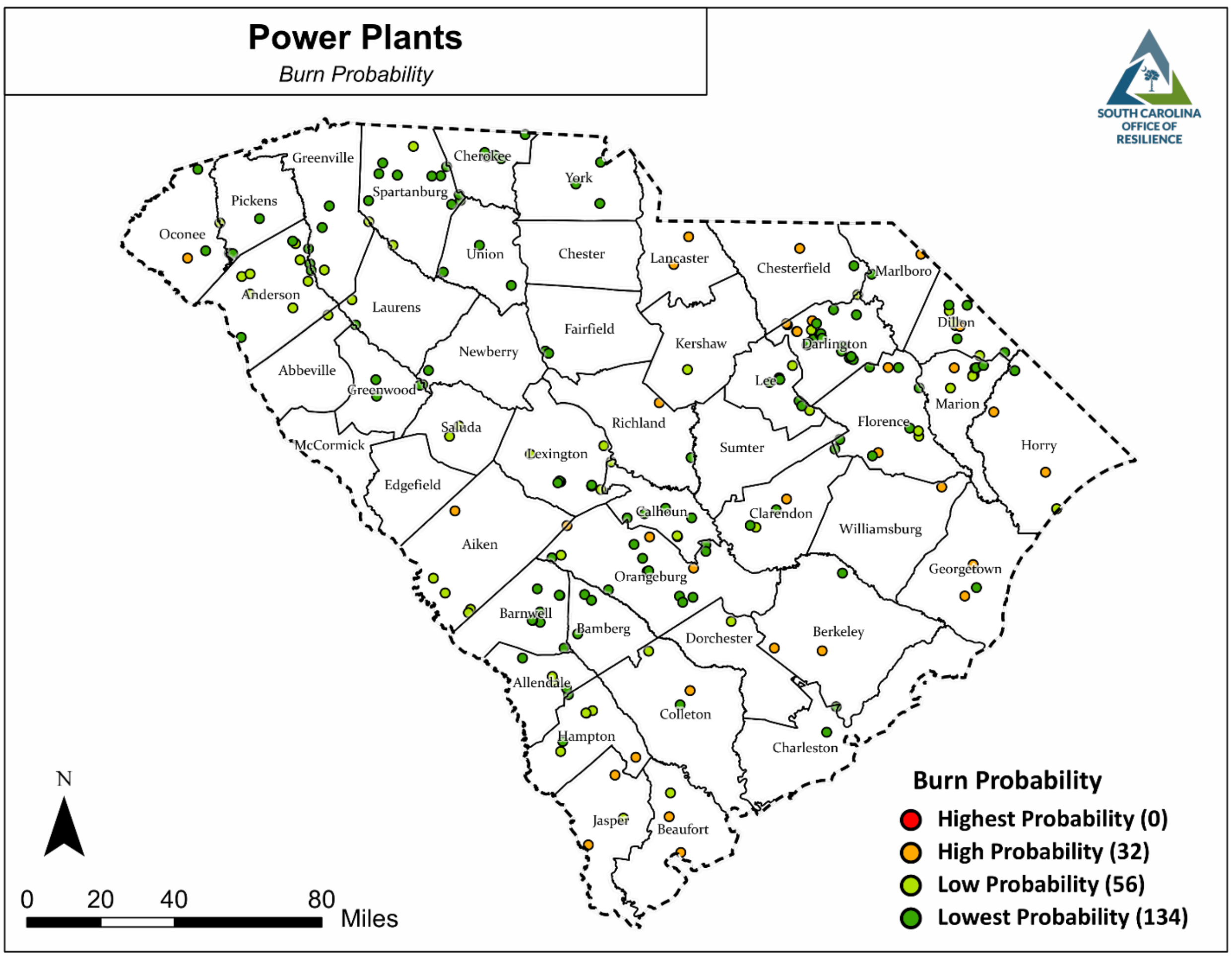


Figure 6.34: Estimated Burn Probability of power plants (Department of Homeland Security). Wildfire data provided by SouthWRAP.

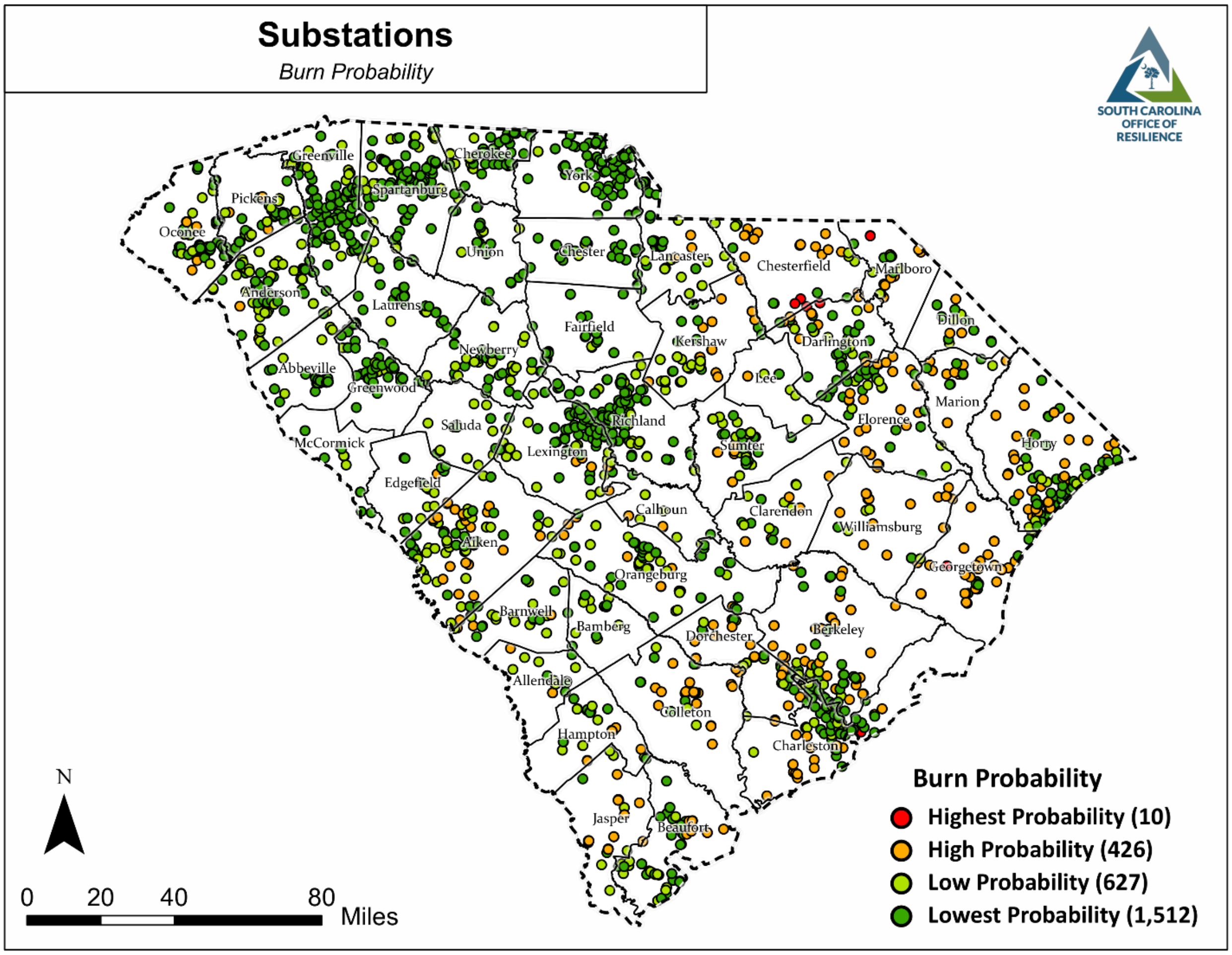


**Figure 6.35: Estimated Burn Probability of power substations (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

## INTERNET AND COMMUNICATIONS

Internet and communications connectivity are an essential part of life for most Americans. The connectivity of the internet is used for education, business, shopping, social interactions, and healthcare. Connectivity allows those that live in rural areas to access to healthcare specialists, work remotely, market their goods and services, and access services that are not available locally. There have been large investments in connecting rural communities with broadband high speed internet. The South Carolina Office of Regulatory Staff, State Broadband Office coordinates and manages the hundreds of millions of dollars that have been made available through the American Rescue Plan Act (ARPA), the Investment in Infrastructure and Jobs Act (IIJA), and several other state and federal funding sources. The following figures show the burn probability for cellular towers (Figure 6.36), land mobile broadcast towers (Figure 6.37), and paging transmission towers (Figure 6.38).

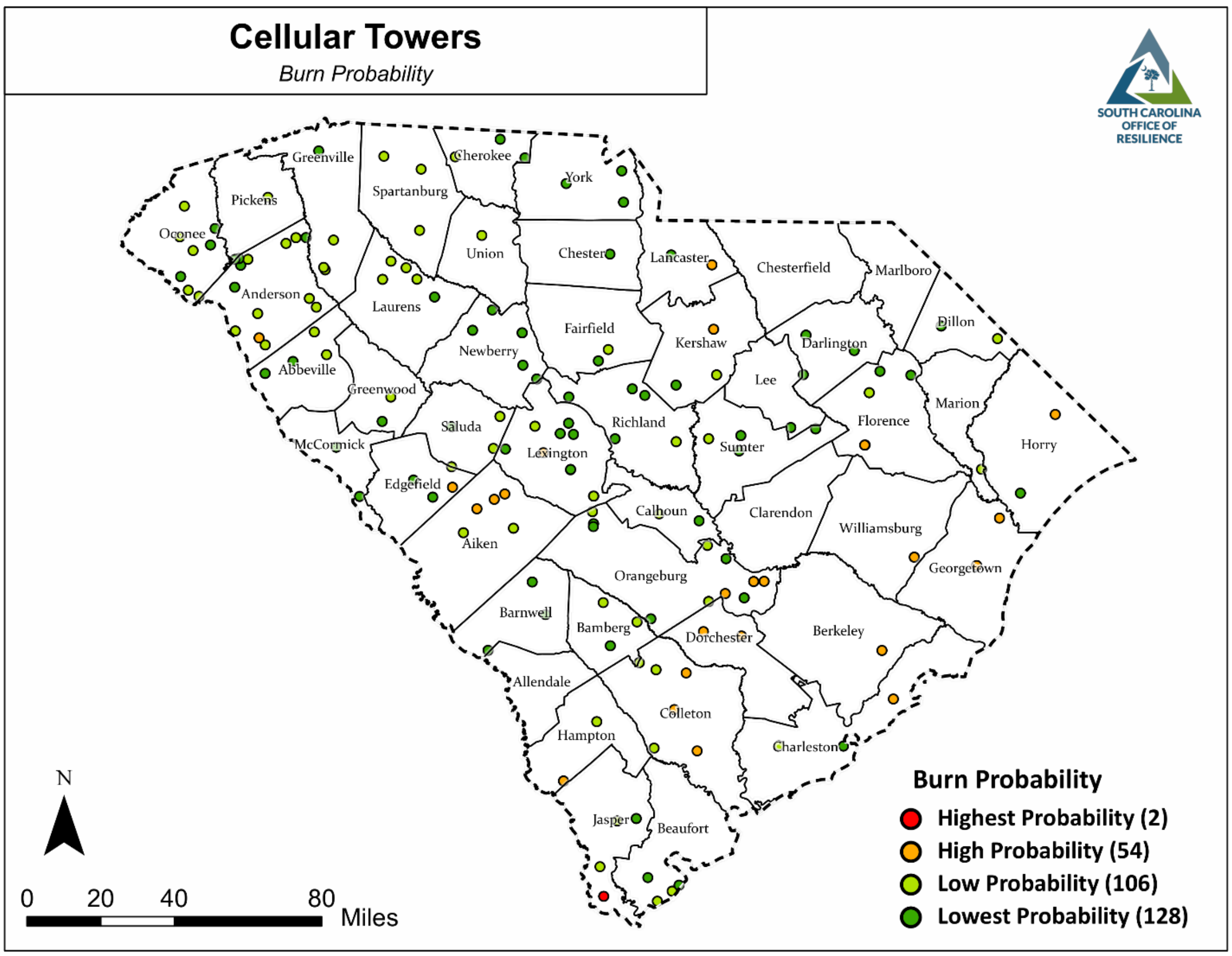


**Figure 6.36: Estimated Burn Probability of cellular towers (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

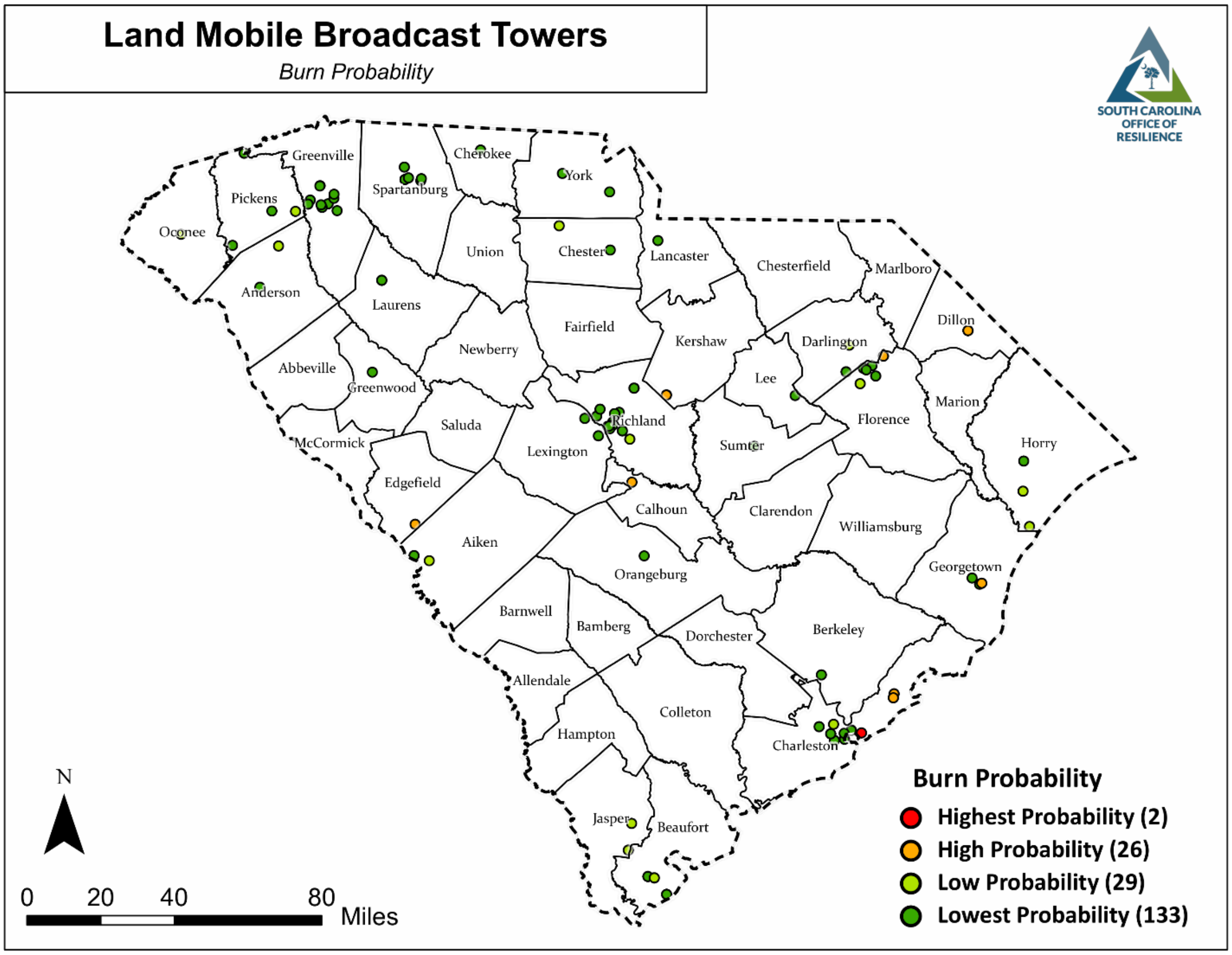


**Figure 6.37: Estimated Burn Probability of land mobile broadcast towers (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

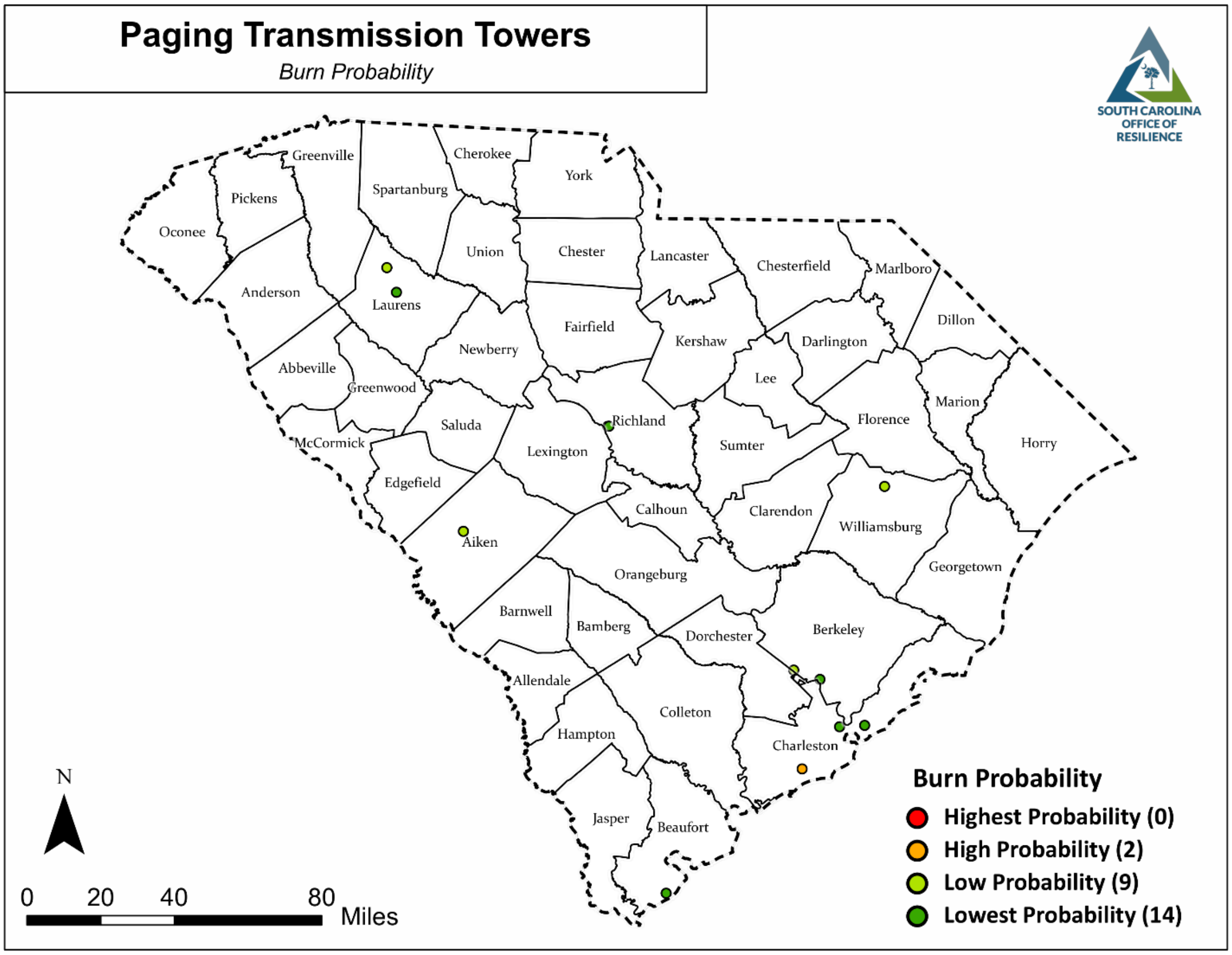


**Figure 6.38: Estimated Burn Probability of paging transmission towers (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

## FOOD SYSTEMS

DHEC's GIS Hub includes a SC Food Desert Map to help partner agencies identify underserved areas to develop strategies to increase access to healthy food. Healthy food can be even harder to obtain before, during, and after hazardous events.

Public refrigerated warehouses support this food system by storing perishable food. These temperature controlled storage facilities can also serve as other types of products such as medication, plants, and flowers. Additionally, there are cultural resources and other fragile items that may need to be kept in a facility with a specific constant temperature. Figure 6.39 shows the burn probability for public refrigerated warehouses.

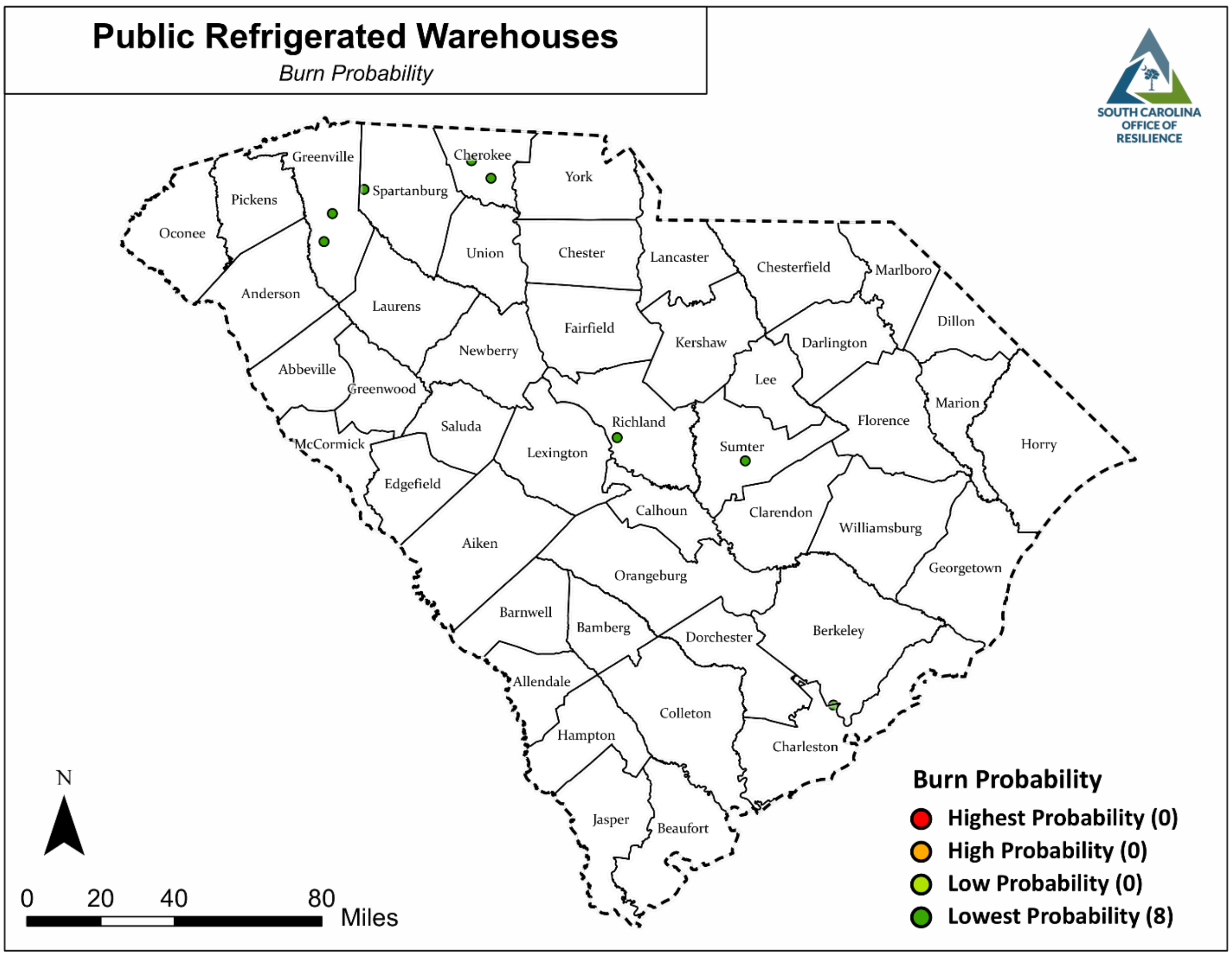


**Figure 6.39: Estimated Burn Probability of public refrigerated warehouses (Department of Homeland Security). Wildfire data provided by SouthWRAP.**

## MANUFACTURING

Manufacturing accounts for 12% of the employment in the State. Businesses in South Carolina manufacture automobiles, appliances, boats, and aircraft (SC Department of Commerce, 2020). Figure 6.40 shows the burn probability for manufacturing facilities.

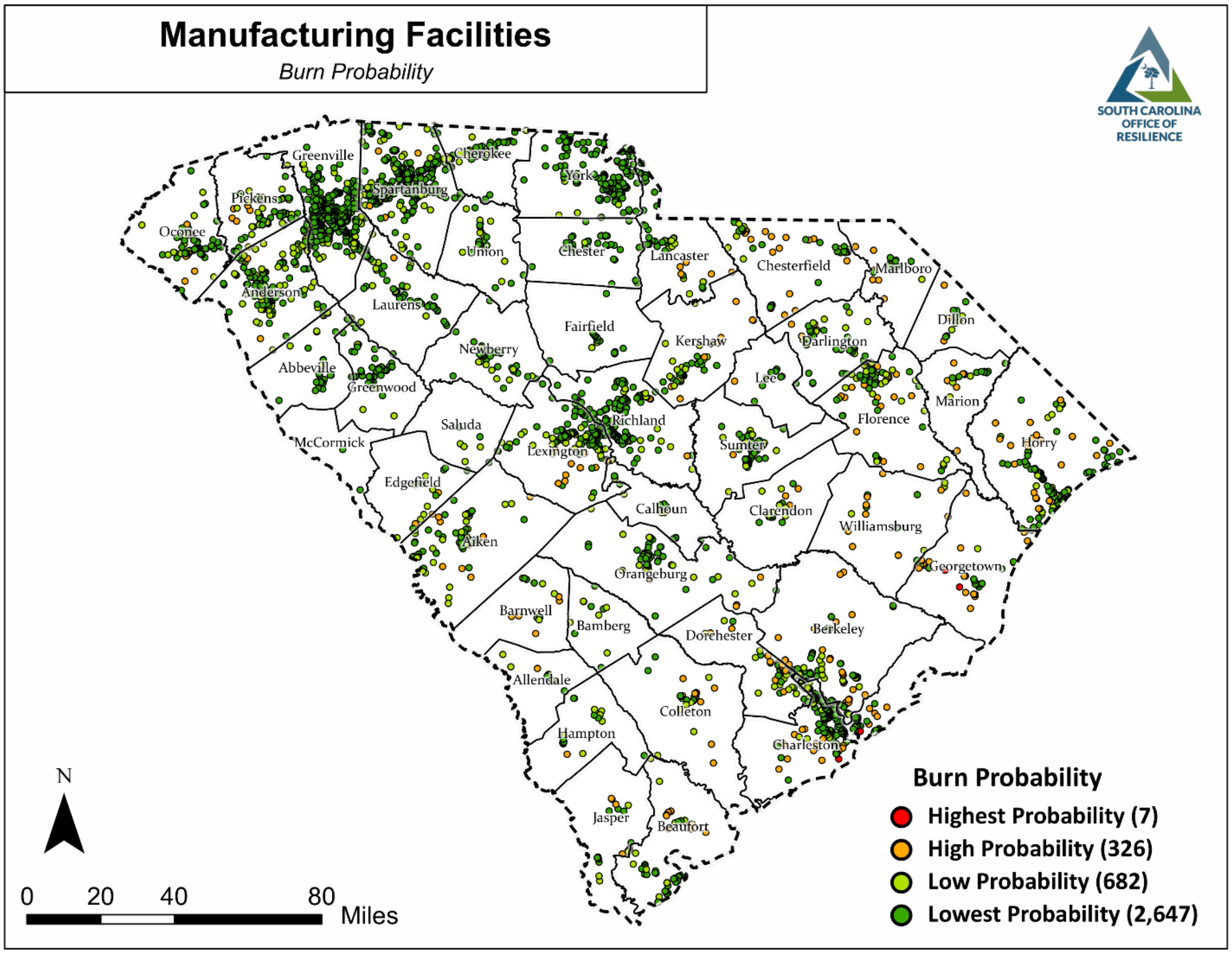


Figure 6.40: Estimated Burn Probability of manufacturing facilities (SC Department of Commerce). Wildfire data provided by SouthWRAP.

## INDUSTRIAL SITES AND BUILDINGS

According to the South Carolina Department of Commerce, there are over 230 industrial buildings across the state. Additionally, there are designated industrial sites, that can help determine where industrial buildings are likely to be constructed. Figure 6.41 shows the burn probability for industrial buildings. Figure 6.42 shows the burn probability for industrial sites.

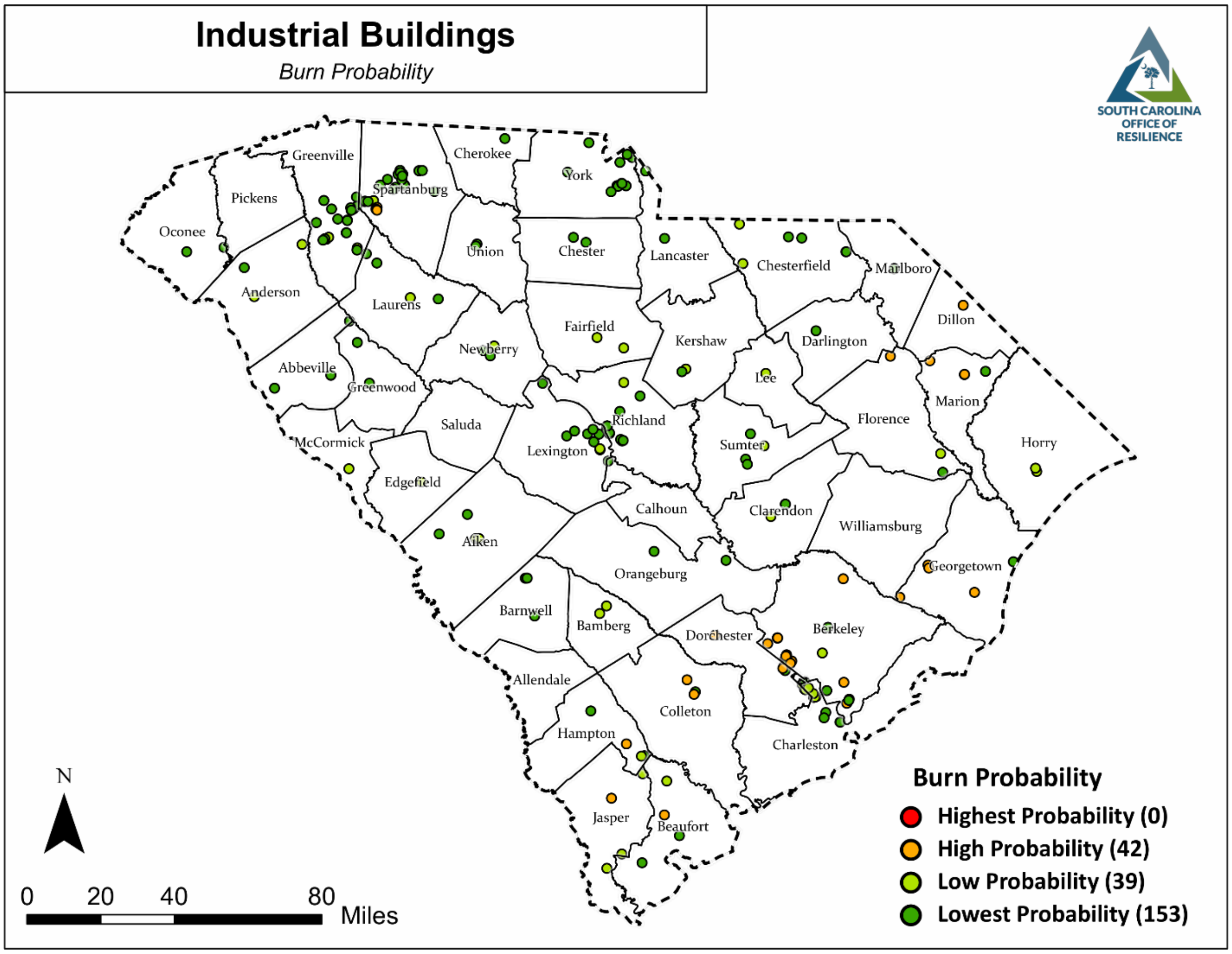


Figure 6.41: Estimated Burn Probability of industrial buildings (SC Department of Commerce). Wildfire data provided by SouthWRAP.

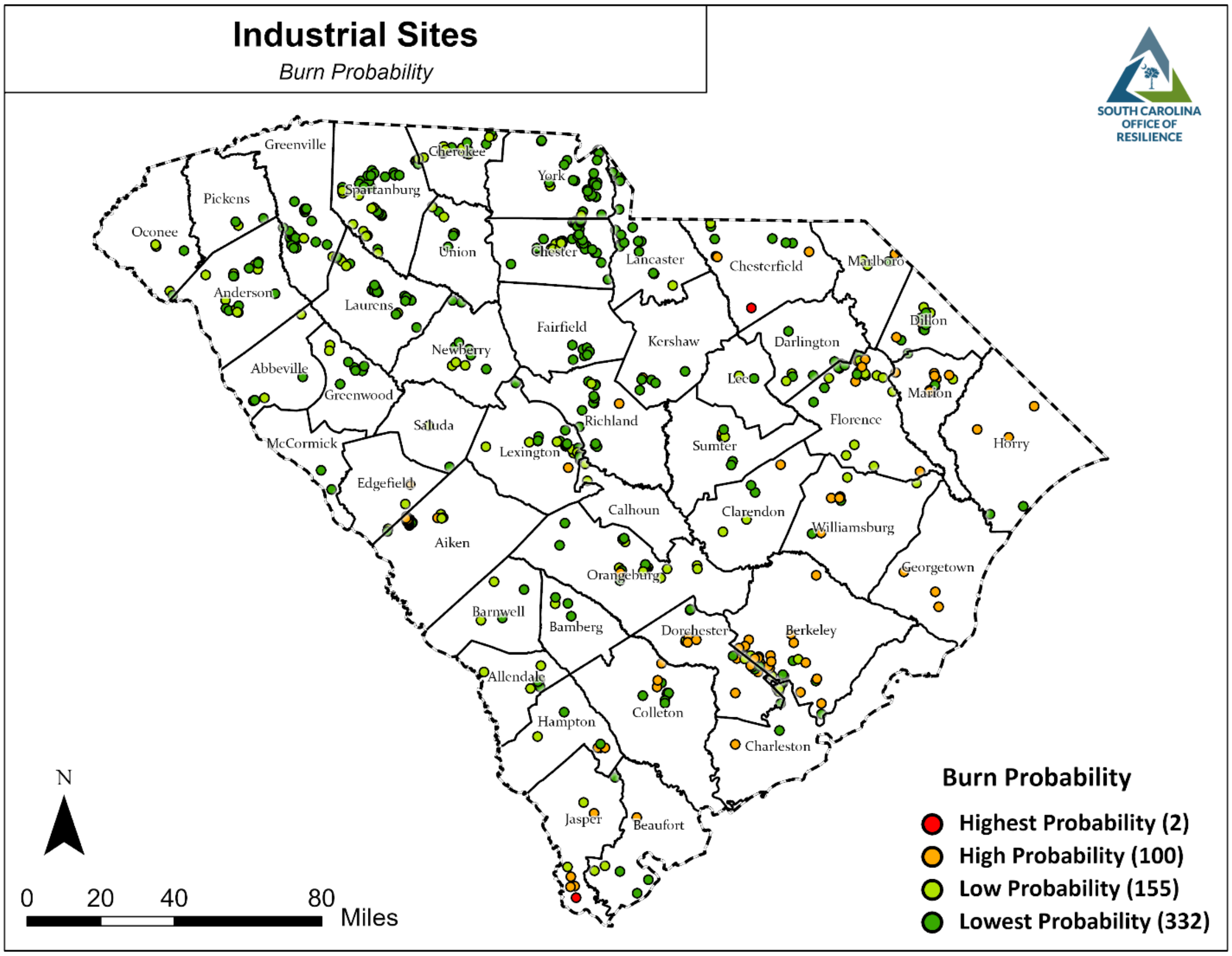


**Figure 6.42: Estimated Burn Probability of industrial sites (SC Department of Commerce). Wildfire data provided by SouthWRAP.**

## OTHER WILDFIRE METRICS

Forest, timberlands, and agriculture lands cover roughly 13.6 million acres of South Carolina and wildfires are common occurrences. On average, approximately 1,400 wildfires burn nearly 11,000 acres in South Carolina each year (SC Forestry Commission (SCFC), 2021). Large tracts of forest and increasing population imply the potential increase in wildfire exposure and impacts on communities in South Carolina. There are two additional tools SCOR used to identify the potential risk of wildfires in South Carolina: the SouthWRAP WUI Risk Index and the FEMA National Risk Index.

### WILDLAND URBAN INTERFACE (WUI)

The Wildland Urban Interface (WUI) Risk Index layer is a rating of the potential impact of a wildfire on people and their homes. The key input, WUI, reflects housing density (houses per acre) consistent with Federal Register National standards. The location of people living in the Wildland Urban Interface and rural areas is key information for defining potential wildfire impacts on people and homes.

Urban wildfires nationwide have been on the rise, primarily due to the pattern of human development near wildlands. The Wildland Urban Interface (WUI) is the measure of interspersion between residential areas and areas with natural wildfire fuels. This intermingling of human structures and wildlands identifies areas where wildfire carries increased potential to have a direct impact on communities. It is important to note that the WUI does not assess the severity of wildfire impacts, just the exposure to potential impacts. A high WUI score indicates an area where human structures and natural fuels exist closely together. A low WUI score indicates that the area either has just a few structures near natural fuels (rural areas), or that there is little natural fuel near community structures (urban cores).

To better target where communities are the most vulnerable to severe wildfire impacts, the WUI has been augmented with fire severity models in the Wildland Urban Interface Risk Index (WUI Risk Index) as seen in Figure 6.43. Areas identified as having a high WUI Risk Index indicate both a high WUI score and more intense wildfire and are expected to have the most severe impacts if a wildfire does occur. The WUI Risk Index is derived using a Response Function modeling approach. Response functions assign a net change in the value to a resource or asset based on susceptibility to fire at different intensity levels, such as flame length (Southern Group of State Foresters, 2023). The WUI Risk Index range of values is from 1 (least impact) to 9 (greatest impact).

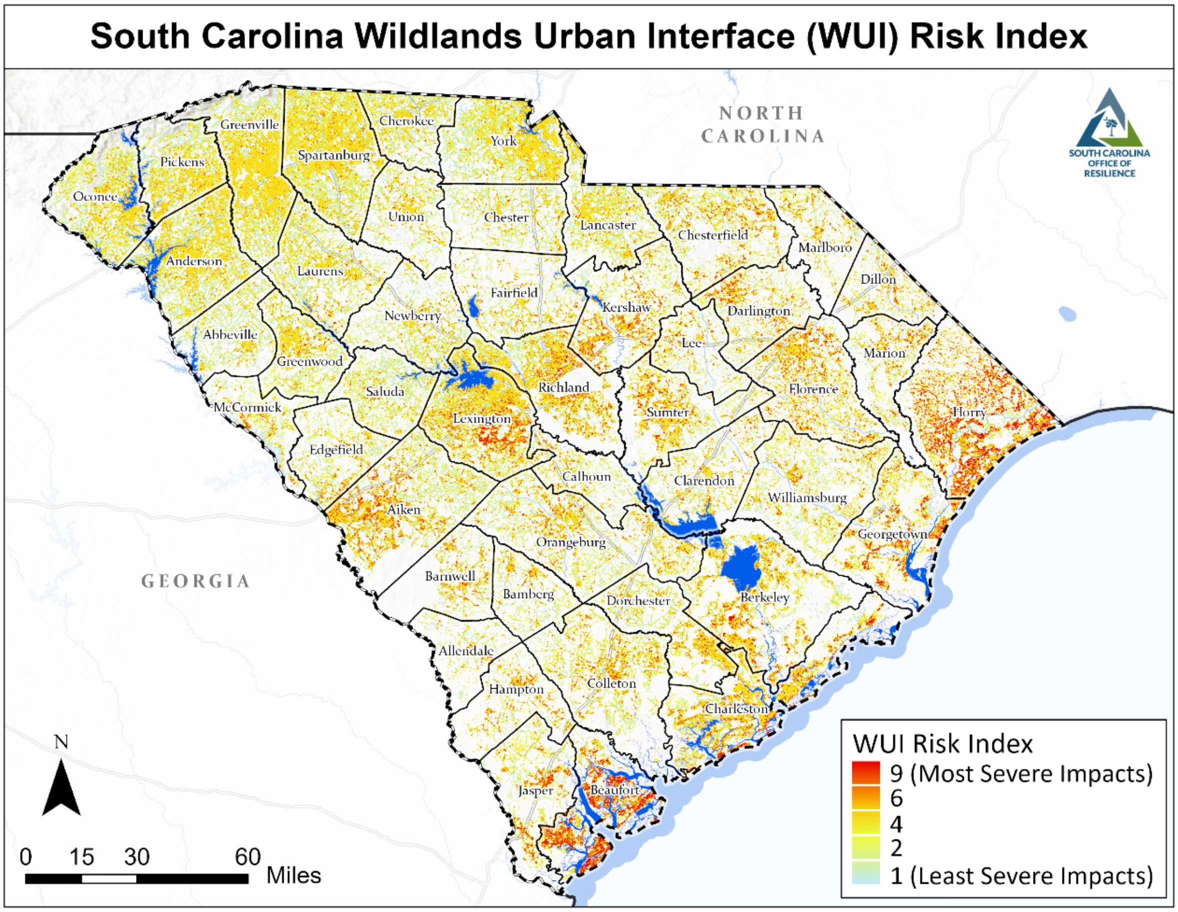


Figure 6.43: SC Wildlands Urban Interface Risk Index

## NATIONAL RISK INDEX

In the National Risk Index, a Wildfire Risk Index Rating, shown in Figure 6.44, represents a community’s relative risk compared to the rest of the United States. The majority of the state is low to moderate risk according to FEMA which corresponds well with the SouthWRAP Burn Probability (Figure 6.1) and WUI Risk Index (Figure 6.43).

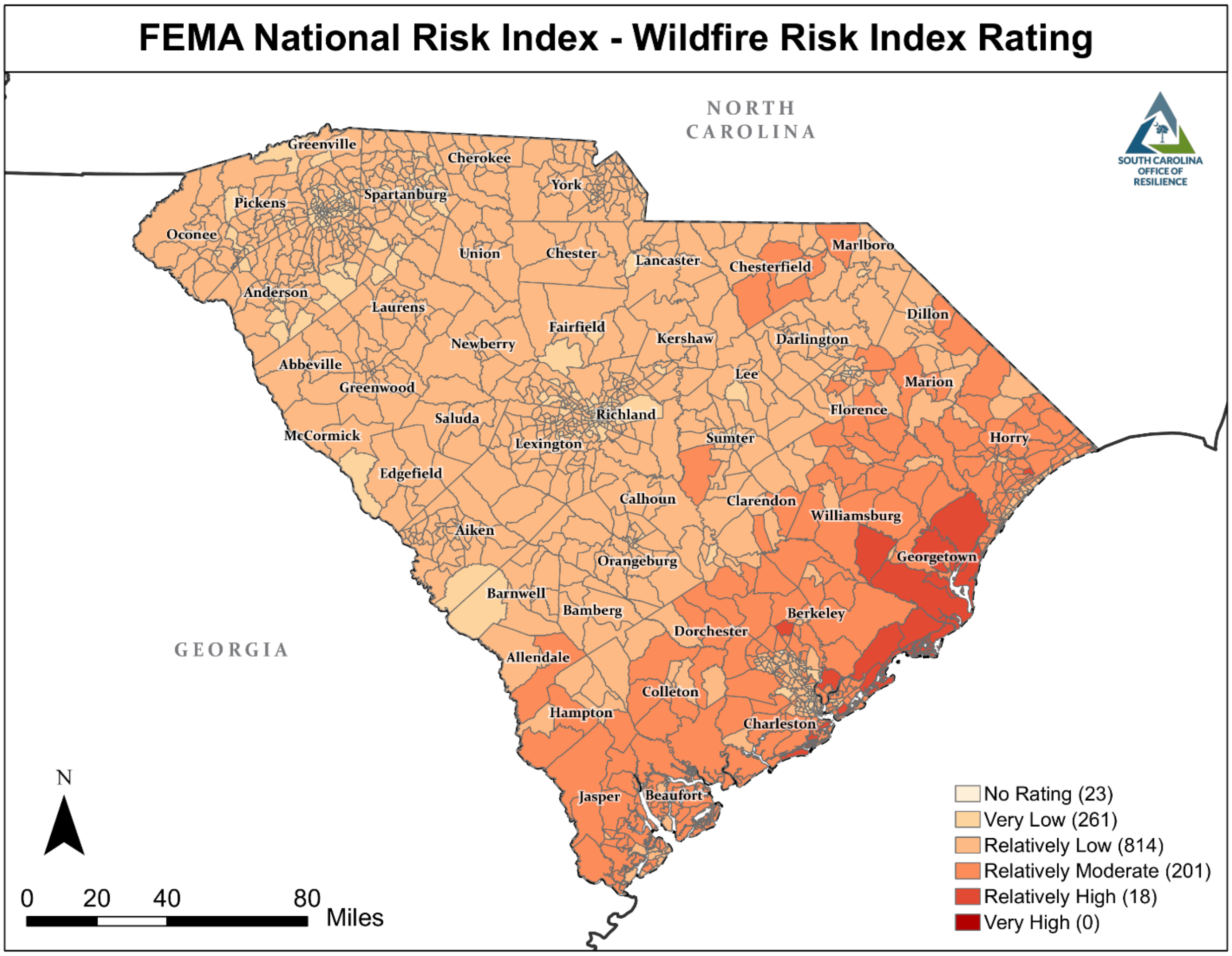


Figure 6.44: FEMA Hazard Risk Index Rating for wildfires in South Carolina by Census Tract.

# DROUGHT

## DROUGHT INDICATORS

Drought results from less than normal precipitation over an extended period, often resulting in a water shortage for some activity, sector, or the environment. In contrast to other environmental hazards, droughts typically develop slowly over weeks, months, or years. Three main categories physically define drought: meteorological, agricultural, and hydrological. These categories help determine the economic, ecological, and societal impacts of droughts in communities. Drought impacts most of the industries in the State, but agriculture, forest, and water supply are very susceptible to drought.

The South Carolina Drought Response Committee (DRC) is the major drought monitoring and decision making entity for the state. It is comprised of five state agencies and 48 local members and is chaired and supported by the SC Department of Natural Resources and the SC State Climatology Office. The 48 local members are comprised of different stakeholder groups to ensure robust sectoral input for drought monitoring and response.

While the DRC is a statewide entity, the state has four drought management areas (DMAs) that generally follow the four major river basins, but are fitted to the counties, as drought status in South Carolina is declared at the county level. This approach allows for smaller scale (county) drought conditions while also considering the geographical relationship of water supplies from the top to the bottom of the water basin. Figure 6.45 below shows the four DMAs. Each of the DMAs has 12 local representatives, providing equal local-level and sectoral representation for all the DMAs.

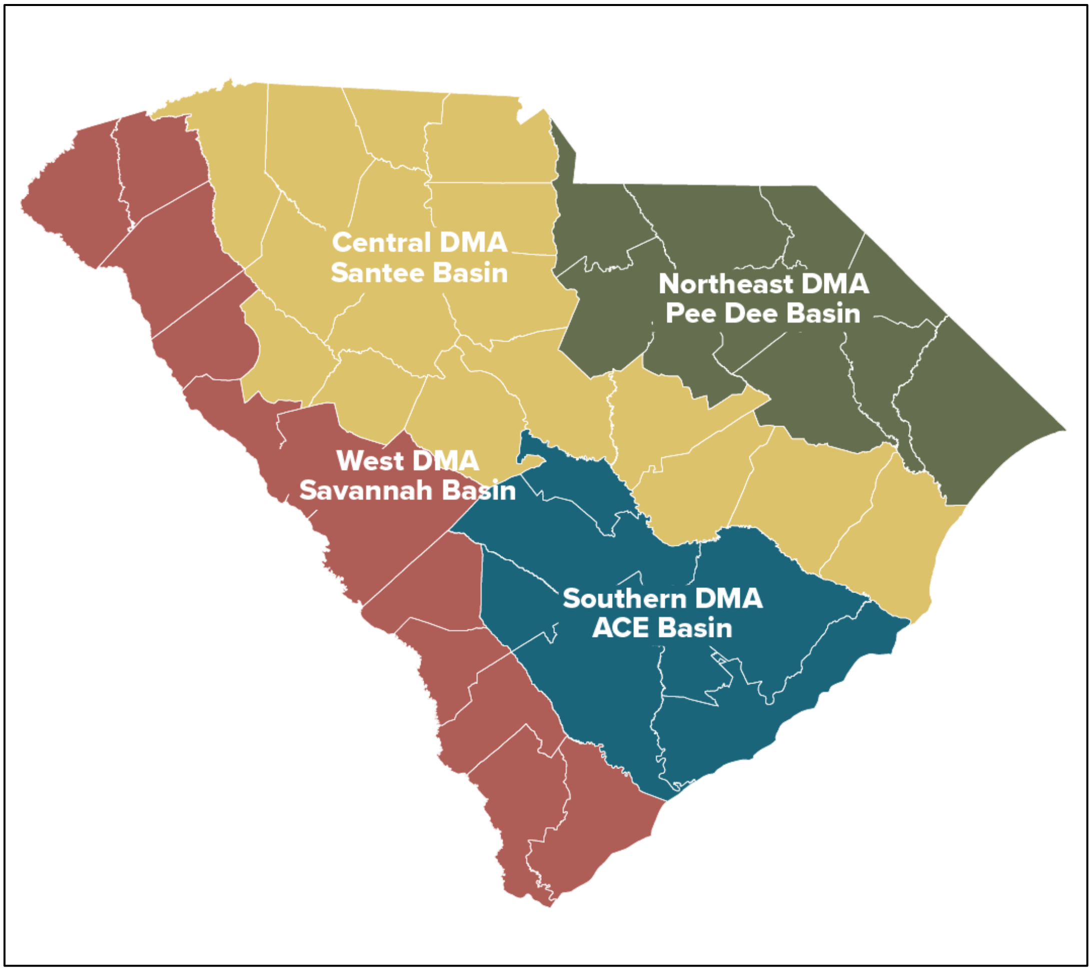


Figure 6.45: South Carolina Drought Management Areas (DMAs) (SC State Climatology Office)

The Drought Regulations of the South Carolina Drought Response Act outlines the process and procedures for the DRC. The DRC continually monitors conditions and convenes a meeting when conditions warrant a discussion for potential response.https://cisa.sc.edu/PDFs/2017 SC Drought Tabletop Exercise/SC Drought Regulations.pdfhttps://cisa.sc.edu/PDFs/2017 SC Drought Tabletop Exercise/SC Drought Response Act.pdf The DRC uses seven different drought indicators to monitor conditions. Five of these are indices (Palmer Drought Severity Index (PDSI), Crop Moisture Index (CMI), Keetch-Byram Drought Index (KBDI), Standardized Precipitation Index (SPI), the US Drought Monitor (USDM) and two are hydrologic values for groundwater and surface water. The use of multiple indicators allows for a comprehensive approach for monitoring drought conditions across multiple sectors, as no one indicator or indicator type can accurately depict drought severity for all sectors.

When the DRC meets, it votes on the status of each county. The status depends on the indicators, along with state-agency and local-level reports. Based on the indicators and reports, each county can be classified in either “normal,” “incipient,” “moderate,” “severe,” or “extreme” conditions. Generally, a county can only change by one category per DRC meeting. When a county is classified in “moderate” conditions or worse, the DRC will decide what non-essential water curtailment needs to be made at the local level to help conserve water. All local public water suppliers in the state must have a local drought management plan and ordinance to respond to and manage drought periods. The Governor may call for further water conservation than the DRC’s recommendations or call for mandatory water conservation. If drought conditions become so extreme, beyond the scope of the DRC, the State’s Emergency Operations Plan (Appendix 10) goes into effect for drought response. Fortunately, there has not been a drought so extreme in South Carolina that Appendix 10 of the State’s EOP plan has been enacted.

As discussed in Chapter 4 of this document, future droughts have mixed projections. While increased temperatures have the ability to accelerate the hydrologic cycle, leading to increases to both precipitation and evapotranspiration, it is difficult to determine how this will lead to changes in water availability. Although South Carolina is expected to see more rain overall, precipitation may come in the form of more intense events, leading to less “water recharge” events for soils. In conjunction, increased temperatures have the ability to increase evapotranspiration. These changes may allow for increased drought impacts to agriculture and ecology. However, a change in rain fall delivery, increased temperatures and evapotranspiration, and population growth all have the ability to affect the current balance between water supply and water demand for municipalities, providing a potential for more drought impacts to public water suppiers  (Carter, et al., 2018).

## NATIONAL RISK INDEX

The National Risk Index’s Drought Risk Index Rating, shown in Figure 6.46, represents a community’s relative risk when compared to the rest of the United States. The Risk Index highlights areas that have large agriculture concentrations as the risk to the damage to buildings is low in the case of a drought.

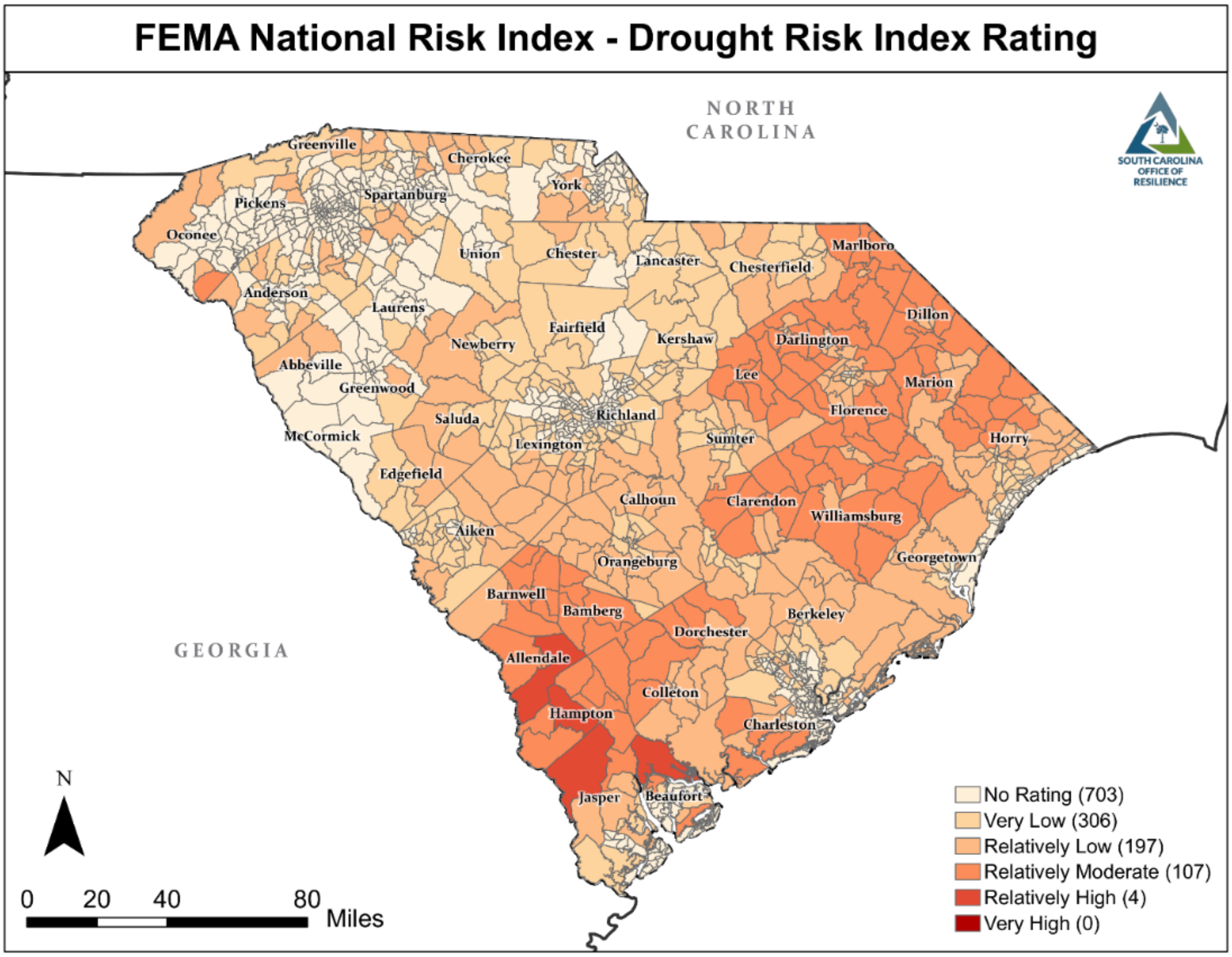


**Figure 6.46: FEMA Hazard Risk Index Rating for droughts in South Carolina by Census Tract.**

## HEAT

Excessive heat events occur whenever the heat index values meet or exceed established excessive heat warning thresholds established by local or regional managers. Extreme heat is influenced by humidity, where the muggy conditions can exacerbate the temperature and make it feel hotter than it is (Centers for Disease Control and Prevention, 2019). Recent evidence suggests that humans have a physical heat tolerance limit at a wet bulb temperature of 95 °F. Above this threshold of heat and humidity, the human body can no longer cool through perspiration (Sarofim, et al., 2016), although adverse health effects and declined ability to perform tasks can be experienced at much lower temperatures (Heal & Park, 2016). Higher heat index values add stress to individuals with preexisting health issues like the elderly, obese, those with mental illness, those with heart disease, and other chronic diseases (Centers for Disease Control and Prevention, 2019).

### STATEWIDE HEAT RISK ASSESSMENT

Heat has been one of the most dangerous weather-related hazards in recent decades (National Weather Service, 2022). Historic analysis indicates maximum summer temperature increases across the state, as documented in Chapter 4. Urban areas within the State have experienced significant increasing trends, exceeding the national average for heatwave timing, frequency, and intensity (Habeeb, Vargo, & Stone, 2015). These trends are likely to accelerate, as are increasing overnight low temperatures, compounding the impacts of urban heat islands. Chapter 4 of this report identifies that by the end of the century the average number of days above 95 °F will increase by up to 50 days per year (Figure 6.47).

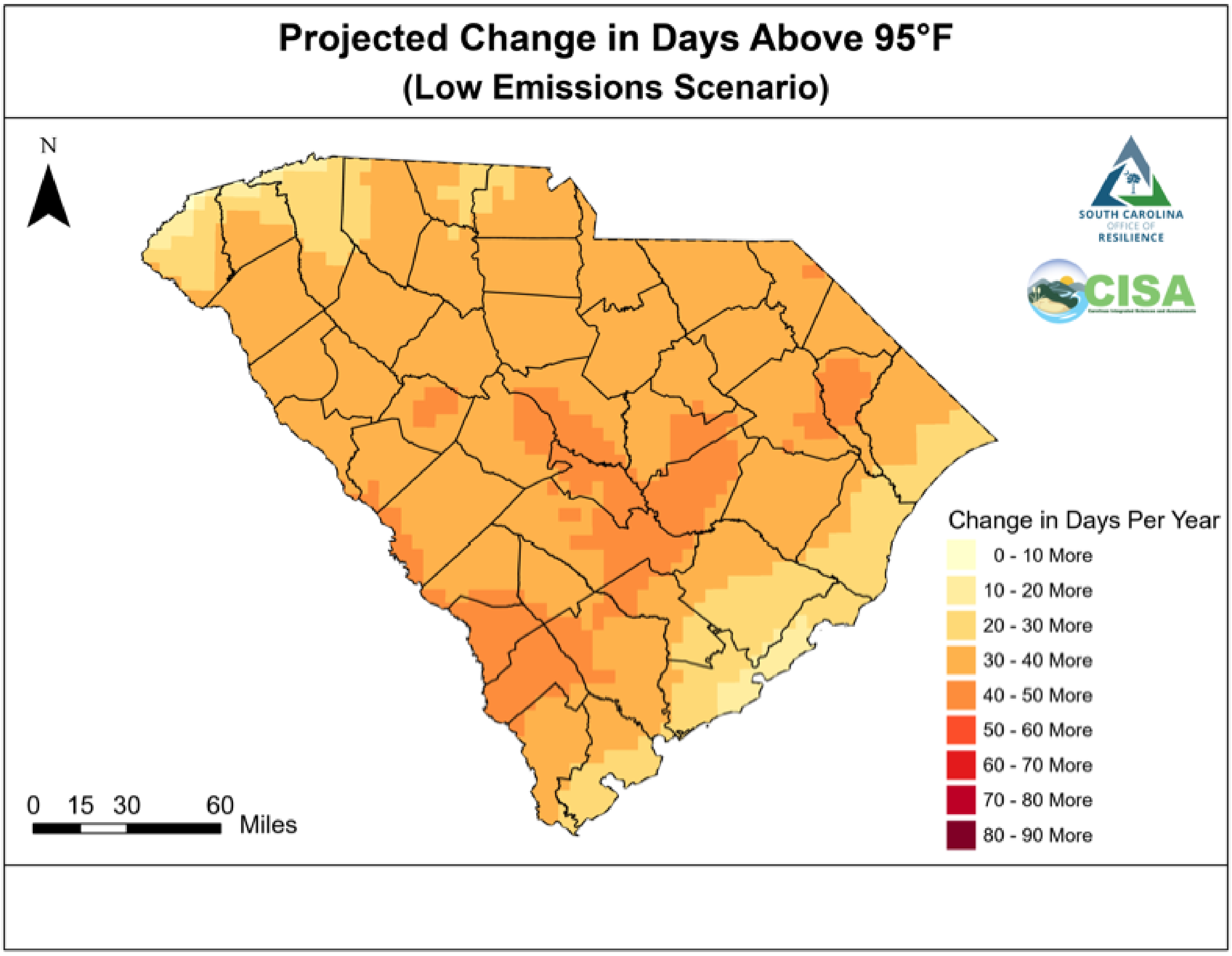


**Figure 6.47: Projected increase in the average number of days per year with maximum temperature above 95F by 2100 (RCP 4.5 emissions scenario)**

Infants, children, and older populations (<65 years and especially <85 years), pregnant women, people working outside and those wearing additional personal protective equipment, as well as those with or recovering from COVID-19, or with other preexisting conditions are at greater risk (Global Heat Health Information Network, 2022). Football players are another specific risk population. They have been found to be 11 times more likely than other athletes to experience a heat-related illness are particularly at risk due to their summer practice season, protective equipment, and tendency to have higher body mass index values compared with other athletes (Kerr, Casa, Marshall, & Comstock, 2013).

A wide range of health conditions are exacerbated by high ambient heat conditions as well as heatwaves. These illnesses include cardiovascular, respiratory, and renal illnesses; diabetes; hyperthermia; mental health issues; and pregnancy (Ye, et al., 2012). South Carolina has among the higher percentages nationally of adult population with these heat sensitive illnesses (Table 6.3). South Carolina was 5$^{th}$ among a geographically diverse group of 20 US states studied for heat stress illness hospitalizations (2001-2010) with Colleton, Darlington, Florence, and Marion Counties reporting the highest rates in the state (Choudhary & Vaidyanathan, 2014). Research in North Carolina highlighted the increased odds of pregestational births associated with days of high temperatures but less than heatwave conditions (Ward, et al., 2019).

**Table 6.2: Rates of Climate Sensitive illnesses negatively Affected by high ambient heat levels in South Carolina 2021 (Source: America's Health Rankings)**

| | National Ranking (1 best- 50 lowest) | Percentage of adults |
|---|---|---|
| **Access to Care – Annual** | 44 | NA |
| **Asthma** | 22 | 9.4 |
| **Cardiovascular Diseases** | 45 | 11.1 |
| **Chronic Kidney Diseases** | 43 | 3.7 |
| **Chronic Obstructive Pulmonary Disease** | 38 | 8.1 |
| **Diabetes** | 45 | 13.6 |
| **Obesity** | 40 | 36.2 |

Future temperature increases and more frequent and intense heat waves will likely cause the Southeast to experience a disproportionate health burden (Smith, Zaitchik, & Gohlke, 2013; Vose, Easterling, Kunkel, LeGrande, & Wehner, 2017). A few studies provide an indication of the anticipated increased heat stress using some assumptions, often historically based temperature- mortality relationships, to reduce the uncertainty. The difficulty in projecting heat health impacts reflects the complexity of the social, behavioral, and physiological processes shaping exposures, preexisting conditions, and access to health care, in addition to the challenge of projecting climate extremes.

Schwartz et al. (2015) used two different climate models (GFDL- CM3 and MIROC5) and historical temperature-mortality relationships in projecting premature heat-related deaths for 209 US cities including 5 in South Carolina. The range of rising mortality rates shown in Table 6.4 does not include any assumptions about adaptive actions that could reduce impacts (Schwartz, et al., 2015).

Modelling of extreme-temperature related mortality in Charlotte, North Carolina calculated an increase of 2.74 and 6.34 deaths/100,000 under 3.6°F (2.0°C) and 7.2°F (4.0°C) scenarios, respectively (Environmental Protection Agancy (EPA) , 2021). Another research team considered the risk of kidney stone disease and kidney stone presentations in South Carolina beginning with past relationships to temperature and projecting how that relationship would change under two climate scenarios, one warmer (RCP 4.5) and one much warmer (RCP 8.5) (Kaufman, et al., 2022). Based on this analysis, by 2085–2089 (vs. 2010–2014), the estimated total statewide kidney stone presentations attributable to heat are projected to increase by 2.2% under RCP 4.5 and 3.9% under RCP 8.5 with related total excess costs of approximately $57 million and approximately $99 million, respectively (Kaufman, et al., 2022).

**Table 6.3: Projected excess heat deaths in South Carolina cities**

| Projected excess heat deaths (mean ± 1 Standard Deviation) GFDL- CM3 model<br>Heat Deaths (April to September) | | | | | |
|---|---|---|---|---|---|
| | **Population** | **1990** | **2030** | **2050** | **2100** |
| Charleston | 345,379 | 14.95 ± 4.96 | 31.45 ± 7.98 | 36.59 ± 6.94 | 53.84 ± 6.02 |
| Columbia | 639,401 | 21.22 ± 12.26 | 53.8 ± 16.35 | 63.42 ± 14.4 | 98.95 ± 14.38 |
| Greenville | 439,607 | 10.68 ± 17.9 | 37.53 ± 12.7 | 45.33 ± 12.18 | 75.85 ± 14.75 |
| Myrtle Beach | 254,638 | 10.59 ± 5.43 | 26.32 ± 6.94 | 31.19 ± 6.33 | 48.59 ± 6.31 |
| Spartanburg | 290,717 | 1.47 ± 8.4 | 19.53 ± 9.13 | 25.15 ± 9.05 | 48.36 ± 11.47 |
| **Projected excess heat deaths (mean ± 1 Standard Deviation) MIROC5 model<br>Heat Deaths (April to September)** | | | | | |
| | **Population** | **1990** | **2030** | **2050** | **2100** |
| Charleston | 345,379 | 14.95 ± 4.96 | 23.65 ± 4.81 | 27.82 ± 5.55 | 45.1 ± 4.59 |
| Columbia | 639,401 | 21.22 ± 12.26 | 39.69 ± 10.16 | 48.28 ± 10.96 | 80.3 ± 9.21 |
| Greenville | 439,607 | 10.68 ± 17.9 | 24 ± 7.82 | 29.48 ± 7.8 | 51.13 ± 7.4 |
| Myrtle Beach | 254,638 | 10.59 ± 5.43 | 16.85 ± 4.39 | 20.23 ± 4.83 | 36.23 ± 4.86 |
| Spartanburg | 290,717 | 1.47 ± 8.4 | 9.88 ± 5.35 | 13.63 ± 5.63 | 29.31 ± 5.53 |

## HEAT WAVE

Heat waves are defined as two or more days of unusually hot weather (outside of the historical averages) (National Oceanic and Atmospheric Administration (NOAA) , 2023).

In the National Risk Index, a Heat Wave Risk Index Rating, shown in Figure 6.48, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States. For the index, FEMA defines a heat wave as a period of abnormally and uncomfortably hot and unusually humid weather typically lasting two or more days with temperatures outside the historical averages for a given area. According to FEMA, “no rating” indicates that the Risk Index score cannot be calculated for that community.

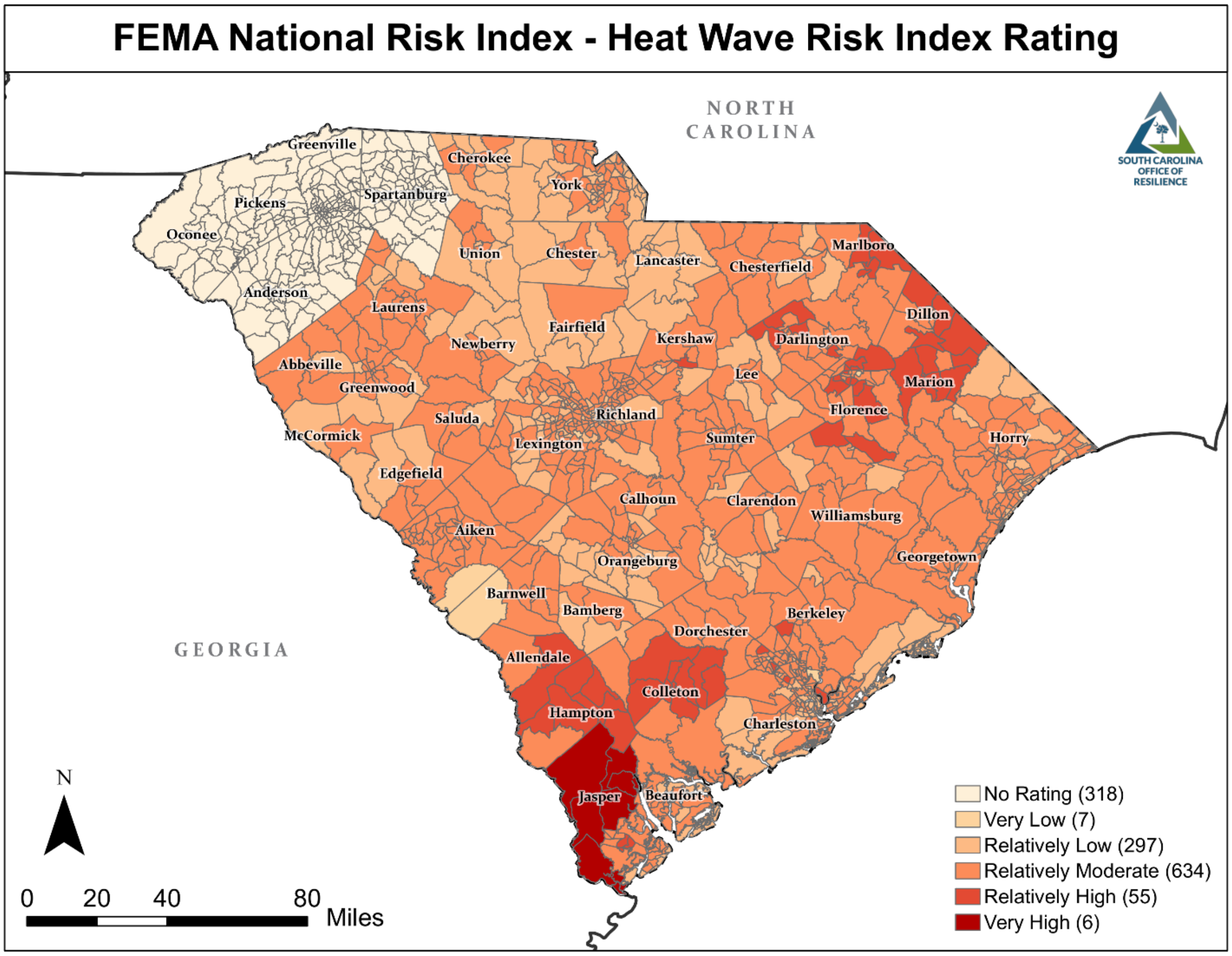


Figure 6.48: FEMA Hazard Risk Index Rating for heat waves in South Carolina by Census Tract.

## URBAN HEAT ISLANDS

The City of Charleston (Figure 6.49), Richland County, and the City of Columbia (Figure 6.50) have participated in a national urban heat island mapping initiative funded through a NOAA and National Integrated Heat Health Information System (NIHHIS) grant program called HeatWatch. A heat island is an area that is hotter than the area around it. This is often associated with urban areas where infrastructure and buildings absorb more heat than forests, grasses, and bodies of water. HeatWatch is a national effort to record the heat index throughout participating cities on a single day, to see how the heat index varies from one area of a city to the next. This program results in detailed maps of heat islands using sensors that record temperature and humidity (City of Charleston, SC, n.d.). This mapping is vital to understand heat vulnerability and provides data to direct actions to reduce those vulnerabilities (City of Columbia, SC, n.d.). Below are maps from these initiatives.

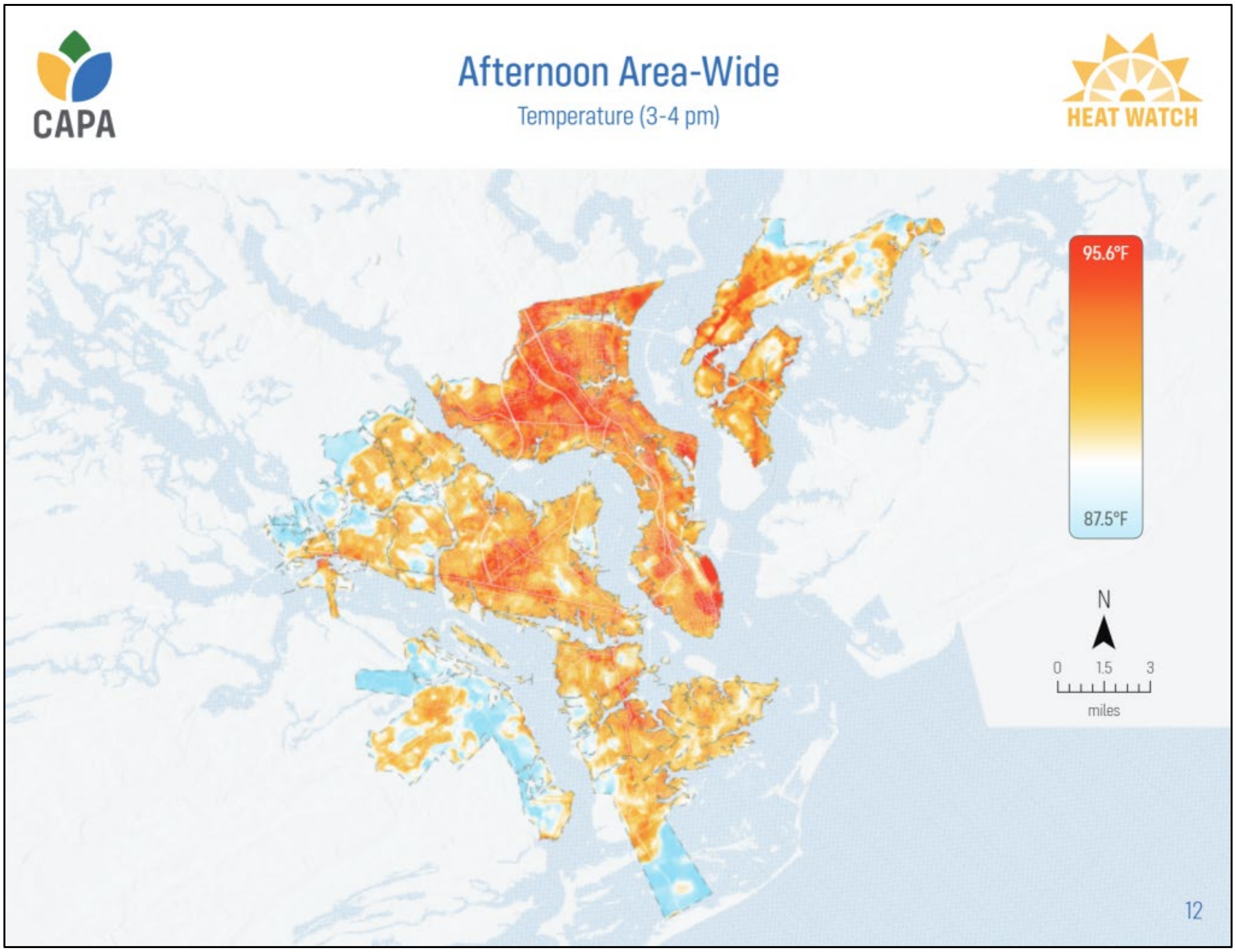


**Figure 6.49: Charleston HeatWatch Afternoon Area-Wide Temperature (CAPA Strategies, 2021)**

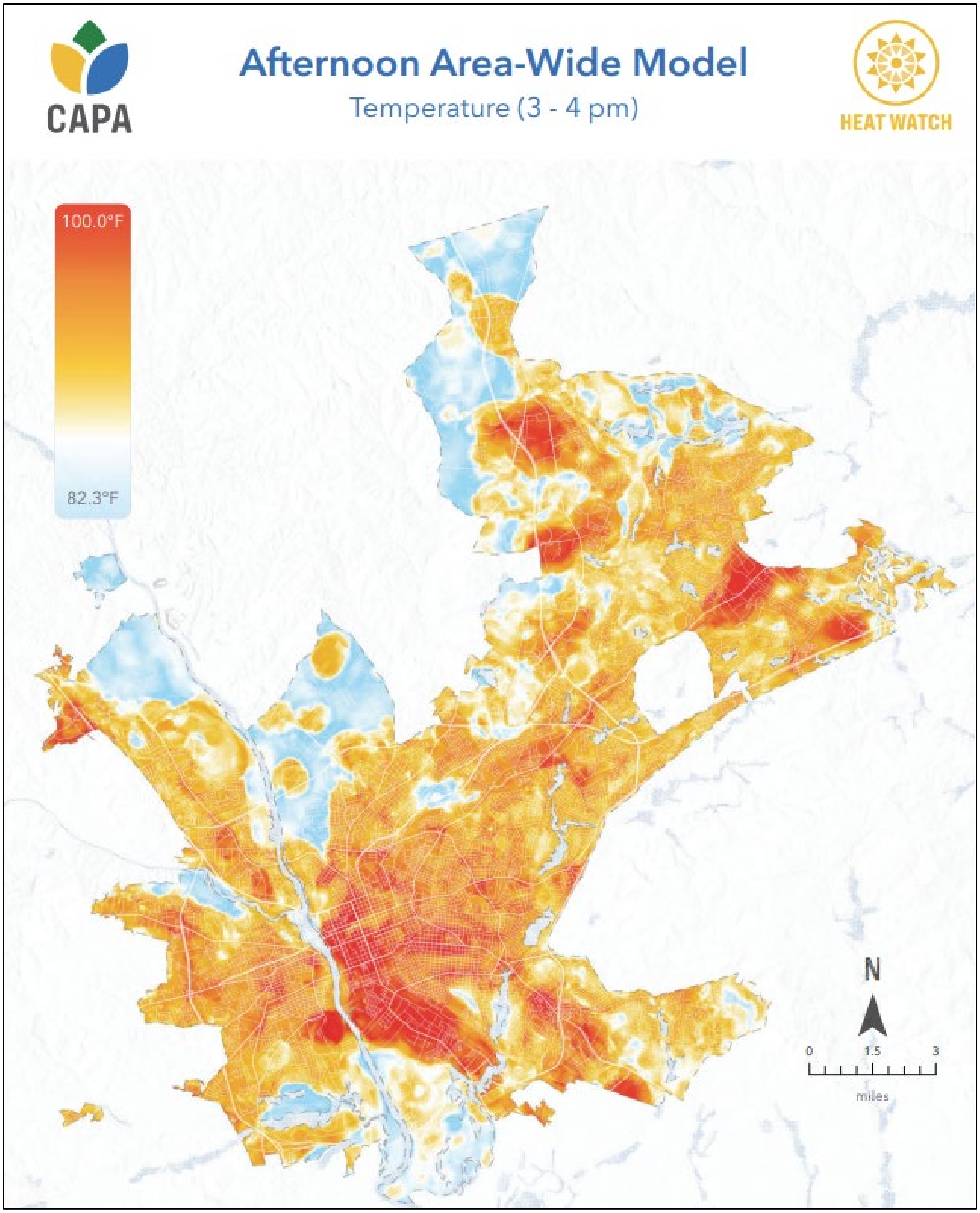


**Figure 6.50: Columbia HeatWatch Afternoon Area-Wide Model Temperature (CAPA Strategies, 2022)**

## SEVERE THUNDERSTORMS

Thunderstorms occur frequently in South Carolina, with the state experiencing on average 45 to 72 thunderstorm days per year (National Oceanic and Atmospheric Administration, 2023). When severe, thunderstorms have the potential to produce damage-causing hail, lightning, high winds, and tornadoes.

Since 2001, there have been 1,661 severe thunderstorm events in South Carolina. Two particularly destructive storms in 2008 and 2014 occurred that caused 7.5 million and 8.5 million dollars of damage respectively (National Center for Environmental Information, 2021). In 2008, several supercell thunderstorms affected the southern part of Upstate South Carolina that caused very large hail stones along with destructive tornadoes. The 2014 storm was very similar in that it was a collection of thunderstorms that developed in the Piedmont region and moved slowly across the Upstate.

### HAIL

Hail is precipitation in the form balls or lumps, consisting of concentric layers of ice, formed in cumulonimbus clouds. It forms when updrafts within a thunderstorm force liquid water upward into subfreezing air, where they collide and combine with supercooled droplets. Eventually, the hailstone becomes too heavy to be supported by updrafts within the storm, and it falls to the ground.

### LIGHTNING

Lightning is another thunderstorm hazard. It is the sudden visible flash of energy and light caused by an electrical discharge from within the storm. The movement of rain and ice creates an electric charge, with the negative charges forming at the bottom of the cloud and positive charges toward the top. Positive charges build upon the ground underneath the cloud; lightning is the resultant discharge when the two charges connect. According to the most recent Annual Lightning Report, over 2.9 million lightning, in-cloud and cloud to ground, flashes and strikes were observed across South Carolina in 2022 (Vaisala, 2022).

The National Risk Index, shown in Figure 6.51 through Figure 6.53 below, represent the potential risk of lightning.

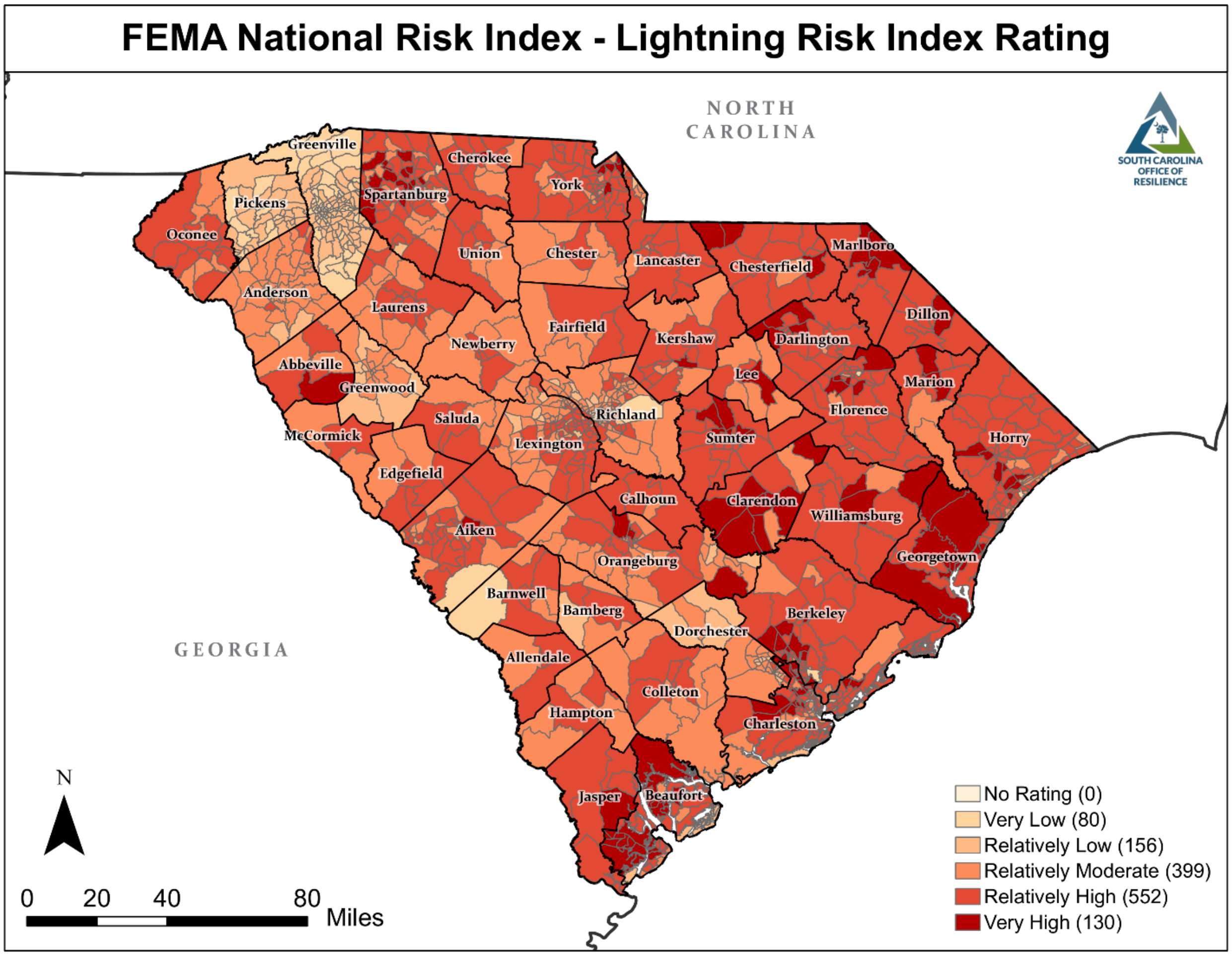


**Figure 6.51: Lightning Risk Index Rating**

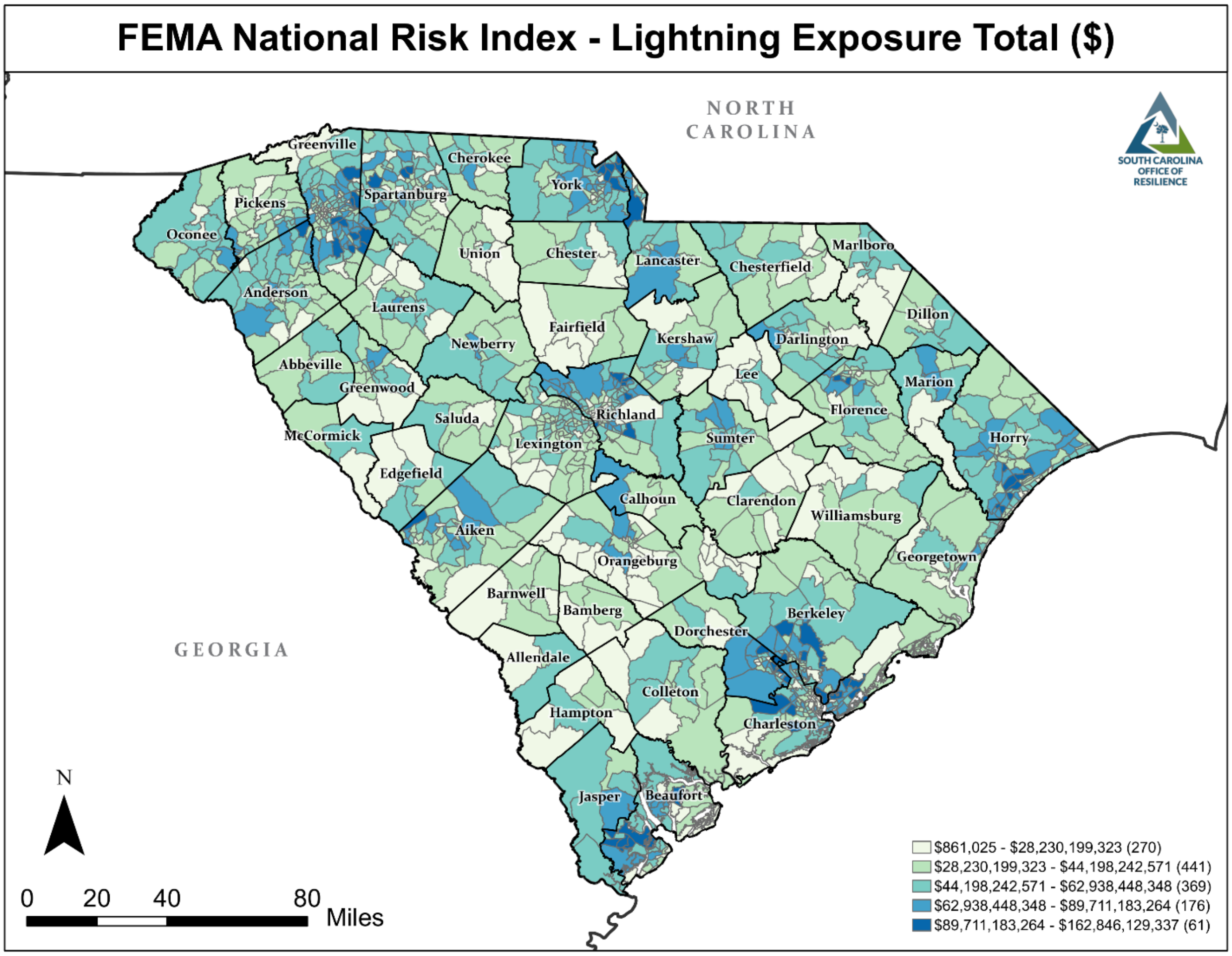


Figure 6.52: Total Lightening Exposure Cost

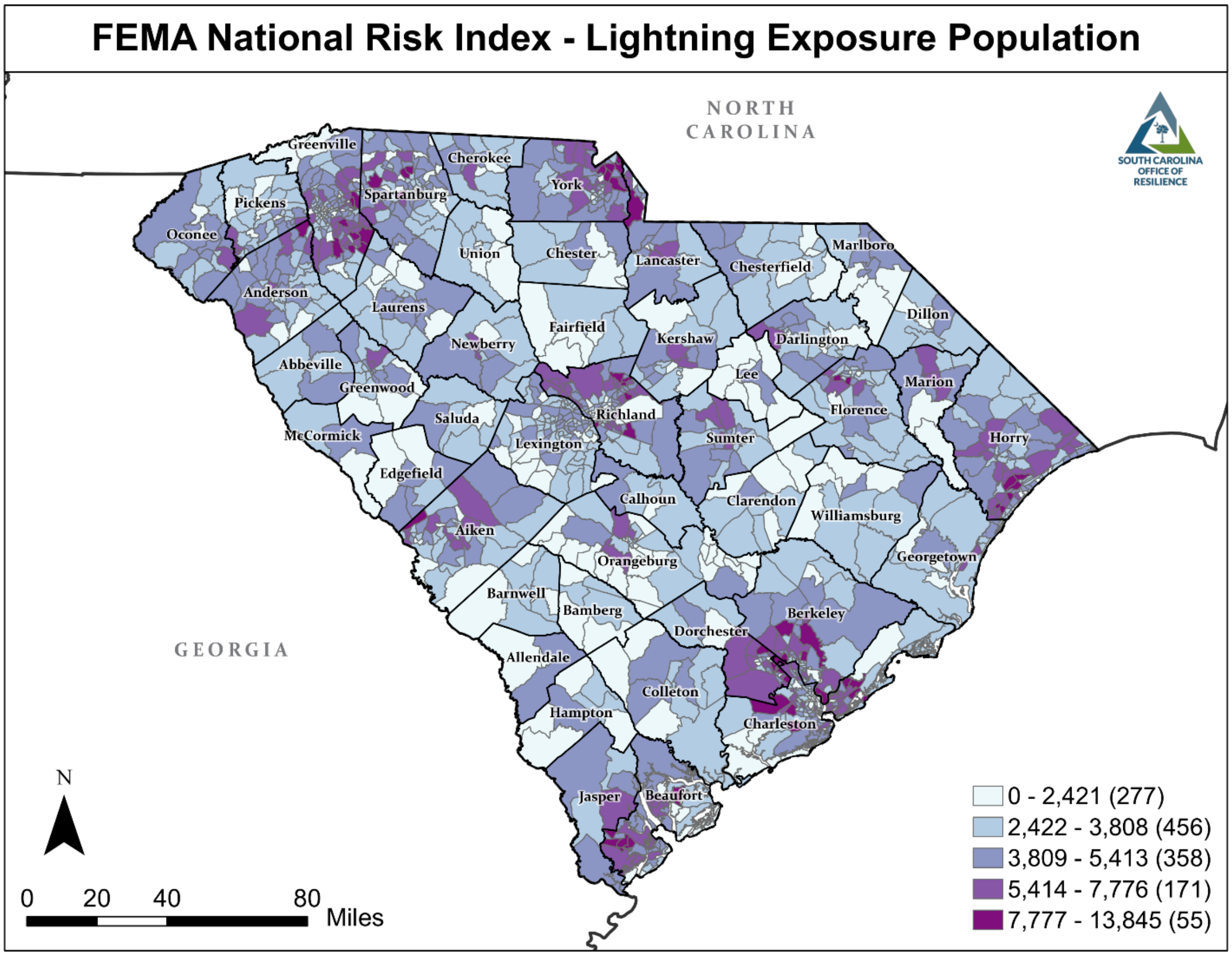


Figure 6.53: Lightning Exposure to Population

## DAMAGING WINDS

Strong winds are winds greater than 50 mph and are generally produced by thunderstorms but can be caused by various processes. Straight-line winds are a term used to define non-rotational thunderstorm winds, unlike tornadoes (National Weather Service, n.d.). Downbursts are thunderstorm winds driven by falling precipitation that can exceed 100 mph. Derechos are long-lived and damaging thunderstorms, whose winds can extend away from the thunderstorm (National Weather Service, n.d.). In South Carolina, extreme winds are the most reported hazard to NCEI in the last 20 years with 3,112 unique events reported that have caused 26 deaths, 110 injuries, and close to $70 million in damages (National Center for Environmental Information, 2021).

The National Risk Index's Strong Winds Risk Index Rating, shown in Figure 6.54, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States.

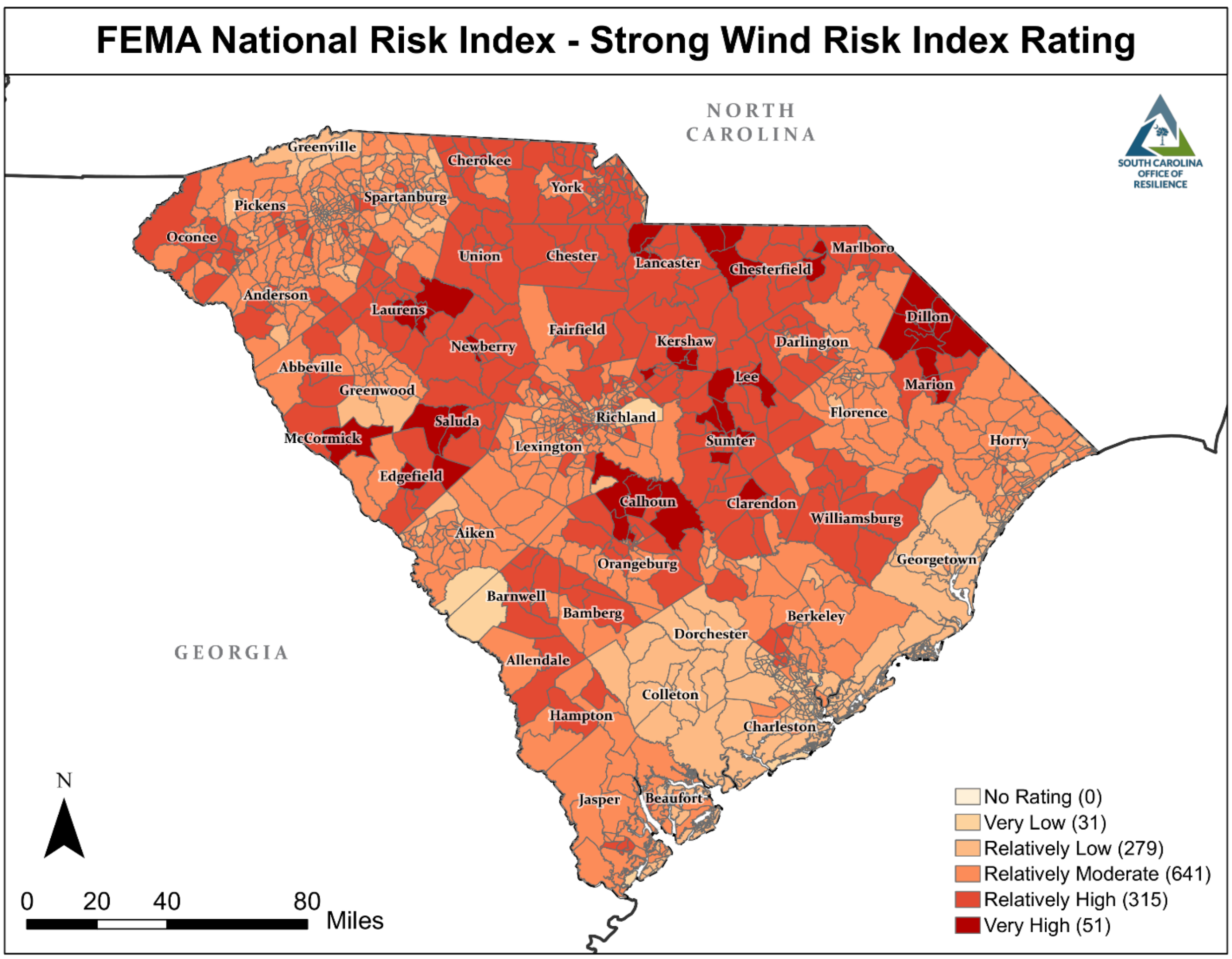


Figure 6.54: FEMA Hazard Risk Index Rating for strong winds in South Carolina by Census Tract.

## TROPICAL SYSTEMS AND HURRICANES

While hurricanes are considered, "low frequency/high consequence events," South Carolina is 5$^{th}$ (fifth) in the ranking of states where hurricanes hit the most, behind Florida, Texas, Louisiana and North Carolina (State Climatology Office, HURDAT Re-analysis noaa.gov).

Based on a period of record from 1851 to 2022, the state has roughly an 80% chance of being impacted by a tropical cyclone each year. Since 1851, South Carolina has been impacted by 263 tropical cyclones: 140 of these tracked into the state, while only 44 made direct landfall. Four of these landfalls were major hurricanes, with a Saffir-Simpson Hurricane Wind Scale of Category 3 or higher. It is also important to note that while these major hurricanes are devastating, minor hurricanes and tropical storms can also have significant impacts through additional hazards, such as rainfall, tornadoes, and strong winds. The State Climatology Office at SCDNR released an update to their comprehensive report in May 2023 on tropical cyclones and their impact in South Carolina.

A tropical cyclone's strength is classified by the Saffir Simpson Hurricane Wind Scale. Three of the strongest storms to directly impact the state since 1900 are: Hurricane Hazel (1954), Hurricane Gracie (1959), and Hurricane Hugo (1989). As described in Chapter 4, climate projections suggest more rapid intensification of storms; on the other hand, increased wind shear in the future could keep some storms from forming.

The Atlantic Tropical Cyclone season officially begins on June 1 and lasts through November 30; however, documented storms have impacted the State outside of these dates. The primary hazards from tropical cyclones are inland flooding, wind damage, tornadoes, and storm surge. The extent and severity of how these hazards affect the state are dependent on the track and landfall point of the storm, along with the size of the wind field, the forward speed of the storm, the bathymetry of the coastline, and the angle of the storm approaches the coast. The combination of these hazards causes tremendous impacts on the citizens of South Carolina and makes assessing the vulnerability to any given sector challenging to estimate.

### STORM SURGE

Storm surge is the most significant coastal tropical cyclone-related hazard, posing the greatest threat to life and property along the coast. It is a rise of water generated by a storm higher than the predicted astronomical tides. The strong winds in a tropical cyclone primarily cause storm surge. As the tropical cyclone approaches land, it encounters shallower water, and the water is pushed inland. The highest surge levels at the coast typically occur to the right of the storm's center, and the stronger, larger, and faster tropical cyclones usually produce the highest surge.

Since storm surge is independent of tides and waves, the flooding it causes can be additive in its risk and bring those tidal forces and wave actions into areas not commonly affected by storm surge. This rise in water can result in devastating flooding in coastal areas and can cause significant damage to homes, businesses, and infrastructure.

## WIND

Devastating winds are the hazard most often associated with tropical cyclones. The Saffir-Simpson Hurricane Wind Scale (Table 6.6) is used to characterize potential damage to property based on the hurricane's maximum sustained wind speed.

**Table 6.4: The Saffir-Simpson Hurricane Wind Scale and descriptions of estimated property damage (National Hurricane Center, 2023).**

| Category | Sustained Winds | Types of Damage Due to Hurricane Winds |
|---|---|---|
| **1** | 74-95 mph<br>64-82 kt<br>119-153 km/h | **Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days. |
| **2** | 96-110 mph<br>83-95 kt<br>154-177 km/h | **Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks. |
| **3**<br>**(major)** | 111-129 mph<br>96-112 kt<br>178-208 km/h | **Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes. |
| **4**<br>**(major)** | 130-156 mph<br>113-136 kt<br>209-251 km/h | **Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months. |
| **5** | 157 mph or higher | **Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and |

| | | |
|---|---|---|
| **(major)** | 137 kt or higher | power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months. |
| | 252 km/h or higher | |

Tropical cyclones can devastate inland areas, even if they make landfall in locations other than the South Carolina coast. Heavy rainfall can cause flash and riverine flooding, while strong winds and tornadoes can uproot trees, damage buildings, and cause power outages. Even areas far from the coast can be affected by the aftermath of a tropical cyclone, and the damage to infrastructure can take weeks or months to repair. In the National Risk index, a Hurricane Risk Index Rating, shown in Figure 6.55, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States.

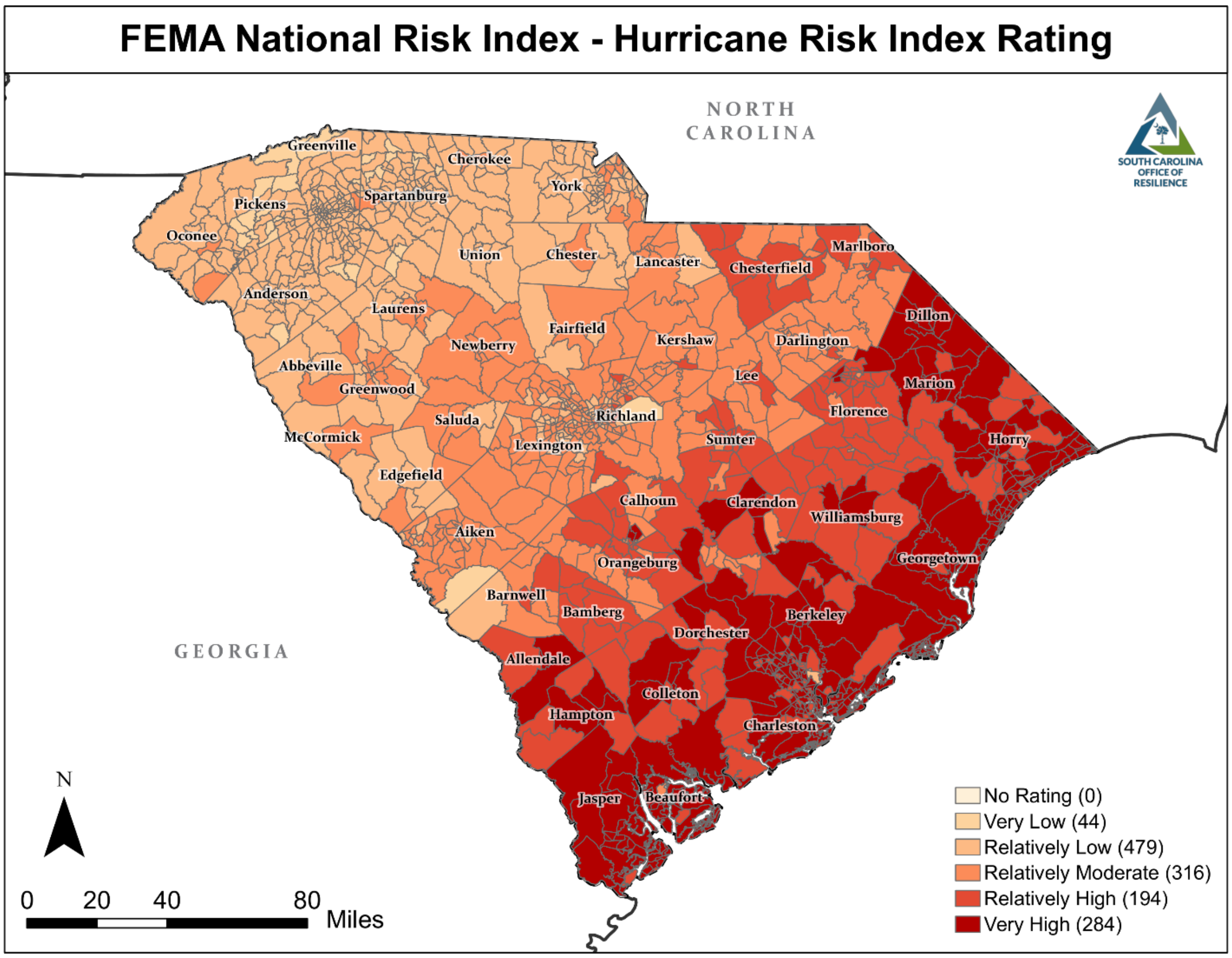


Figure 6.55: FEMA Hazard Risk Index Rating for hurricanes in South Carolina by Census Tract.

## TORNADOES

South Carolina has a history of tornadoes, documented by the State Climatology Office, the

National Weather Service, and NOAA's Storm Prediction Center back to 1950. Tornadoes are violently rotating air columns that descend from a thunderstorm and come in contact with the ground. The strength of a tornado is determined by the amount of damage left in its wake and is rated on the Enhanced Fujita Scale. The weakest tornadoes are rated EF-0 (estimated winds of 65 -85 mph) and the strongest are rated EF-5 (estimated winds over 200 mph). Before 2008, the original Fujita Scale rated them from F-0 to F-5, which had limitations. A count of EF/0 to E/F4 tornadoes observed yearly between 1950 and 2020 shows an increasing trend in the number of tornadoes South Carolina has seen since the early 1990s. However, this is mainly due to the advent of NEXRAD radar in 1994-1996, which allows meteorologists to better detect weaker EF/F-0 & EF/F-1 tornadoes and increasing population density.

To account for these changes in observing practices, Figure 6.56 below shows the number of E/F2 or greater tornadoes annually between 1950 and 2020. While no significant trend is shown, the state still experiences devastating impacts from these events due to increases in population and development since 1950. Additionally, as discussed in Chapter 4, current climate projections predict that tornado alleys are shifting east toward the state.

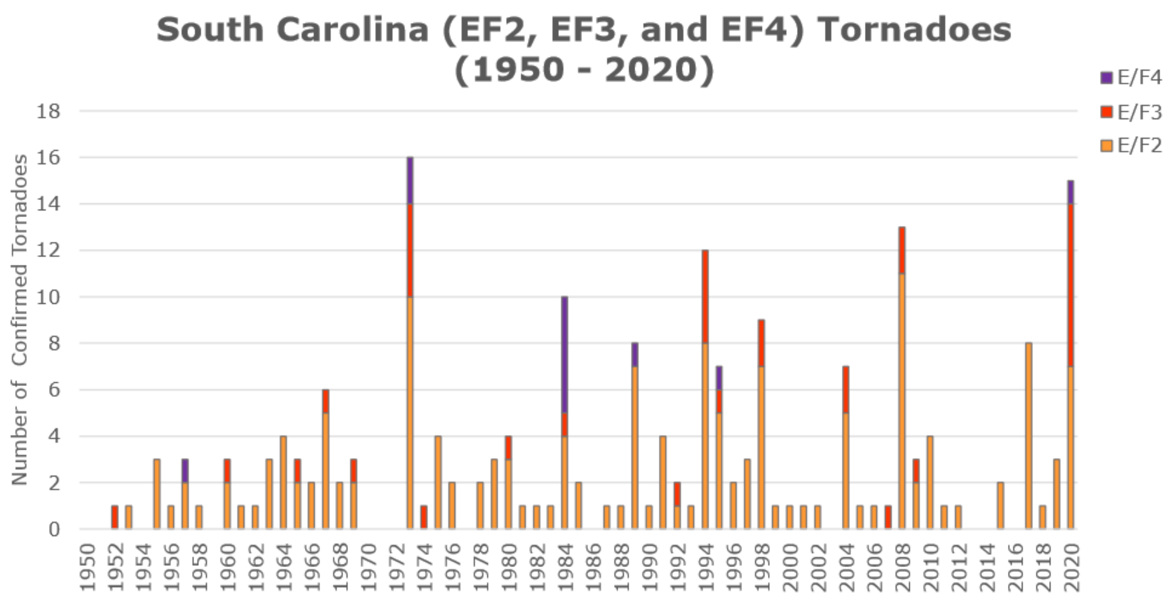


Figure 6.56: South Carolina Tornados (SC Climatology Office)

Figure 6.57 illustrates the probability of tornadoes every month, showing a peak during spring and in September. The springtime peak of tornado activity is typical for the southeastern and south-central United States, resulting from increasingly warm and humid air becoming available for storm systems crossing the region to produce intense thunderstorms. The September peak is primarily driven by tornadoes spawned by tropical cyclones affecting the state.

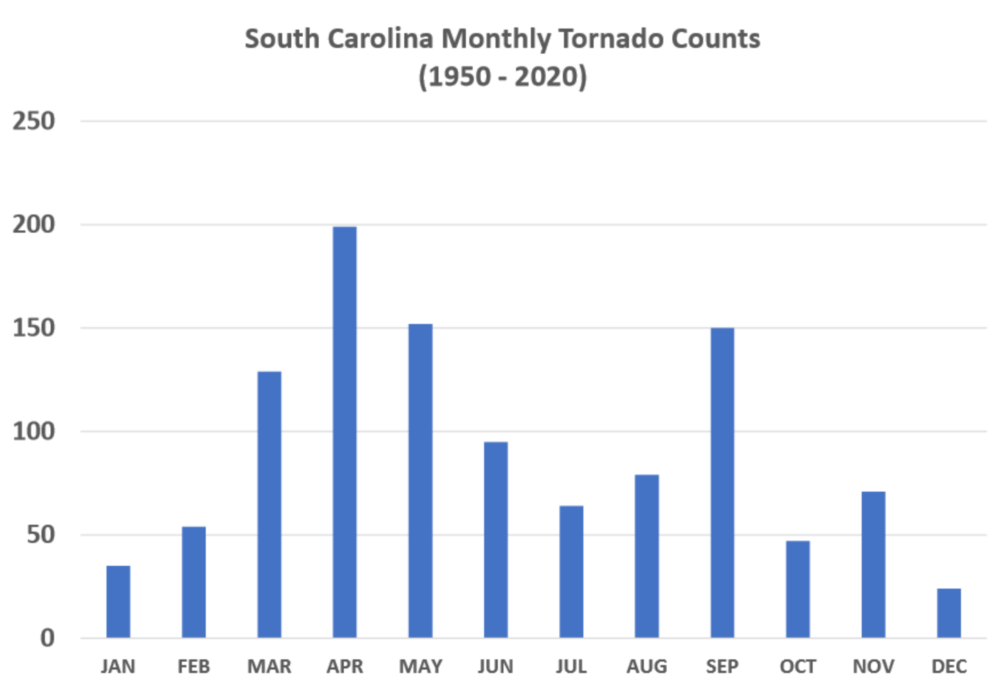


Figure 6.57: SC Monthly Tornado Counts (SC Climatology Office)

Tornadoes are a hazard that can impact anywhere in South Carolina and produce powerful winds and lift debris that can impact structures or other objects. Typically, tornadoes cause the greatest damages to non-reenforced structures or light construction buildings such as mobile homes, sheds, or residential homes. In the National Risk index, a Tornado Risk Index Rating, shown in Figure 6.58, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States.

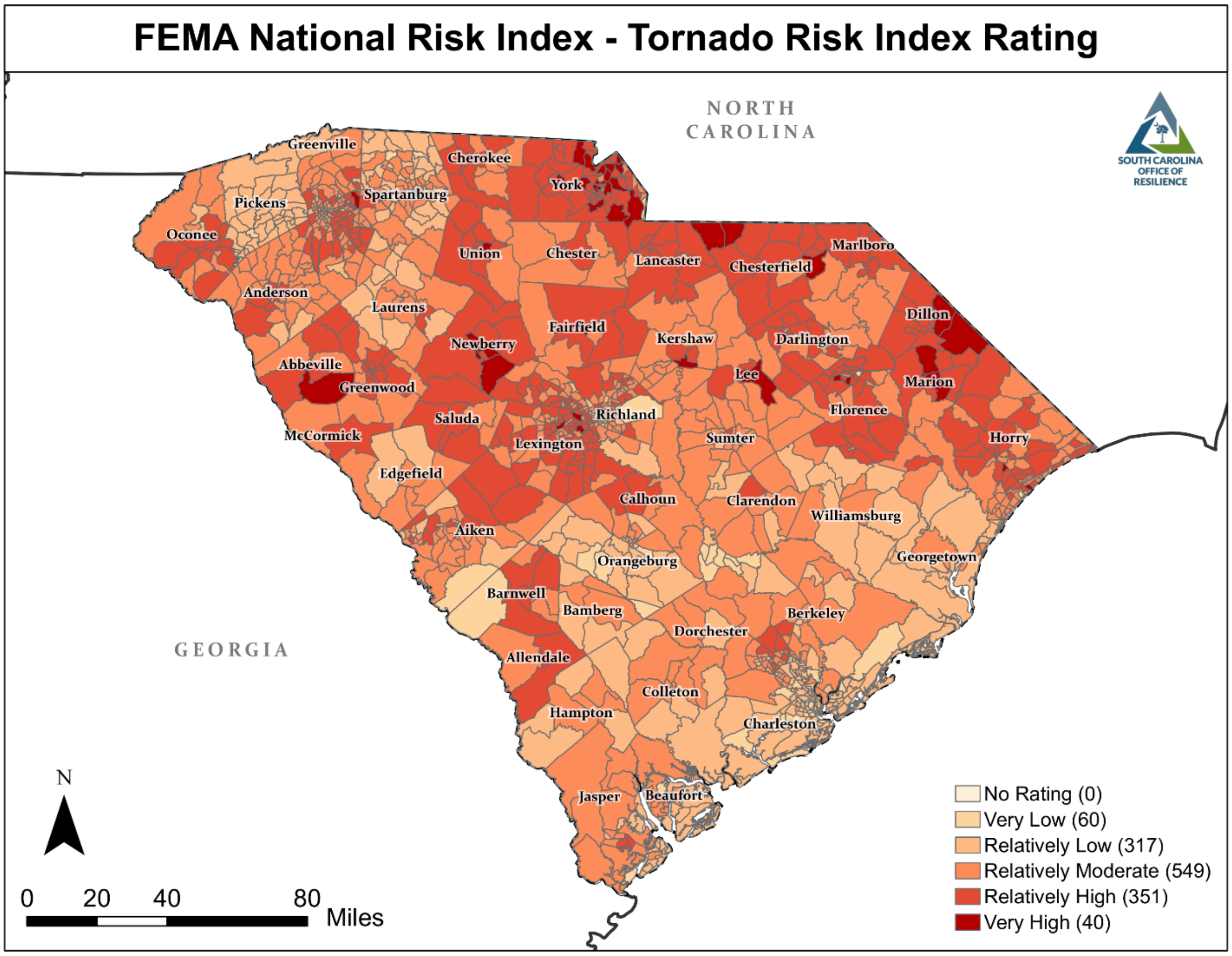


**Figure 6.58: FEMA Hazard Risk Index Rating for tornadoes in South Carolina by Census Tract.**

## WINTER WEATHER

Extreme winter weather events in South Carolina are relatively rare but cause significant impacts across the state. A database of events since 1958 is recorded on SCDNR Climatology Office's Winter Weather webpage. Winter weather events include Blizzard, Cold/Wind Chill, Extreme Cold/Wind Chill, Frost/Freeze, Heavy Snow, Ice Storm, Sleet, and Winter Storm events. These events can disrupt communications and power as a result of trees or branches falling on suspended lines (see Energy Office Report on the Resiliency of South Carolina's Electric and Natural Gas Infrastructure Against Extreme Winter Storm Events), disrupt travel plans through impairing roadways, and damage both residential and agricultural plants.

Since 2001 there have been a total of 104 events that have caused millions of dollars in property damage and agricultural losses (National Oceanic and Atmospheric Association (NOAA), 2021). A late season freeze in April 2007 generated over $32 million in crop damages, which killed off 80 to 90% of the peach crop (National Oceanic and Atmospheric Association (NOAA), 2021).

The National Risk Index's Winter Weather Risk Index Rating, shown in Figure 6.59, represents the potential impact to people, buildings, and agricultural value when compared to the rest of the United States.

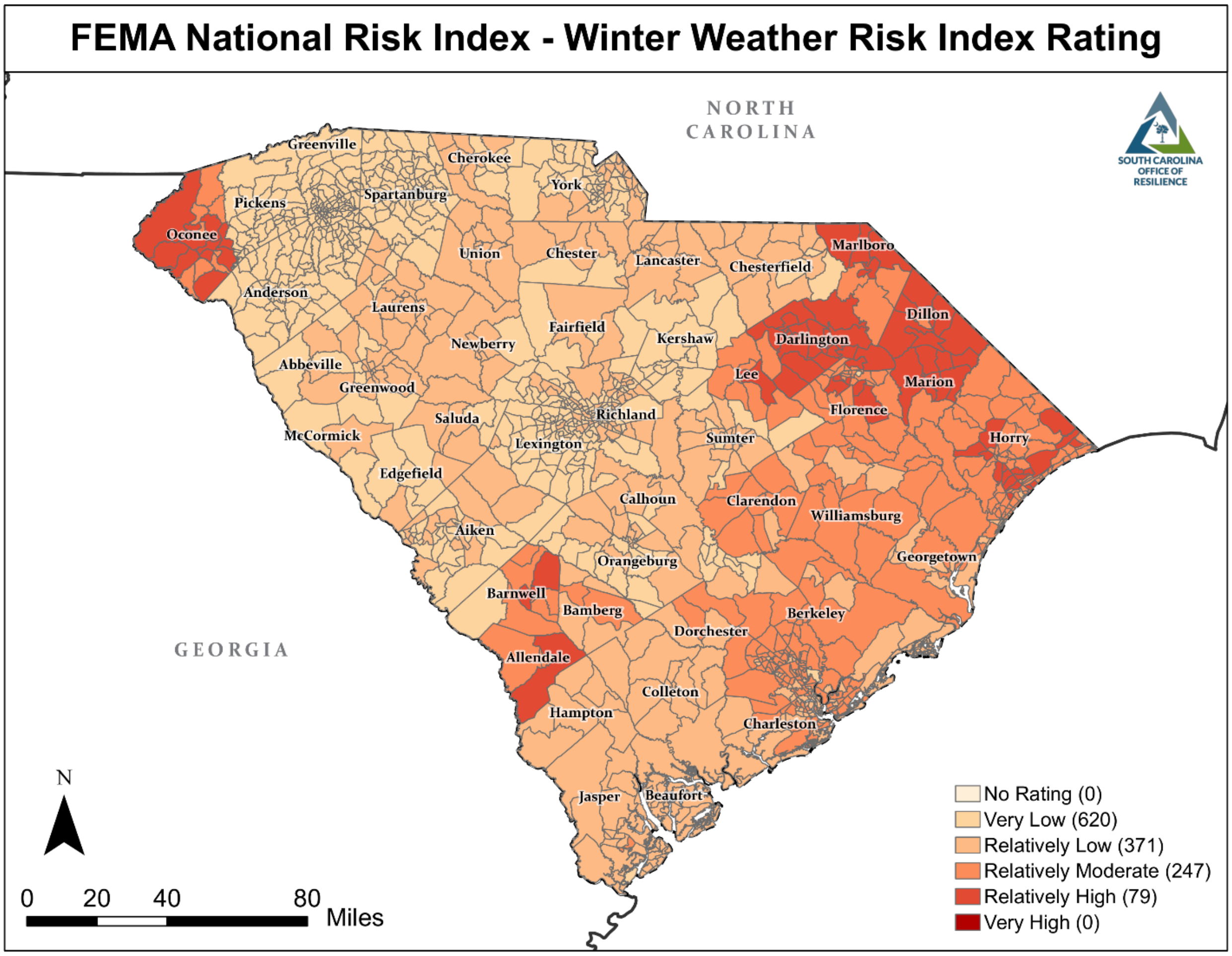


Figure 6.59: FEMA Hazard Risk Index Rating for winter weather in South Carolina by Census Tract.

# SEISMIC EVENTS

## EARTHQUAKES

Earthquakes occur when forces build up and are suddenly released within the earth's crust, causing blocks of earth to move as an earthquake along fault lines. There are three main types of faults: strike-slip, normal, and thrust (Figure 6.60). Strike-slip faults occur when earth's crustal plates move laterally against each other (Figure 6.60a). Normal faults occur when one block slides downward in reference to the other block due to tensional or extensional forces to the blocks (Figure 6.60b). Thrust (reverse) faults occur when one block is thrusted over another (Figure 6.60c). Most large earthquakes, greater than magnitude 5 on the Moment Magnitude Scale (Mw), occur along crustal plate boundaries, but do not exclude earthquakes in the middle of plates or along inactive boundary zones. According to the USGS, South Carolina has experienced 229 earthquakes since 2001, with 46 events larger than a magnitude 2.5 Mw. The largest event since 2001 reached a magnitude 4.1 Mw in Parksville, SC, on November 11, 2014 (Figure 6.54) (US Geological Survey (USGS), 2023).

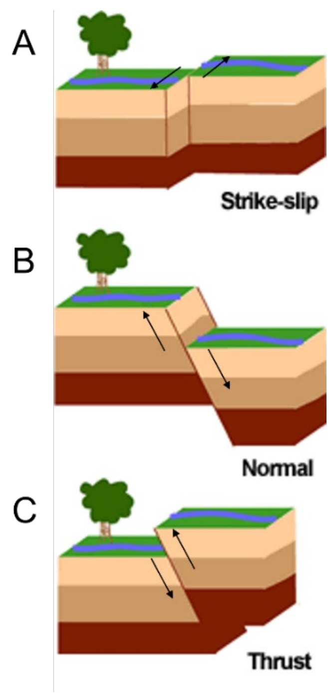


**Figure 6.60: Three types of faults, black arrows represent observed motion, edited from (US Geological Survey, 2022).**

The United States Geological Survey (USGS) [Earthquake Hazard Program] and the [South Carolina Geological Survey (SCGS)] monitor and calculate potential impacts from earthquakes. Intensity, location (epicenter or hypocenter), and other information is collected and housed by multiple sources including the USGS, SCGS, and academia. The University of South Carolina's School of Earth, Ocean and Environment maintains the South Carolina Seismic Network that houses nine seismic monitoring stations, six in the Charleston/Summerville area and three around the rest of the State (University of South Carolina, 2023).

Earthquake vulnerability assessment involves evaluating the potential damage and losses that could occur in a specific area as a result of an earthquake. With the available technology, earthquakes are practically impossible to predict, although historic events provide context and allow for a probabilistic estimate of future events. The USGS Earthquake Hazard Program maintains a database of historic earthquakes and calculates the probabilistic 1% annual chance of an event that is used by the FEMA National Risk index in their base calculations (Zuzak, et al., 2023). Seismic hazard analysis involves evaluating the likelihood and severity of earthquakes in a specific area. It considers factors such as the frequency of earthquakes, the location and depth of fault lines, and the geological characteristics of the region. Figure 6.61 maps the measured historic earthquakes in South Carolina between 1913 and 2022 and their magnitude (US Geological Survey (USGS), 2023).

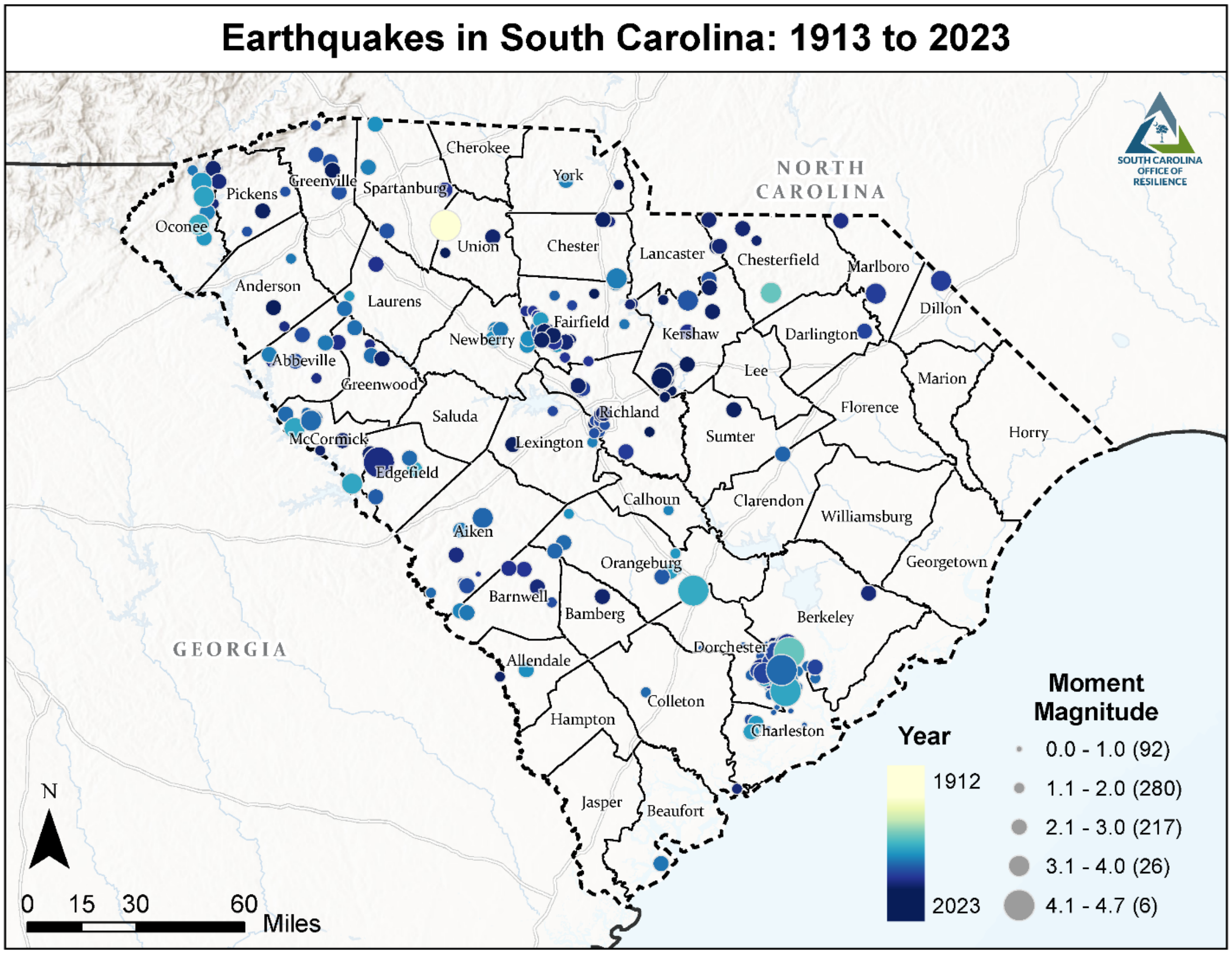


Figure 6.61: Historic Earthquakes in South Carolina (US Geological Survey (USGS), 2023)

## PEAK GROUND ACCELERATION

Peak Ground Acceleration (PGA) is a primary assessment tool for communities to better mitigate and plan for a potential earthquake. PGA is the maximum acceleration a ground surface experiences during an earthquake. It is a measure of the intensity of ground shaking and is used to assess seismic hazard and design earthquake resistant structures. A broad guide is that the higher the PGA, the higher the potential damage or hazardous conditions to the community. The USGS provides data to aid in the development of building codes that include ground acceleration metrics. The SC Building Codes Council maintains the seismic design boundary maps for each county on its website and has adopted the 2015 International Residential Code for the 2021 cycle (Labor Licensing Regulation, 2023). Figure 6.62 and Figure 6.63 represent the PGA probabilities in South Carolina.

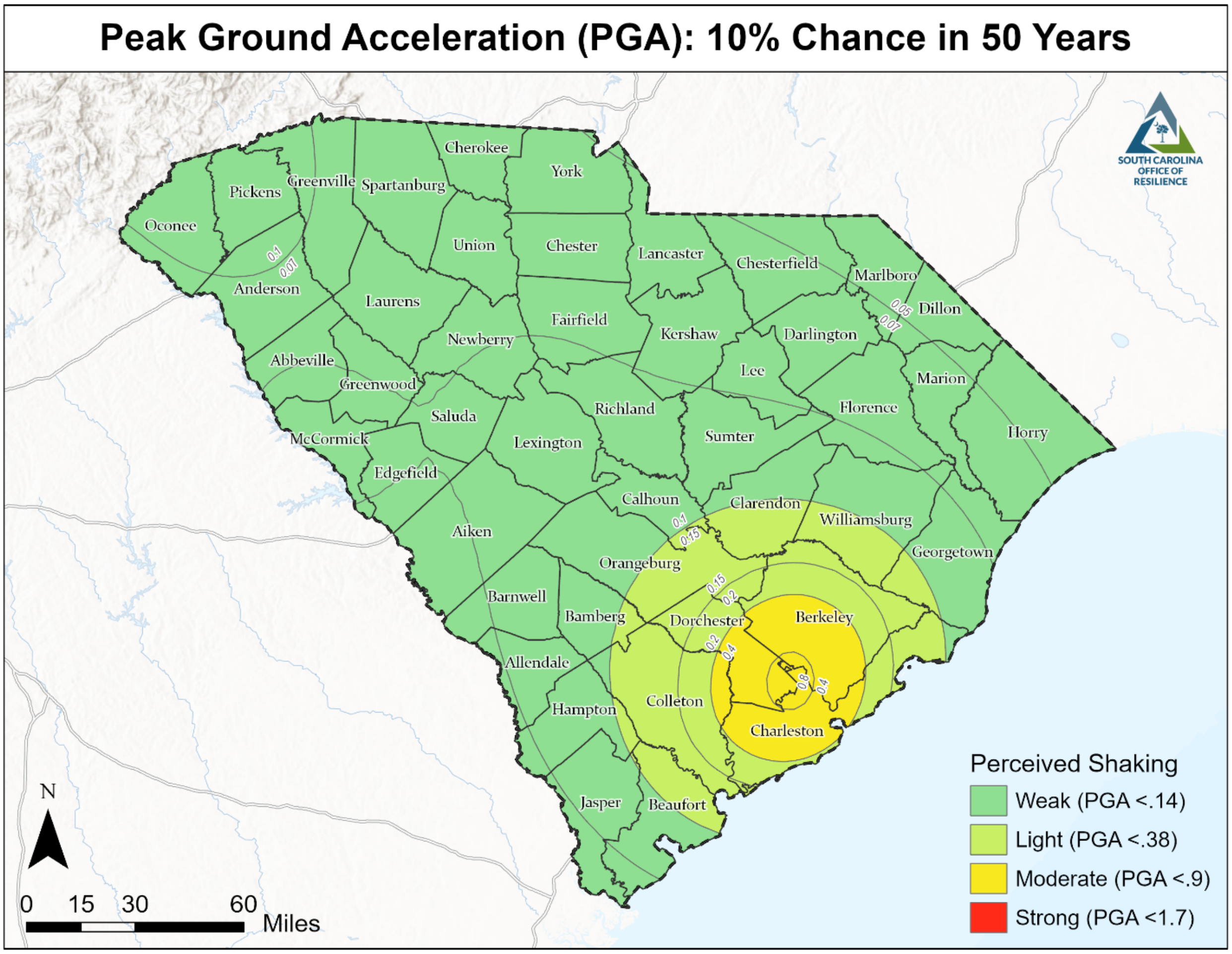


Figure 6.62: Peak Ground Acceleration (PGA) impact for SC in 10% chance in the next 50 years (U.S. Geological Survey (USGS), 2019)

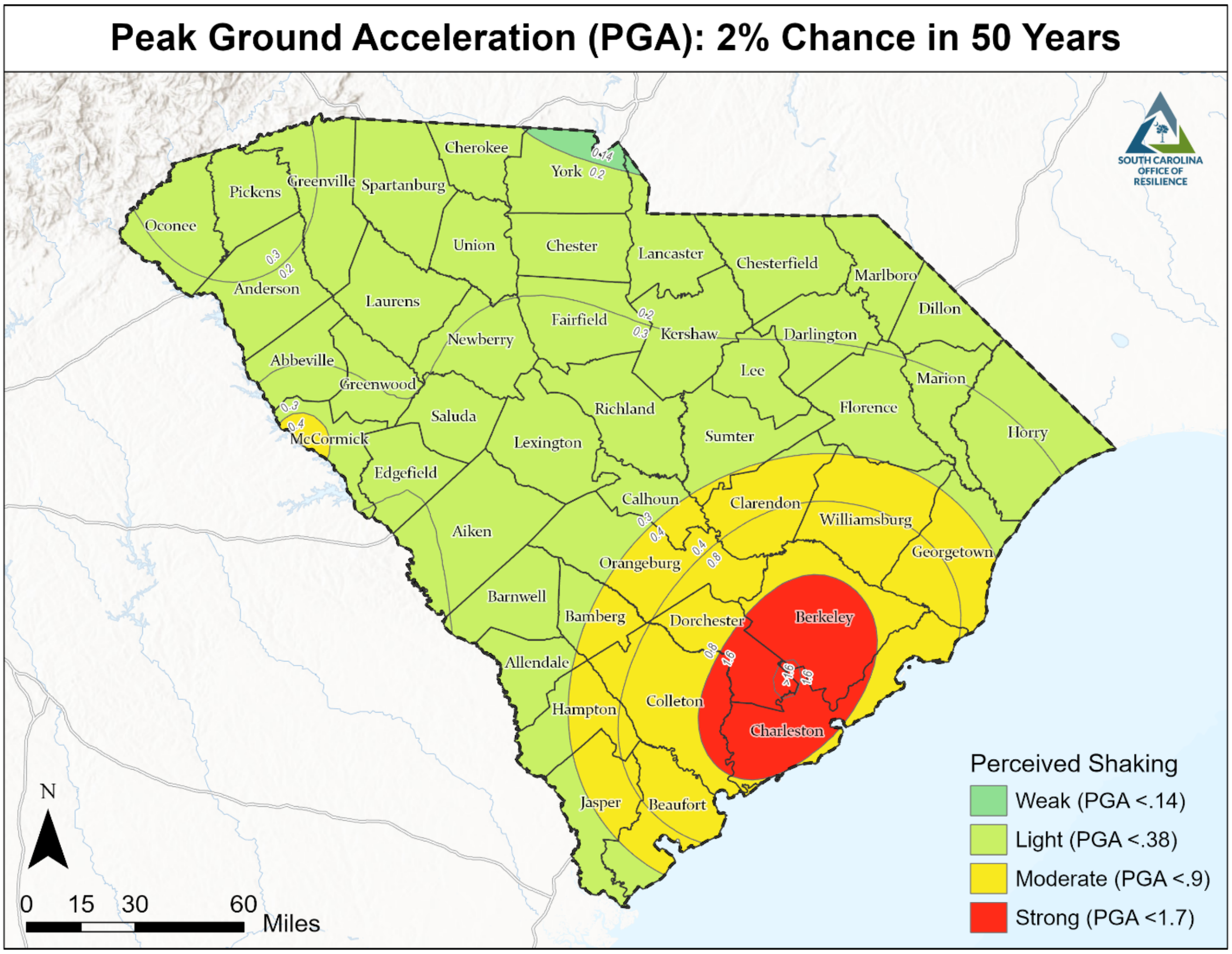


Figure 6.63: Peak Ground Acceleration (PGA) impact for SC in 10% chance in the next 50 years (U.S. Geological Survey (USGS), 2019)

## GEOLOGIC HAZARDS OF THE COASTAL PLAIN

Figure 6.64 illustrates potential geologic hazards associated with earthquakes across the Coastal Plain. The unconsolidated sediments that make up the Coastal Plain of South Carolina increase the risk to the following hazards that could be cooccurring during an earthquake:

1. Karst carbonate rocks & karst carbonate sediment: Near-surface sediments with collapse potential
2. Landslide potential: Thick, cohesionless materials at steep riverbanks
3. Sinkhole potential: Mapped based on karstic features
4. Liquefaction Areas: Liquefaction is a phenomenon that occurs when soil loses its strength and stiffness due to an earthquake or other sudden change in stress conditions. When an earthquake occurs, the ground moves rapidly back and forth, causing the soil particles to rearrange and lose their contact with each other. In saturated soil, this can cause the pore water pressure to increase, which can reduce the effective stress and

cause the soil to lose its strength. As a result, the soil behaves like a liquid, rather than a solid, and can cause significant damage to buildings and infrastructure. This can lead to buildings sinking, tilting, or collapsing, and can also damage roads, bridges, and other infrastructure.

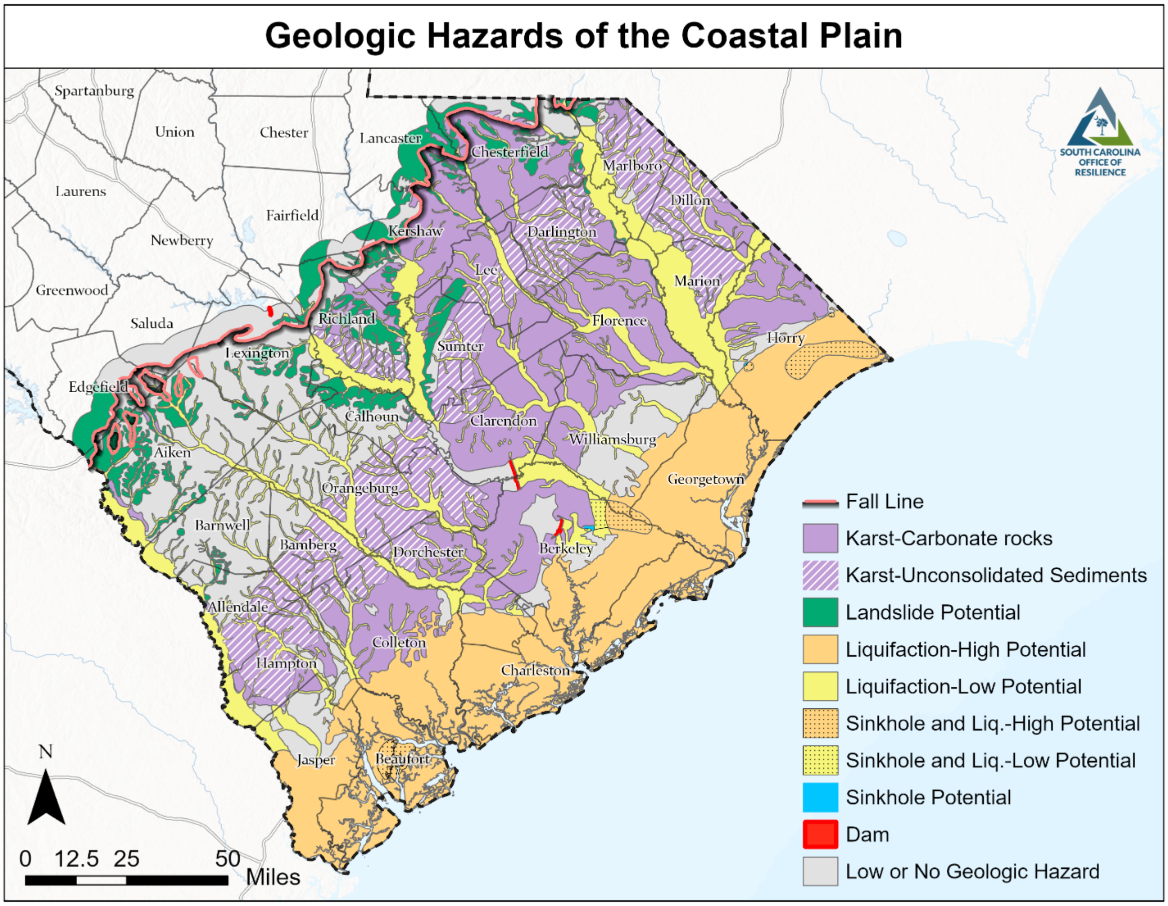


Figure 6.64: Geologic Hazards of the Coastal Plain (South Carolina Geological Survey)

## FEMA NATIONAL RISK INDEX

The National Risk Index, shown in Figure 6.65, represents the potential impact from earthquakes to people, buildings, and agricultural value when compared to the rest of the United States.

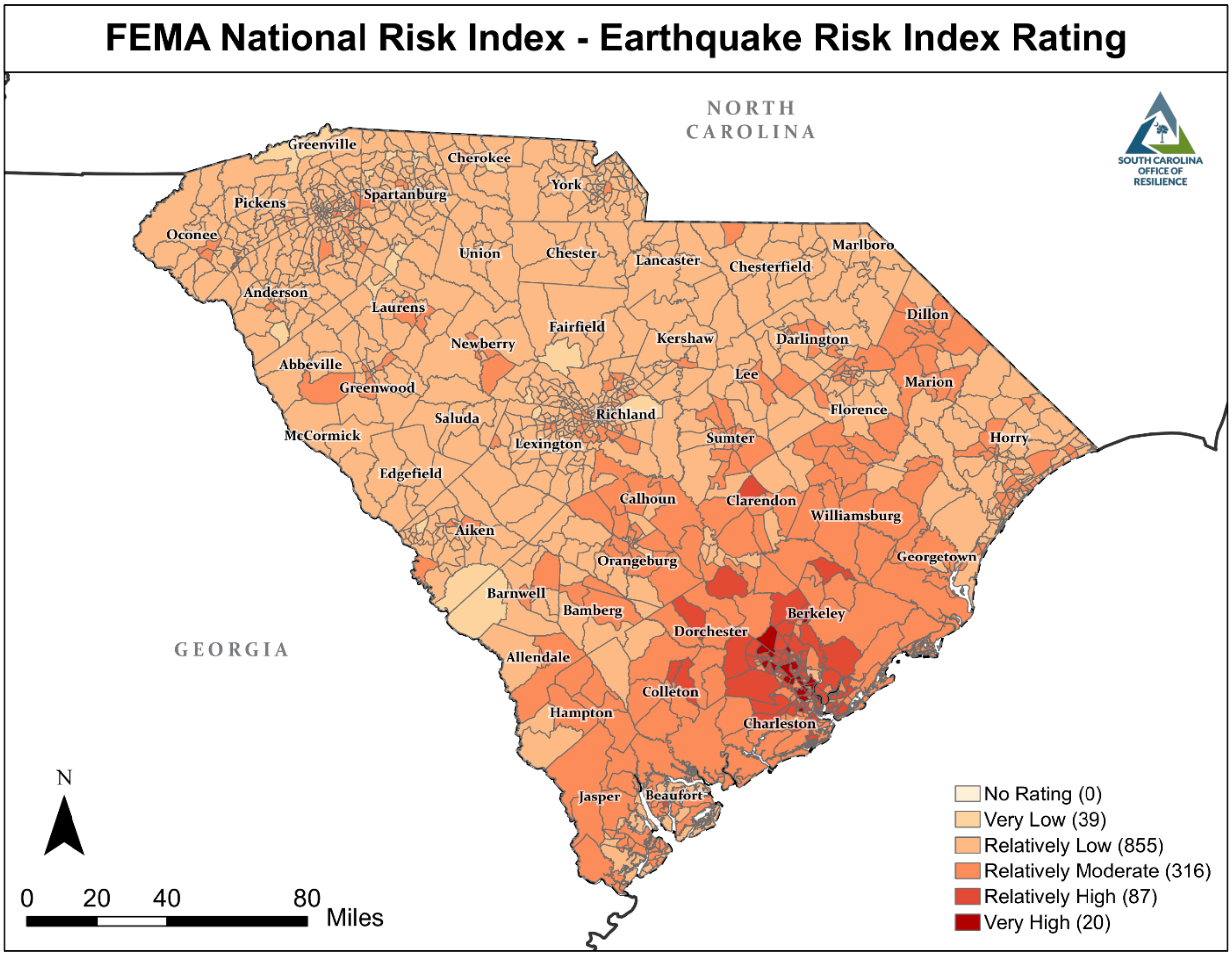


Figure 6.65: FEMA Hazard Risk Index Rating for earthquakes in South Carolina by Census Tract.

## TSUNAMI

Tsunamis are relatively rare events on passive margins like the east coast of the United States. Tsunamis are large, long waves that temporarily raise local sea level and are often generated by large tectonic events such as earthquakes along megathrust fault lines. When an earthquake occurs in the ocean, the crustal plate can shift vertically, which can cause the water column above to also shift. This generates a tsunami, like the 2004 Boxing Day Tsunami that occurred in the Indian Ocean near Sumatra, Indonesia. Submarine landslides can also generate tsunamis in a similar manner. Along the continental slope, the substrate can be destabilized by an earthquake, and as the sediment moves down the slope, if the volume of sediment is large enough, it can cause a depression in the water column above it and cause a tsunami. Lastly, a meteorite impact in the ocean can also cause a tsunami. These types of events are quite rare and in South Carolina since 1950, no tsunamis have been recorded. The last major earthquake that may have generated a tsunami regionally was in 1886, centered in Charleston. A wave was detected in the Cooper River, but it is not well defined if it was a result from the earthquake or a submarine landslide (National Center for Environmental Information, 2021). There is insufficient data to make reasonable decisions or recommendations to mitigate or plan for the impacts of a tsunami.

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