Strategic Statewide Resilience and Risk Reduction Plan

5 | FLOOD RISK AND VULNERABILITY ASSESSMENT

OVERVIEW

This chapter furthers the ability of organizations across the state to anticipate, by identifying current and future flood vulnerabilities. The data identification, collection and coordination of this chapter was done through subcommittees of the Statewide Resilience Plan Advisory Committee.

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KEY FINDINGS

- Flooding in South Carolina is caused by prolonged rain events, short intense rain, overflowing rivers, dam or levee failure, storm surge, and tidal process. Flooding can be broken into three types: river flooding (fluvial), overland flooding (pluvial), and coastal flooding
- Existing estimates of flood frequency are based on historical record and do not account for changes in climate and landscape conditions.
- Existing rainfall intensity, duration, and frequency (IDF) curves from NOAA Atlas 14 are based on the concept of stationarity, the idea that past conditions are predictive of the future. Changing rainfall patterns and a failure to use the most up-to-date data could lead to underestimating likelihood of damaging rain events
- SCOR determined that the intermediate to intermediate-high sea level rise scenario should be considered in the development of the Statewide Resilience Plan.
- Projected sea level rise will lead to increased coastal flooding in low lying areas.
- Land Subsidence is likely contributing to relative sea level rise in many coastal areas.
- Since 2015, all 652 high- and significant-hazard dams in the state have been assessed and the state has invested significant resources in the state's dam safety program.
- Dam failure can lead to flooding downstream. Additionally, there is the potential for mobilization of contaminated sediments that may be trapped behind the dam.
- FEMA flood mapping does not currently capture the full risk of flooding. Supplemental tools such as the First Street Foundation Flood Hazard Layer should be utilized for a more complete understanding of flood risk under both current and under future conditions.
- Using the First Street Foundation Flood Hazard Layer and other publicly available datasets, SCOR assessed and mapped the vulnerability of various facilities

FLOODING

In South Carolina, the causes of flooding include prolonged rain events, short intense rain, overflowing rivers, dam or levee failure storm surge and tidal process. Flooding can be broken into three types: river flooding (fluvial), overland flooding (pluvial), and coastal flooding.

FLOOD FREQUENCY

Flooding is often described by its flood frequency, which can be challenging for those who do not frequently deal with flooding and hydrological data to understand. Often, floods are described by the occurrence intervals of “10-year”, “100-year”, “500-year”, and “1,000-year” events. This does not mean that the event will only happen once every “100 years”, but actually describes the statistical probability of flooding of that magnitude, which may occur more frequently than once every 100 years. The current solution put forth by hydrologist, engineers, emergency managers, and others is to describe flooding based on annual probability. The recurrence interval for a 1 in “100-year” flood event means that it has 1% chance of occurring or being exceeded any given year and is therefore described as 1% annual chance of occurrence (Table 5.1). Consider the analogy of rolling a 6-sided dice. On any given roll, there is a 1 in 6 chance that the dice would rest with a 6 face up, but that does not mean every sixth roll would be land on the 6. An important note, a home in the “100-year” floodplain, based on probability, has at least a 26% chance of having a 1-percent annual exceedance probability (“100-year” flood) event over the life of a 30-year mortgage (Figure 5.1) (Holmes & Dinicola, 2010)

Table 5.1: Flood recurrence interval to annual chance

Recurrence Interval	Percent Annual Chance
2-year	50%
10-year	10%
25-year	4%
50-year	2%
100-year	1%
500-year	0.2%
1000-year	0.1%

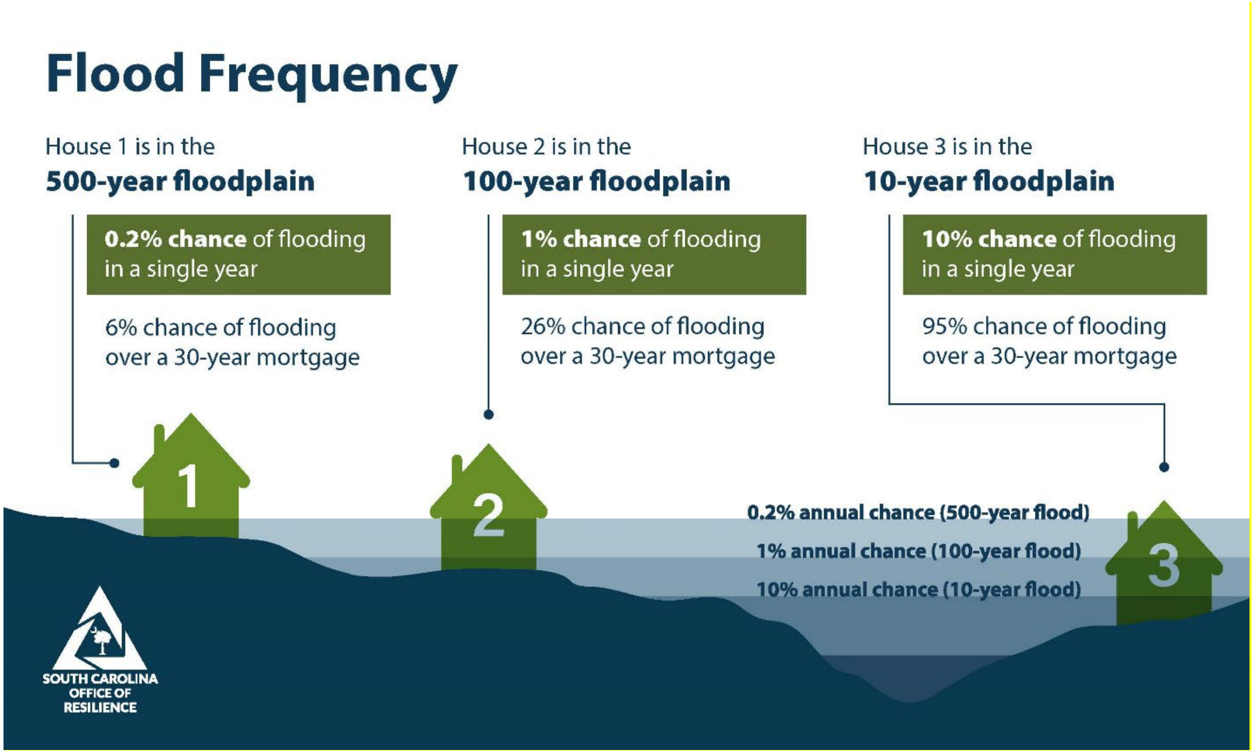


Figure 5.1: Flood Frequency (adapted from Soil & Water Conservation Districts of Montana)

Flood frequency intervals are calculated based on streamflow and stage measurements collected at a stream gage, often a USGS River Gage. The longer the period of record, the better set of data for calculating flood frequency. It is important to have accurate, long-term data to best identify the potential flood hazard at the point of measurement and estimate the potential impact to the surrounding communities

RIVERINE (FLUVIAL)

Fluvial, or river, floods occur when the water level of the river overtops its banks or natural levees (Figure 5.2). Riverine flooding can be devastating because the precipitation needed to cause the flooding does not have to fall where the flooding occurs. In addition to localized areas that may experience flooding immediately after it has rained, peak river flooding frequently occurs a few days after a rainstorm. Since 2000, over 195 riverine floods have been reported in South Carolina to the National Centers for Environmental Information database by local emergency managers, news reporters, and emergency responders (National Oceanic and Atmospheric Association, 2023).

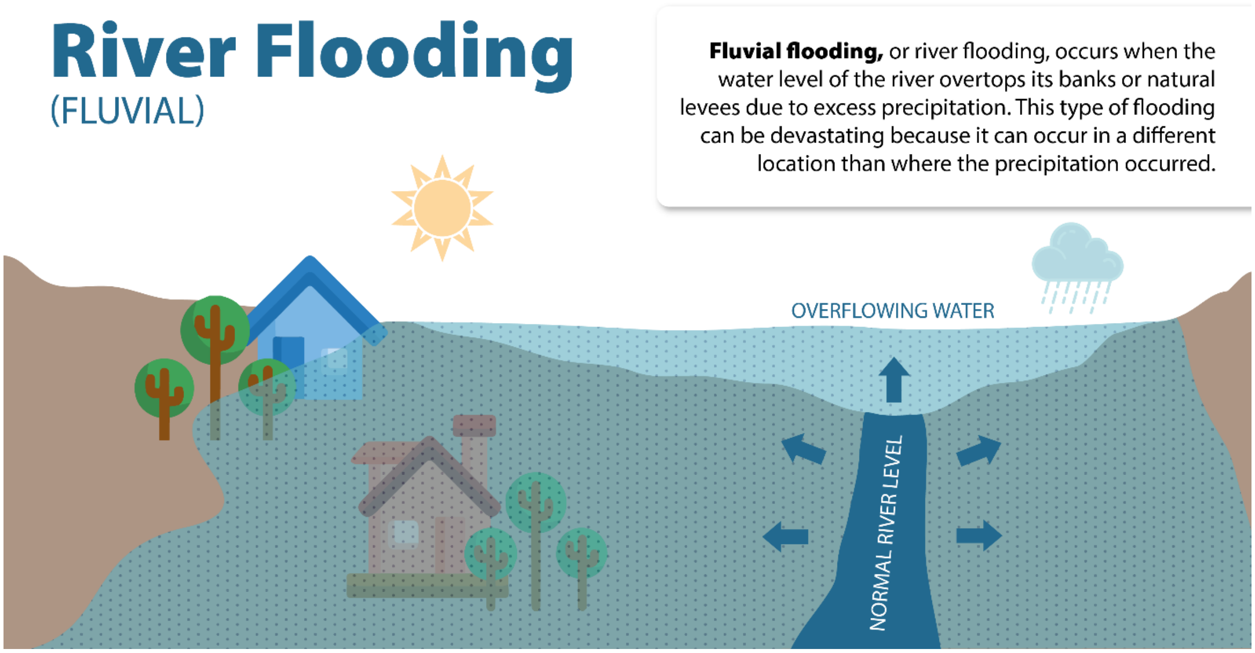


Figure 5.2: Fluvial Flooding (SCOR)

PLUVIAL FLOODING

Pluvial flooding occurs when an extreme rainfall event creates a flood independent of an overflowing water body (Figure 5.3). Pluvial flooding occurs when there is inadequate drainage for the amount of rainfall that falls in a given area (Rosenzweig, et al., 2018). Pluvial flooding can be split into two different categories: flash flooding and surface water flooding.

Flash floods are defined by the National Weather Service as:

> "A flood caused by heavy or excessive rainfall in a short period of time, generally less than 6 hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through riverbeds, urban streets, or mountain canyons sweeping everything before them. They can occur within minutes or a few hours of excessive rainfall. They can also occur even if no rain has fallen, for instance after a levee or dam has failed, or after a sudden release of water by a debris or ice jam" (National Weather Service (NWS), n.d.).

Rainfall flows over the surface of the landscape as it moves toward the established drainage system but when the amount of rain is higher than the capacity of the drainage system to drain the water, the water floods at points where the flow is restrained.

Surface water floods are specifically associated with urban environments and occur when there is insufficient drainage and the water discharges into the streets or surrounding structures (National Oceanic and Atmospheric Association (NOAA), 2021). Urbanization has been linked to an increase in flash flooding due to the increase in impermeable surfaces (Konrad, 2003). In South Carolina since 2000, there have been 440 flash flood events as recorded in NOAA's Storm Event Database (National Oceanic and Atmospheric Association, 2023)

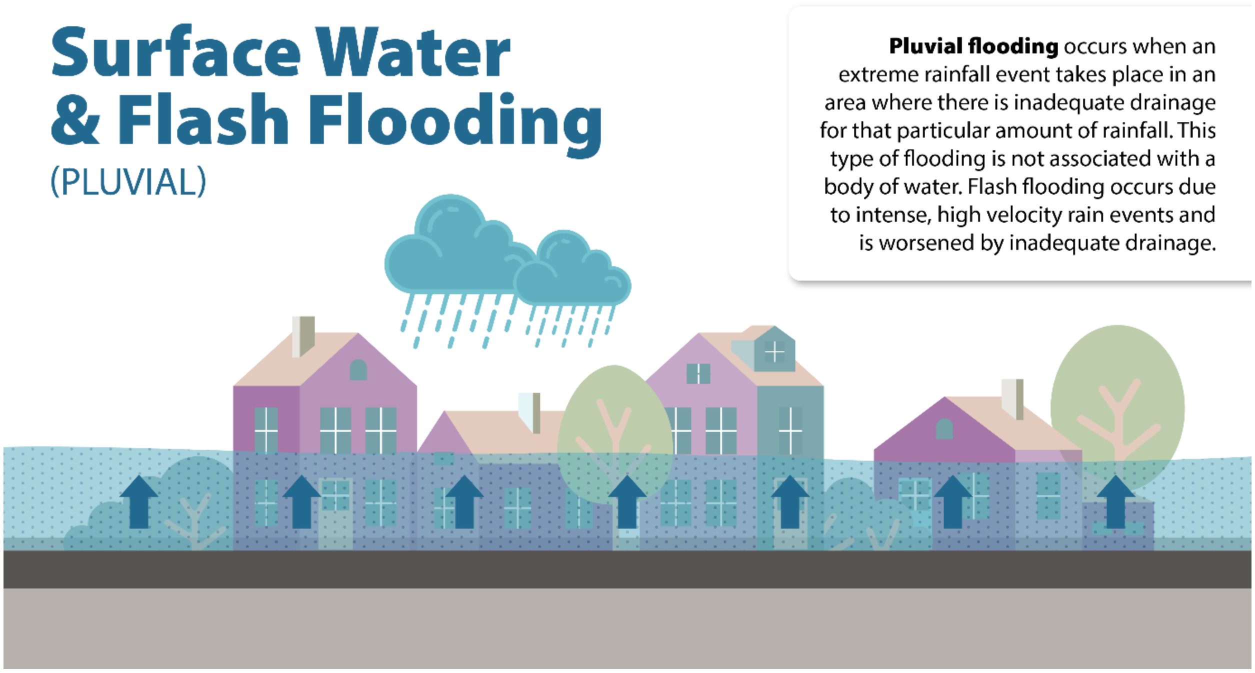


Figure 5.3: Pluvial Flooding (SCOR)

COASTAL FLOODING

The coastal system is complex and impacted by the interactions of inland flooding and marine processes. Coastal flooding can be caused by storm surge, high tides, compound flooding, and sea level rise. Onshore winds and the gravitational pulls of the moon and sun on the earth can also amplify coastal flooding events.

STORM SURGE

For coastal communities, storm surge flooding is often the greatest hazard during a hurricane and can be defined as a rise of water generated by a storm that is higher than the normal tides (Figure 5.4). A hurricane's strong winds and low barometric pressure drive the storm surge. Wind-driven storm surge is the main component of surge and is produced by water being pushed toward the shore by the force of the winds moving cyclonically around the storm. The strong winds of hurricanes rotate around its center while converging toward the center. The convergence creates a mound of seawater. As a hurricane approaches a coastline, the mound causes rising water levels. As it moves toward land, strong winds also push seawater ashore to the right of its track with respect to its forward motion, causing the highest storm surge to affect areas just to the right of a hurricane's eye as it moves ashore.

The component caused by low pressure is small compared to the wind's contribution, about five percent of the total. Water bulges upward in areas of low pressure, and the bulge becomes more pronounced as pressures drop.

When the storm surge impacts land, it pushes water up waterways, into infrastructure, and over land, appearing as a temporary increase in sea level. The rise can be rapid, sometimes like a tsunami (National Hurricane Center, 2023). Since storm surge is independent of tides and waves, the flooding it causes can be additive in its risk and brings destructive wave action to areas not normally affected.

The 1989 landfall of Hurricane Hugo caused 13 impact fatalities (mostly drownings) and $8 to $10 billion in damages (National Oceanic and Atmospheric Association (NOAA), 1989; National Oceanic and Atmospheric Association, 2023). Since Hugo, there has been a significant federal, state, and local investment in many coastal management policies (such as mandatory evacuation orders) and projects (such as beachfront flood mitigation) (SC Department of Health and Environmental Control (DHEC), 2022). For example, over 60 million cubic yards of sand have been placed along South Carolina beaches and dunes over the last several decades

(Elko, et al., 2021). Such large-scale beach and dune restoration projects may have reduced flood risk along the South Carolina beachfront (Kana & Barrineau, 2021).

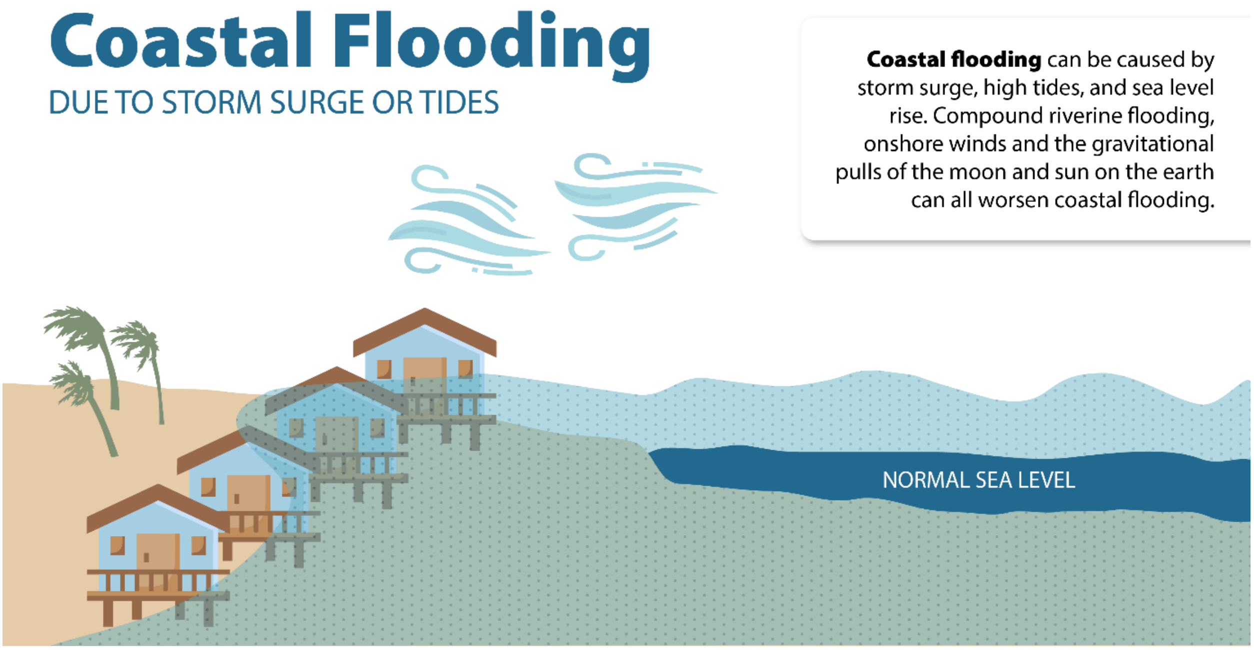


Figure 5.4: Coastal Flooding (SCOR)

TIDAL FLOODING

While coastal flooding caused by large events such as tropical storm surge receive a lot of attention, small, sustained changes in the system can be equally disruptive. For example, tidal flooding is low level inundation that disrupts daily activities, associated with high tides (Moftakhari, AghaKouchak, Sanders, Allaire, & Matthew, 2018). In low lying coastal areas, major damage is often associated with high tide flooding. High tide flooding has increased in the U.S. by about 50% in the last 20 years (National Oceanic and Atmospheric Association (NOAA), 2021).

When the moon is in alignment with the earth and sun during the full or new moon, it has a greater gravitational effect on the tides. The moon’s orbit around the earth is elliptical with the furthest point of the ellipse called apogee and nearest point perigee. Spring tides occur when the moon orbit is in perigee or apogee (Figure 4). As the Earth rotates around the sun, the moon’s orbit changes in reference to the sun (Espenak & Meeus, 2006). When perigee occurs with the full or new Moon, about 6-8 times a year, higher than average spring tides flooding can occur (National Oceanic and Atmospheric Association, 2021). These perigean spring tides, commonly referred to as “king tides” or “spring tides”, along with the increase of sea level, have started to regularly flood coastal roads and marsh front shorelines that have not historically.

As sea level continues to increase along the South Carolina coastline (described in more detail in the next section), everyday occurrences such as high tides and coastal winds can cause flooding events. High tide flooding along estuarine or marsh front shorelines has increased due to the low-lying nature of the South Carolina coastline and increased development of coastal communities. Along with estuarine flooding events, higher tides also impact our beaches and dunes and may be causing additional erosion in these environments.

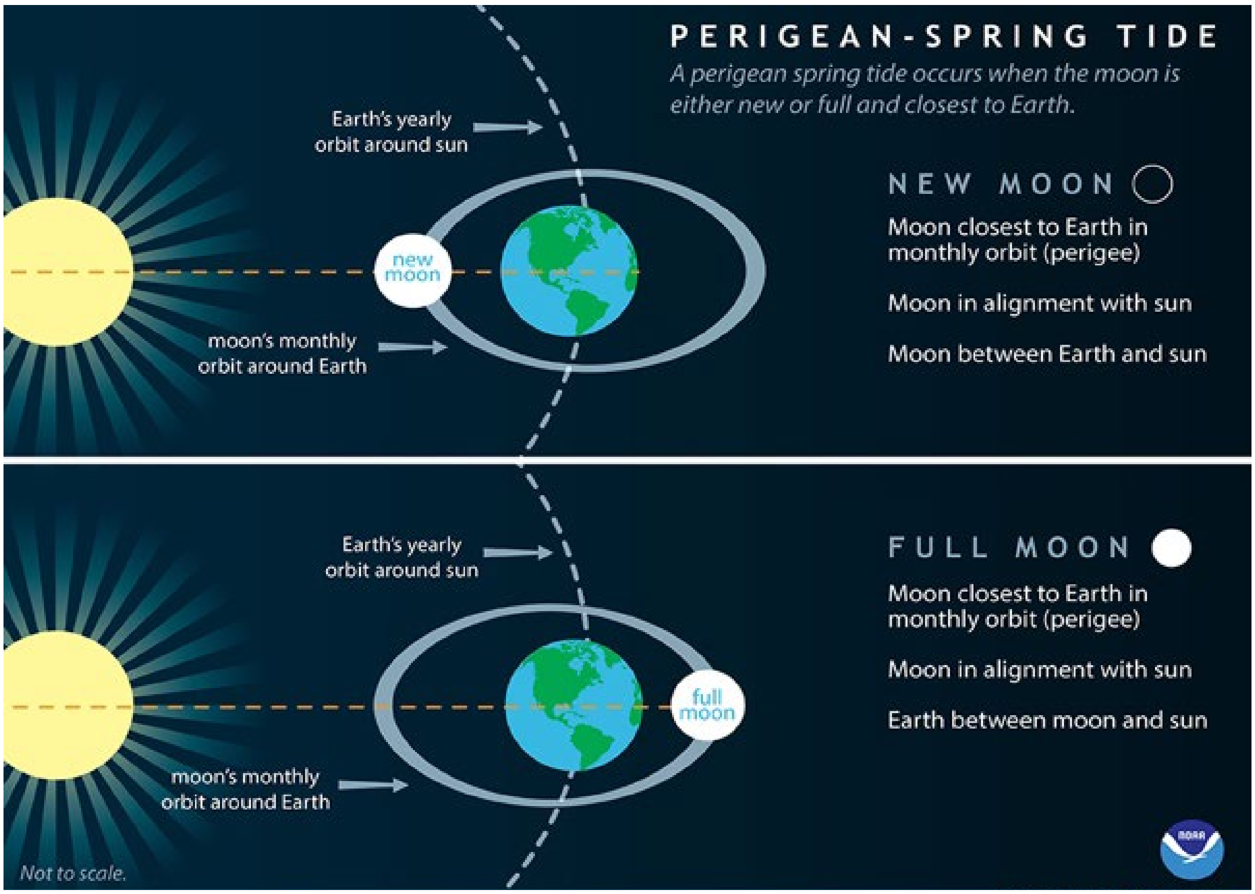


Figure 5.5: The moon's position within its orbit strongly influences gravitational pull on the Earth's tides (NOAA, 2021).

COMPOUND FLOODING

Compound flooding occurs when extreme tides, storm surge, pluvial or fluvial flooding combine in coastal areas (Wahl, 2017; Bevacqua, et al., 2020). Within coastal systems, flooding is rarely caused by a single driver (Wahl, 2017). The low-lying nature of South Carolina's coastlines means that flooding often compounds. This also makes cataloging the cause of impacts to a specific type of flooding difficult. In the National Center for Environmental Information database, storm surge and tides are not credited with any damage nor injury or deaths

(National Oceanic and Atmospheric Association, 2023). This may be because when recent storm surge has occurred, there has also been pluvial or fluvial flooding reported to the National Centers for Environmental Information (NCEI) database (National Oceanic and Atmospheric Association, 2023).

SEA LEVEL RISE

Climate model experts have developed a range of plausible future sea level rise scenarios, ranging from extreme, high, intermediate-high, intermediate, intermediate-low, and low (Figure 5.6). Sea level rise is not a new concept and has been observed in South Carolina with Charleston Harbor tidal gage since 1920, cataloging a rise of 10.9 inches since 1950 (South Carolina's Sea Level is Rising, 2022). Sweet et al. (2022) at NOAA project that sea level will continue to rise and have described six difference scenarios, extrapolation from observed tidal gages, low, intermediate-low, intermediate, intermediate-high, and high. The extrapolated observed tidal gage or present trajectory scenario calculates median sea level rise to be 16.14 inches (0.41 meters) by 2050, which falls between the intermediate (14.17 inches or 0.36 meters) and intermediate-high (16.93 inches or 0.43 meters) (Figure 5.6) (Sweet, et al., 2022). These scenarios support planning and decision-making in light of uncertainties regarding sea level rise risk. Higher-end projections represent scenarios in which South Carolina’s sea level rises precipitously while lower-end projections showcase more conservative sea level increases. Long-term planning, however, must consider a broad range of possible outcomes, including high-consequence, low-probability events.

Following discussions with the Statewide Resilience Plan Advisory Committee, SCOR determined that the intermediate to intermediate-high scenario should be considered in the development of the Statewide Resilience Plan. While the intermediate to intermediate-high scenario should be considered for future projects, SCOR recognizes the need to ensure a balanced approached to resilience that considers economic and environmental needs. Therefore, project-specific factors, such as the consequences of failure, current and future economic feasibility, and environmental impacts, may warrant the use of higher or lower projections. SCOR worked with scientists at University of South Carolina, SCDNR Climatology Office, and Carolinas Integrated Sciences and Assessments (CISA) to generate a report that includes an analysis of South Carolina’s observed climate record, translation of model output into future state-level climate projections, and synthesis of relevant peer-reviewed research. The findings of this report can be found in Chapter 4.

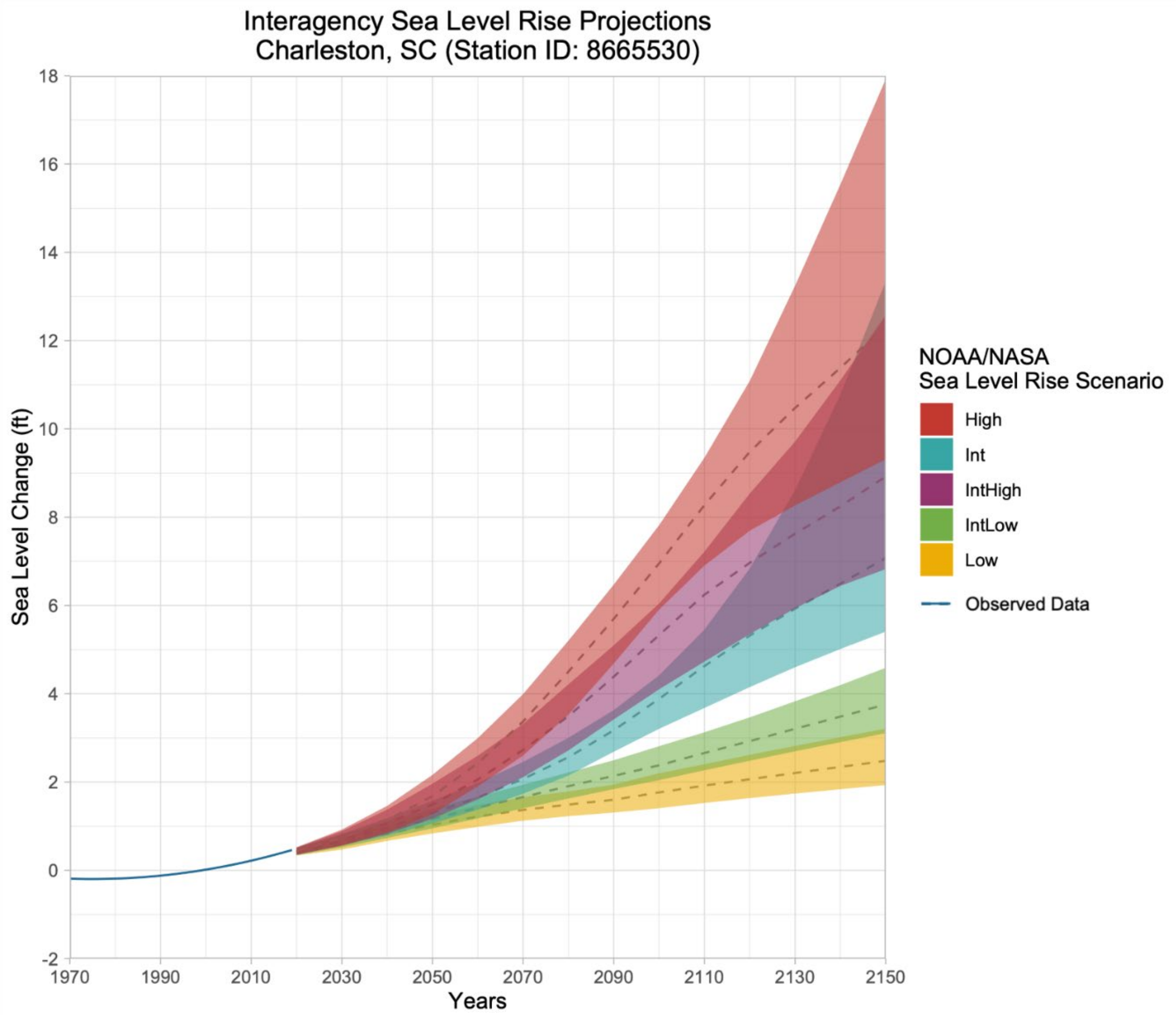


Figure 5.6: Sea level rise projections for Southeastern United States from NOAA's recent report (Sweet, et al., 2022). Edited from Sweet et al. (2022) Figure 2.3.

According to historical data at the Charleston Harbor gauge, "major" (8+ ft) flood events as well as the overall number of flood days have increased from 1970 to 2021 (Figure 5.7 and Figure 5.8) (National Weather Service (NWS), 2022). In fact, half of the top heights at the Charleston gauge have occurred since 2016, coinciding with tropical systems. However, as seen in the figures below, flood days are not limited to tropical system events. Most of the flooding days are a result of tidal flooding.

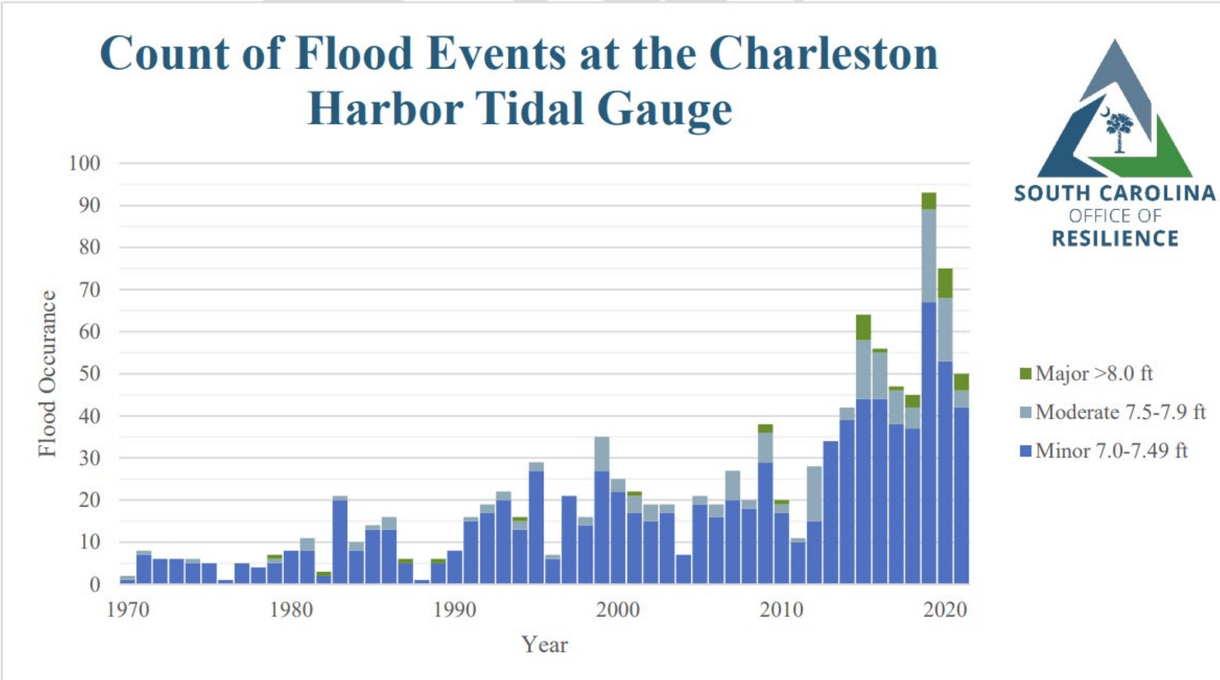


Figure 5.7: Number of flood events at Charleston Harbor gauge (National Weather Service (NWS), 2022).

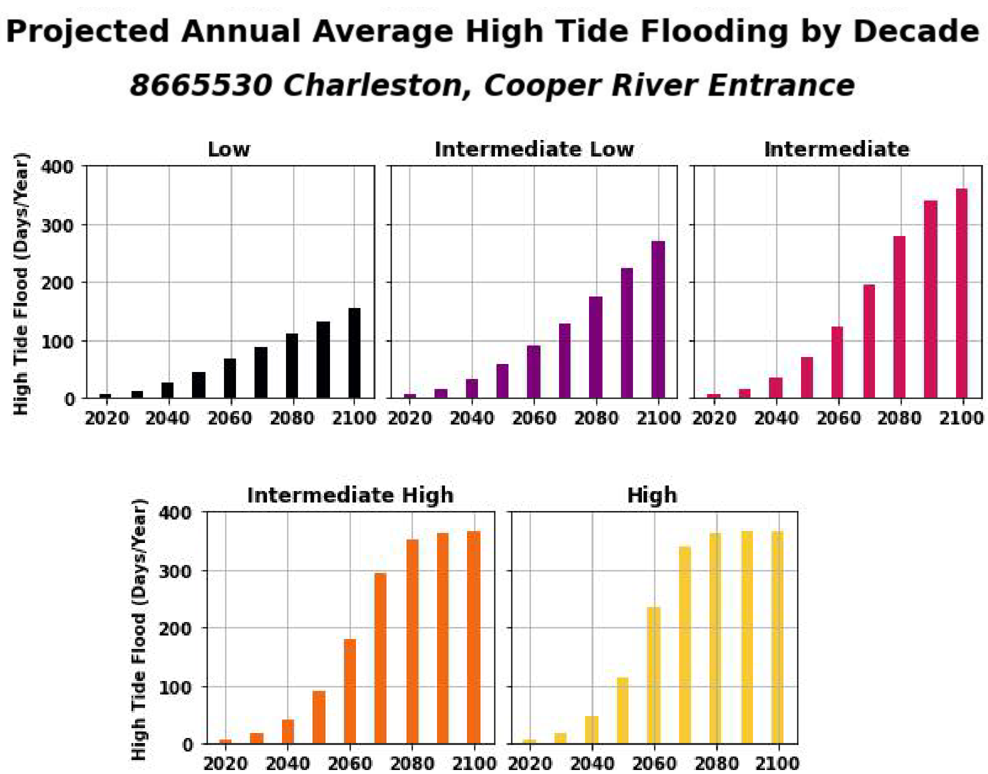
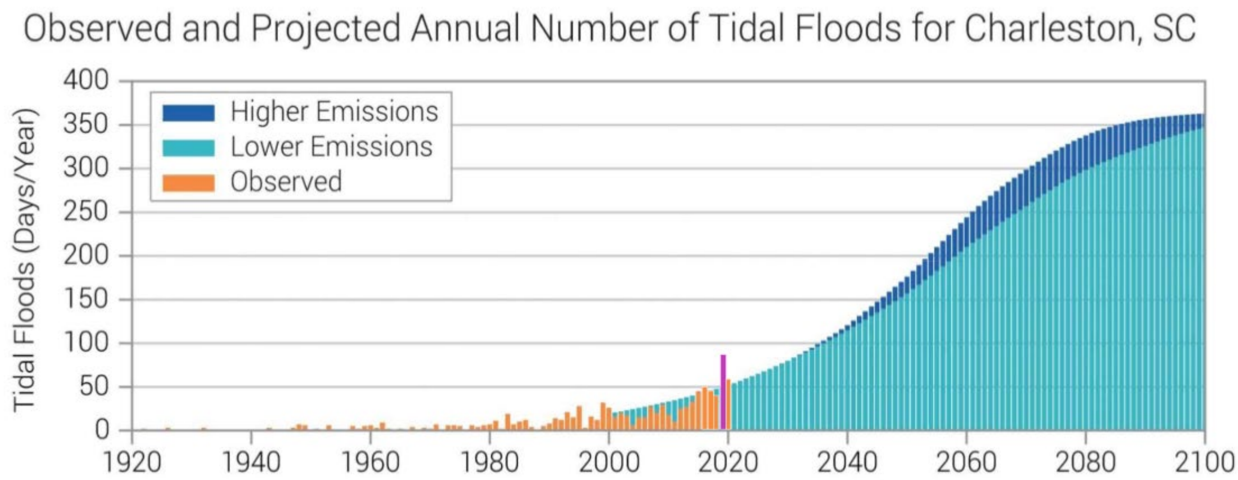


Figure 5.8: Total number of flood days at Charleston Harbor gauge, edited from (National Oceanic and Atmospheric Association, 2022)

Figure 8 combines the historical tidal floods in Charleston and pairs it with projected figures based on higher and lower emission pathways. Current projections have tidal flooding in Charleston doubling to over 100 days a year by 2040 and up to 350 flooding days by 2100.



Source: NCA State Summaries, NOS/ NOAA

Figure 5.9: Observed and projected annual number of tidal floods for Charleston, SC (NCA State Summaries, NOS/NOAA)

In addition to the general flood risk from sea level rise, the projected trend will have wider reaching community effects, including erosion, a higher groundwater table, saltwater intrusion, corrosion of underground infrastructure, and the migration of salt marshes. One consequence of sea level rise is the impact to groundwater resources. The surficial, or unconfined, aquifer in the coastal region interacts directly with the sea water through tidal pumping through the unconsolidated sandy sediment that makes up the coastal areas in South Carolina. As sea level rises, the saltier ocean water layers under the fresh ground water due to density differences and as tides fluctuate, the water table will rise with the rising tide (Bowes et al., 2019; Cooper, 1964; Hoover et al., 2017; Plane, Hill, & May, 2019; Rotzoll & Fletcher, 2013). The rising of the water table also has detriments to pluvial flooding events due to the decreasing ability of the ground to absorb rainwater during a rain event. A secondary, non-flooding hazard associated with sea level rise is an increase in saltwater intrusion into coastal aquifers. Saltwater intrusion is not new to South Carolina and impacts many coastal drinking water sources. According to the USGS Report 2009 –5251, saltwater intrusion in Hilton Head Island has been observed since the 1970s and is described and modeled in the report (Payne, 2010).

LAND SUBSIDENCE

Land subsidence is the gradual sinking or settling of the land surface due to a variety of factors such as natural geologic processes, compaction, and groundwater pumping. When it occurs in coastal communities, it can have severe impacts on the surrounding environment and human populations. One of the primary impacts of land subsidence on coastal communities is increased vulnerability to flooding and storm surges. As the land sinks, sea levels effectively rise, exacerbating the risk of coastal inundation during extreme weather events.

In South Carolina, land subsidence is currently measured using InSAR satellite by the USGS in its most recent release of data (Barnard, et al., 2023). Coastal South Carolina has an estimated subsidence rate of approximately 0.15 cm per year (cm/yr) or 0.059 inches per year (in/yr). The average is not distributed equally across the coastal area (Figure 5.10). The coastline can experience up to 0.75 cm/yr (0.3 in/yr) of subsidence, with the Charleston area experiencing anywhere from 0.46-0.25 cm/yr (0.18-0.1 in/yr) (Figure 5.10). While InSAR data can be useful for examining land subsidence, the potential for error in remote measurements necessitates the need for direct instrumentation. At least three extensometers, which are used to measure vertical land movement, are needed along the coast to monitor and measure land subsidence. These extensometers should extend through the full sediment stack so that the causes of land subsidence can be determined. Causes may include excessive groundwater extraction, surficial weighting, or natural processes.

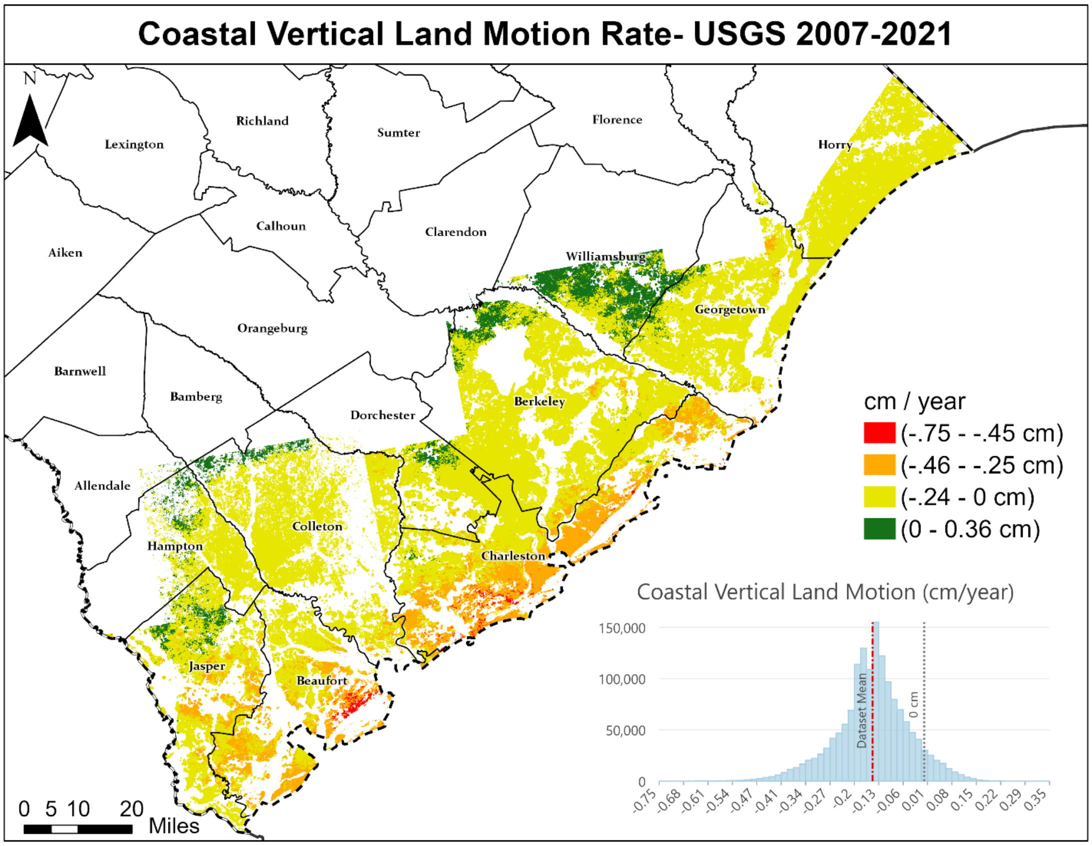


Figure 5.10: Land subsidence in coastal South Carolina (Barnard, et al., 2023)

DAM FAILURE

The South Carolina Dams and Reservoirs Safety Act charges DHEC with administration of a program to protect citizens' health, safety, and welfare by reducing the risk of failure of dams. Dams are regulated based on the height and/or amount of water impounded by the structure according to the following criteria:

- Measures 25 feet in height from the invert of the receiving stream or natural ground
- Capable of impounding 50-acre feet or more
- Smaller than either of the criteria above but failure of the dam would likely result in loss of human life, regardless of size

Dams regulated by DHEC are classified based on the hazard brought about to life and property should the dam fail. Hazard classifications are high hazard, significant hazard, and low hazard (Table 5.2).

Table 5.2: Dam Hazard Classifications (DHEC)

Hazard Classification	Classification Description
High Hazard (Class I)	Dam failure would likely result in loss of life or serious damage to home(s), industrial and commercial facilities, important public utilities, main highway(s) or railroads
Significant Hazard (Class II)	Dam failure wouldn't likely result in loss of life but may damage home(s) industrial and commercial facilities, secondary highway(s) or railroad(s) or interrupt the service of relatively important public utilities.
Low Hazard (Class III)	Dam failure may cause minimal property damage to others. Loss of life is not expected.

The regulations promulgated under authority of the act specify the process of obtaining permits for the construction of new dams and for the alteration, repair, or removal of existing dams.

The regulations outline the procedures for inspection of regulated dams and issuance of maintenance/repair orders, as well as emergency orders in situations where there is imminent risk of dam failure which may impact life or property. Dam owners are responsible for maintenance of the structural integrity of their dams.

In 2015, 51 dams failed in the Midlands, Pee Dee and Lowcountry due to the historic rainfall and subsequent flooding associated with Hurricane Joaquin (SC Department of Health and Environmental Control , n.d.). Since 2015, all 652 high and significant hazard dams in the state have been assessed and the state has invested significant resources in the state's dam safety program (SC Department of Health and Environmental Control , n.d.). In 2018, the SC General Assembly directed DHEC to focus the resources of the Dams and Reservoirs Safety Program on regulating the state's high and significant hazard dams only and reclassifying dams when the failure or improper operation of a dam will likely result in loss of human life (2018 Joint Resolution 231 (S.1190)). Considerable efforts and resources have been directed to activities to mitigate the risk of dam failure, and the resultant flooding that would ensue. These include:

- Development of an Emergency Action Plan (EAP) template to guide the actions of owners during a potential dam failure
- Increased staffing to ensure that dams are properly classified and inspected in accordance with the regulations
- Development of dam breach models for most regulated dams to assess potential impacts of dam failure. These are available on a dedicated agency web application.
- Procurement of communications tools, currently ReadyOps, to communicate with dam owners during extreme events

- Development of Screening Level Risk Analysis for High Hazard Dams to gain a more thorough understanding of the risk of dam failure
- Expansion of training and owner outreach initiatives to further the understanding of the responsibility dam owners play in maintaining their dam in a safe condition
- Coordination with SCEMD to include a "Dams Annex" in the South Carolina Hazard Mitigation Plan

HISTORICAL FLOOD IMPACTS

Flooding has the potential to cause major damage to the communities, economies, and ecosystems of South Carolina. South Carolina has 8 major watershed basins and hundreds of sub-basins, along with 2,876 statute miles of shoreline and 30,000 miles of rivers and streams (SC Department of Natural Resources, 2020; National Oceanic and Atmospheric Association, 2016).

As of December 31, 2021, South Carolina ranks 5th in the nation for the number of National Flood Insurance Program (NFIP) policies, with 202,098 in effect (Federal Emergency Management Agency, 2021).

According to the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) Storm Event Database, there have been 807 reported flood events in South Carolina since 2000 (Table 5.3) (National Oceanic and Atmospheric Association, 2023).

Table 5.3: Flooding synopsis in South Carolina by type, 2000-2022 (National Oceanic and Atmospheric Association, 2023).

Event Type	Event type Count
Coastal Flood	60
Flash Flood	491
Flood	197
Hurricane / Tropical Storm / Storm Surge / Tide	59
Total	**807**

RECENT STORM EVENTS

Since 2015, there have been multiple major natural disasters that have caused flooding in South Carolina. These storms caused debilitating damage throughout large sections of South Carolina. Water and wind damage from these events caused homes to become unlivable. Those without the means to repair their homes were either forced to live in unsafe structures, relocate with relatives, or flee the disaster area. The damage continued to be felt by the local economy as businesses lost customers and local government tax revenues diminished. Some communities experienced damage from all three storms and are still struggling to recover and thrive years later. More detailed descriptions of these events as well as other historic floods impacting South Carolina can be found in SCDNR's SC Keystone Riverine Flooding Events report.

OCTOBER 2015 (EXTREME RAIN EVENT/ HURRICANE JOAQUIN)

There was historic precipitation across the state from October 1st- 5th, 2015 associated with Hurricane Joaquin. As described by SCDNR Climatology Office, in late September and early October in 2015, Joaquin temporarily stalled off the coast of South Carolina due to a cold front crossing the state and a high-pressure system to the north (SC Department of Natural Resources, 2015). The interaction of these systems caused a large-scale flow of moist air over the Carolinas and record amounts of rain, with some areas receiving greater than 26 inches over the first week of October (SC Department of Natural Resources, 2015). The rain caused historic flooding across large portions the state, specifically in the midlands and coastal areas. During this event, an estimated $1.5 billion of property, infrastructure, and agricultural damage occurred, 51 regulated dams failed (South Carolina Department of Health and Environmental Control, 2016), and 19 fatalities occurred (National Oceanic and Atmospheric Association, 2016). A more detailed report of this event by SCDNR Climatology Office can be found on their website.

OCTOBER 2016 (HURRICANE MATTHEW)

Hurricane Matthew made landfall near McClellanville, a small fishing community in Charleston County, as a category one hurricane on October 8, 2016. Hurricane Matthew moved slowly across the Carolinas coastline. More than 15 inches of rain occurred in northeastern South Carolina over a 12-hour period. This caused significant flash and riverine flooding in the Pee Dee River Basin and northeastern portion of South Carolina. The peak stage on the Little Pee Dee River at Galivant’s Ferry, USGS Gage 02135000, was 17.1 ft, where major flood stage is 12 ft. The Waccamaw River, USGS Gage 02110704, crested at 17.9 ft, both breaking records set in 1928 from the Okeechobee Hurricane (Weaver, 2016). At the Conway Marina USGS river gage, the major flood stage is 14 feet (United States Geological Survey (USGS), 2023). Major flood stage is defined by NWS as extensive impact to structures, roads, homes, and evacuation may be required. This level of flooding is correlated with the “50” to “100-year” recurrence intervals (National Weather Service (NWS), 2023).

There was significant flooding at the junction of the Lumber and Little Pee Dee Rivers and the surrounding area. During Hurricane Matthew, large amounts of water drained through these rivers and at the convergence and caused significant flooding in the area, including the Town of Nichols. Although not directly in the path of Hurricane Matthew, the town lost 261 homes and almost 150 residents were rescued (Adcox, 2016; Edwards, 2020). A more detailed report of this event by SCDNR Climatology Office can be found on their website.

SEPTEMBER 2018 (HURRICANE FLORENCE)

Hurricane Florence made landfall near Wrightsville Beach, NC, on September 14th, 2018, resulting in significant storm surge and historic rainfall in both North and South Carolina. More than 26 inches of rain fell in Loris, SC, setting a rainfall record (Stewart & Berg, 2019). Riverine flooding occurred in Chesterfield, Darlington, Dillon, Georgetown, Horry, and Marion Counties in South Carolina. In Conway, the Waccamaw River crested at 22.1 ft and flooded close to 1,000 homes and businesses (National Weather Service, 2018). The impacts of the hurricane and subsequent flooding is estimated to have caused $600 million in property damage, evacuation of close to 500,000 people, and major damage to 550 homes (National Oceanic and Atmospheric Association, 2023).

UNDERSTANDING FLOOD RISK & VULNERABILITY

In the first portion of this chapter, we discuss the common monitoring, data, and modeling tools that can be used to assess risk and vulnerability. Then, this chapter provides an assessment of potential losses across the state by combining hazard data with statewide datasets of assets and facilities. In addition, this chapter looks at the intersection of flood hazard exposure and the social factors that influence vulnerability.

ENVIRONMENTAL MONITORING AND DATA

To best assess flood risk and vulnerability, an extensive network of environmental monitoring datasets is needed. Relevant to this planning process has been scientific or modeling data from the following sources: federal agencies (NOAA, USGS, NWS), state agencies (SCDNR, DHEC, SCDOT, and S.C. Sea Grant Consortium), academia, community interest groups, and non-profits. Environmental data is generally widely available and most data owners or managers have website portals that allows access to data such as tide levels (NOAA and SECOORA), land use (NOAA), water quantity (USGS). However, some environmental datasets are not as easy to access or query in order to find data, data descriptions, or data managers.

UGSG RIVER GAGES

In South Carolina, the USGS river gage network is used to monitor river stage (height) and discharge and is the standard used for decision making and environmental monitoring. River gages are needed to monitor the volume of water in the system to aid in water resource management, flood management, ecological monitoring, aid in infrastructure planning and design, and monitor changes to the system through time. South Carolina has roughly 159 USGS river gages throughout the state (Figure 5.11). SCDNR recently received funding to install 30 additional gages. In South Carolina, many agencies, industries, power suppliers, agricultural users, scientists, and communities use the USGS river monitoring network and contribute funding to maintain and operate gages. There are also endeavors to identify more cost effective methods and pilot new technologies to monitor water quantity and quality such as the Intelligent River Project on the Savannah River.

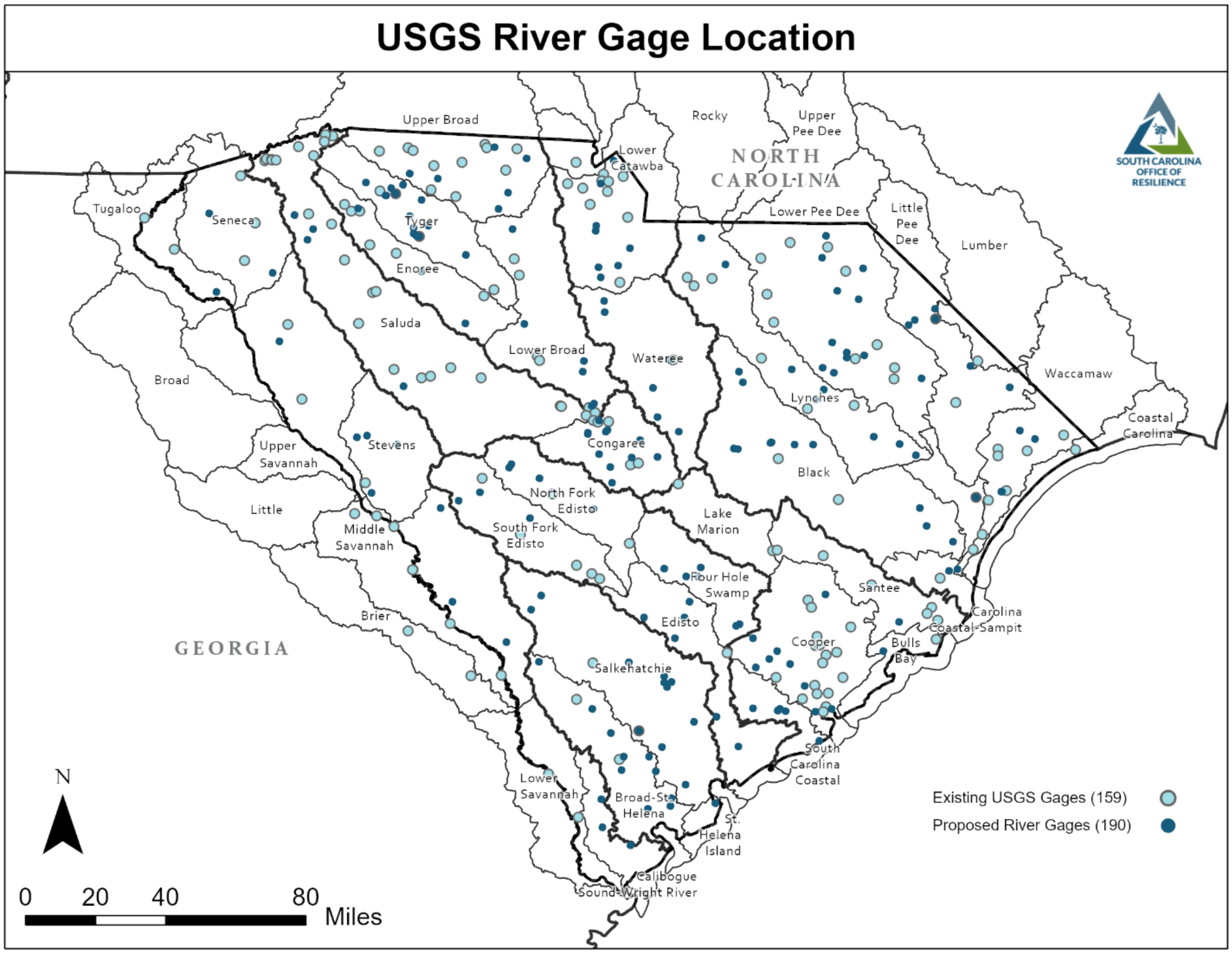


Figure 5.11: USGS river gages and proposed new water level gages in South Carolina

TIDAL GAUGE

There are currently two NOAA Center for Operational Oceanographic Products and Services (CO-OPS) tidal gauges in South Carolina, in Charleston and Myrtle Beach, and one in Savannah, Georgia (Figure 5.12). Similar to USGS river gages, the NOAA CO-OPS stations provide robust high accuracy data and require routine maintenance. These data produced by these monitoring stations inform modeling, monitor sea level trends, and support navigation. New technologies have allowed for lower cost sensors to supplement the NOAA CO-OPS program. These sensors allow communities to monitor tidal levels and provide local level decision makers with additional observations. For example, 18 Hohonu monitoring stations have been installed in South Carolina (Figure 5.12) through a Southeast Coastal Ocean Observing Regional Association (SECOORA) funded project to bring these low cost sensors to communities through the Southeast.

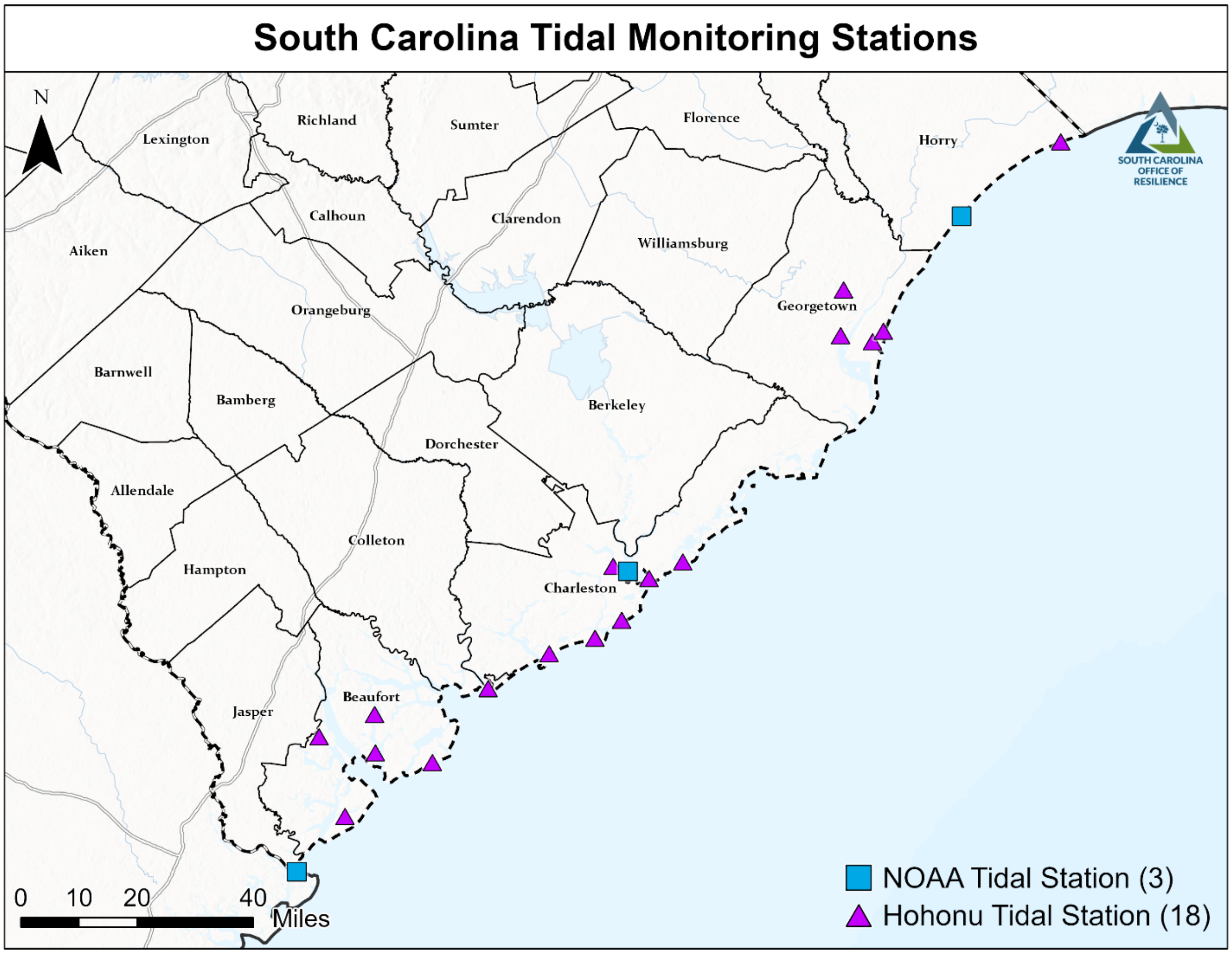


Figure 5.12: NOAA CO-OP and Hohonu Tidal Station Locations Throughout South Carolina

WEATHER STATIONS

The South Carolina State Climatology Office and the National Weather Service Forecast Offices serving South Carolina use several different weather monitoring networks, including the Cooperative Observer Program (COOP), the Remote Automated Weather Stations (RAWS), the Automated Surface Observing Systems (ASOS), and the Automated Weather Observing System (AWOS). These networks monitor and provide data regarding air temperature, precipitation, soil temperature, evaporation, and snow fall. The existing stations utilized by these networks provide an incomplete coverage of South Carolina.

MODELING AND COMPUTATIONAL TOOLS IN SOUTH CAROLINA

Computer models are useful tools that simplify and represent a complex system. With advancements in computer technology, models have increased in accuracy and speed, but have yet to account for every variable that influences a system. Models are built to answer specific questions and are not always useful to guide decision makers on those questions that are outside the original intent of the model. In many cases, several models are consulted depending on the needs of decision makers. The following section reviews a few of the models currently used in South Carolina:

Table 5.4: Existing Models, Data Processing and Managing, and Decision-making tools

Software / Tool Name	Source	Focus
SCDNR Floodplain Inundation Modeling and Mapping Initiative (in development)	SCDNR	Vulnerability Assessment Emergency Management
HEC-RAS 2D (Hydrologic Engineering Center's River Analysis System)	US Army Corps of Engineers	Steady and Unsteady River Hydraulic Calculations
CHEOPS (Computer Hydro-Electric Operations and Planning Software)	HDR, Inc	Hydroelectric Systems
Storm Water Management Model (SWMM)	EPA	Drainage system modeling
NOAA Atlas 14	NOAA	Precipitation Frequency Estimates Infrastructure Design
Bridge Watch	SC DOT	Bridge Monitoring & Alerts
First Street Flood Model	First Street Foundation	Property Level Statistics Current & Future Hazards

SCDNR FLOOD INUNDATION MODELING AND MAPPING INITIATIVE

Since 2016, SCDNR has been tasked with assisting with search and rescue through the production of inundation maps for specific storm events. These maps cover about 25% of the state and are available to be updated as needed.

Through the support of Hazard Mitigation Grant Program funding, the SC Flood IMPACT website was developed to provide inundation information to the public and emergency officials. Currently, three HUC 8 watersheds within the greater Pee Dee watershed are live on the websiteThe rest of the Pee Dee Watershed and a portion of the Santee Watershed are currently under development.

HEC-RAS 2D

The US Army Corps of Engineers (USACE) developed the Hydrologic Engineering Center's River Analysis System (HEC-RAS) to perform one-dimensional steady flow and one and two dimensional unsteady flow calculations, sediment transport / mobile bed computations, and water temperature / water quality modeling (US Army Crops of Engineers, 2022). SCDOT uses HEC-RAS to:

- Design bridges and culverts
- Verify water elevations
- Calibrate of existing models
- Analyze existing structure capacity

CHEOPS

The Computer Hydro-Electric Operations and Planning Software (CHEOPS) was developed by HDR, IncThe model simulates the physical changes and operational constraints of hydroelectric systems. It is used by the Catawba-Wateree River Basin Council and Duke Energy to manage reservoirs and dams (HDR, 2014).

SWMM

EPA's Storm Water Management Model (SWMM) is used for planning, analysis, and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems. It can be used to predict runoff quantity and quality from drainage systems. SWMM was developed to help support local, state, and national stormwater management objectives to reduce runoff through infiltration and retention and help to reduce discharges that cause impairment of waterbodies (Environmental Protection Agency, 2022).

NOAA ATLAS 14

The NOAA Atlas 14 is a precipitation frequency estimation of 5-minutes through 60-day durations at average recurrence intervals of 1-year through 1,000-year (Bonnin, et al., 2006). This allows the calculation and representation of rain amounts at particular locations and for given durations. These curves are used by agencies and stakeholders to design infrastructure, environmental management, stormwater management, hydrologic studies, floodplain and watershed management, and many others. In South Carolina, the Atlas 14 curves were lasted updated in 2006 utilizing data ending in the year 2000 (Bonnin, et al., 2006)

SCOR, the SC Department of Transportation (SCDOT) and SC Department of Natural Resources (SCDNR) have agreed provide funding to include South Carolina in the update of the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Rainfall Intensity- Duration – Frequency (IDF) Curve Numbers for the Mid-Atlantic region. Once completed, the updated IDF Curve numbers for SC will include data gathered after 2000 and allow for a better understanding of the probability of rain events. In addition to updating curve numbers with more recent historical data, IDF Curve numbers that use downscaled global climate projections have been proposed by NOAA as Atlas 15. The first volume of Atlas 15 will address nonstationarity to the present day, while the second volume will include forward-looking projections. Once released, the updated Atlas 14/15 numbers should be used to update regulation and guidance utilized for planning and design.

BRIDGEWATCH

BridgeWatch is a web-based monitoring software that allows SCDOT to predict, identify, prepare for, manage, and record potentially destructive environmental events. BridgeWatch is an application that centralizes and makes accessible all database and site information through an interactive web interface. This application allows SCDOT to efficiently perform the following activities.

- Maintain Plan of Action and flood monitoring data for Federal Highway Administration (FHWA) compliance
- Monitor bridges over water and floodplains for rainfall and flow thresholds using radar and gage adjusted radar rainfall data, USGS gages, NWS rainfall predictions, and SLOSH (Sea, Lake, and Overland Surges from Hurricanes) and ADCRIC (Advanced Circulation) tidal surge predictions modeling programs
- Continuously monitor bridges for seismic events using USGS data
- Analyze threshold alerts sent to SCDOT personnel for rainfall, riverine, tidal, and seismic events
- Access real-time graphical display of geographic data, an inventory of structures being monitored, and the list of those structures experiencing their respective critical event
- Prepare a watch list of structures identified for action according to user-defined protocols

FIRST STREET FOUNDATION FLOOD HAZARD LAYERS (VERSION 2.0)

First Street Foundation describes itself as:

> “A non-profit research and technology group dedicated to quantifying and communicating those risks by incorporating world class modeling techniques and analysis with the most up to date science available in order to simply, and effectively, inform Americans of their risk today and into the future from all environmental changes” (First Street Foundation, 2022).

The foundation produces high resolution flood maps by modeling three main flood types (fluvial, pluvial, and coastal) in different modeling software with 3-meter digital elevation models (DEM) and then combining the flood type models into a single coverage of flooding for each scenario. The modeling software used is Fathom-US for fluvial, a proprietary model for pluvial that integrates the high-resolution DEMs with the NOAA Atlas 14 curves, while coastal flooding is modeled in multiple software packages (GeoCLAW, ADCIRC, and SWAN) due to the complexity of coastal modeling. The Flood Hazard Layers, V2.0, model conditions 30-years into the future. These are then historically validated to corroborate the models based on past events.

Property level statistics allow for an estimated flood inundation level for various modeled scenarios. To model future climate scenarios, First Street identified that the IPCC RCP 4.5 carbon emission scenario is the median projection for future change. To calculate the property value, First Street uses ComeHome by HouseCanary's AVM (Automated Valuation Model), paired with parcel & building characteristic data from such platforms as Lightbox.

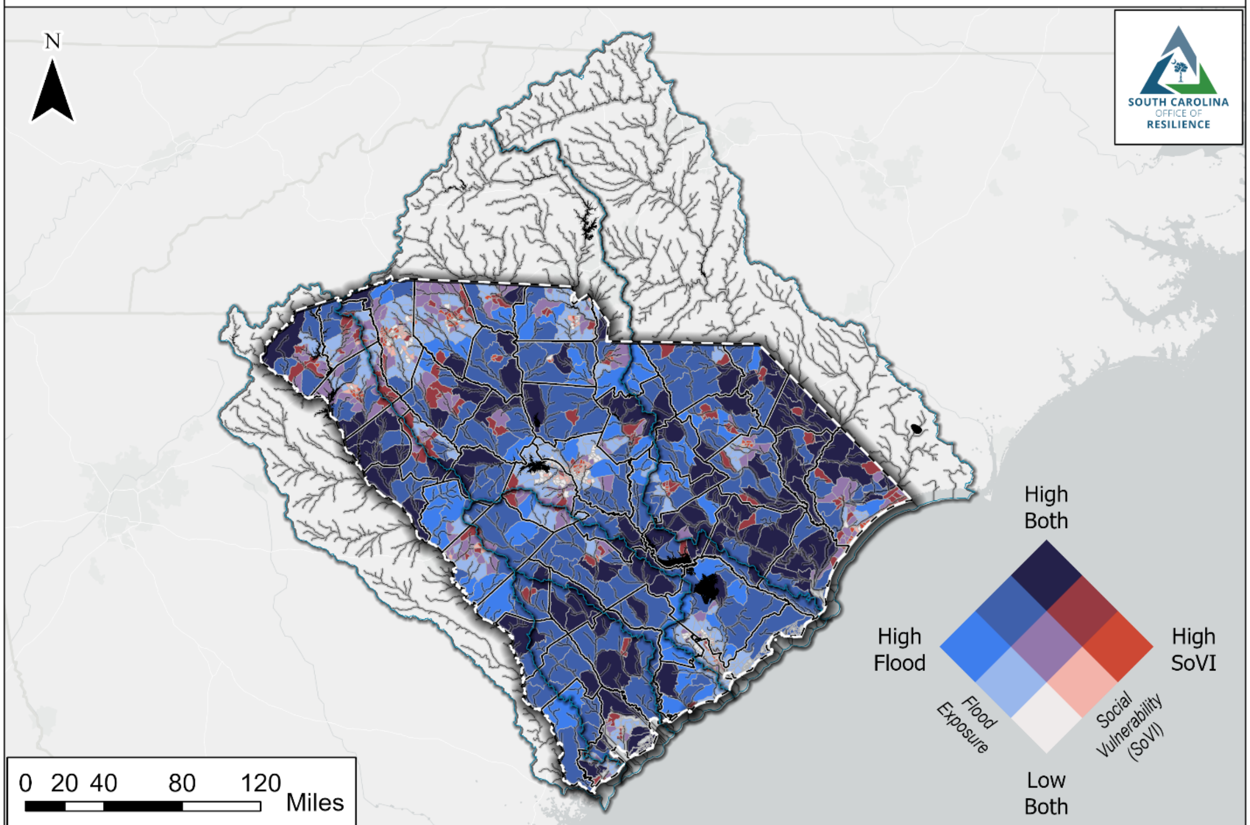
As with any model, there is inherent error due to the limited data available. South Carolina does not keep a complete dataset of parcel statistics at the state level; this data is maintained by counties and municipalities and held in a non-standardized format. Given the national scale of the model, it is a good screening tool, but site-specific modeling is likely needed for answering specific critical questions at more localized scales.

SOCIAL VULNERABILITY & FLOOD RISK

The Social Vulnerability Index (SoVI®), compiled and processed by the Hazards Vulnerability and Resilience Institute at the University of South Carolina (HVRI), measures the social vulnerability of counties in the United States, providing information on "where there is uneven capacity for preparedness and response and where resources might be used most effectively to reduce pre-existing vulnerability" using 29 socioeconomic variables (University of South Carolina, 2022). Total scores, percentiles, and individual scores for each component are available to allow for specific analysis about what demographics drive local vulnerability.

SoVI® overlaid with the 2022 1% annual flood event, as shown by the First Street Foundation model, is shown in Figure 5.13. Appendix D provides these maps by counties to identify areas with high social and physical vulnerability to flooding, while Appendix E contains county level maps for the 2022 1% annual flood event as shown by the First Street Foundation model without the social vulnerability overlay.

Flooding Exposure and Social Vulnerability



Flood Exposure is calculated as the percentage of the Census Tract flooded at a depth greater than 6 inches during a 1% Annual Chance Flood according to the First Street Foundation Flood Model. Social Vulnerability (SoVI) was distributed by the FEMA National Risk Index. SoVI scores are classified by the tract's ranking relative to the rest of South Carolina.

Figure 5.13: Flooding Exposure and Social Vulnerability. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

VULNERABILITY BY SECTOR

DATA SOURCES

FLOOD DATA

First Street Foundation provides parcel level statistics that identify registered parcels across the state. If the parcel has a building on it, the first-floor elevation is used to determine flood inundation, and if not, the point of inundation evaluation is at the geometric center of the parcel. In the following analysis, parcel and property is used interchangeably. This data allows SCOR to not only identify properties that may currently flood, but also plan for potential flooding under various scenarios in the future. In assessing flood vulnerability, the First Street Foundation's flood maps pair well with the FEMA floodplain maps. When comparing the "100-year" flood maps, the First Street Foundation's high-resolution floodplain maps complement and provide additional coverage in areas that have historically reported flooding but which have not been represented or are underrepresented by the FEMA maps. The First Street Foundation's model served as the basis for quantifying the vulnerability of the assets below to flooding. The First Street Foundation's 2022 and 2052 1% annual chance flooding event models were overlaid with data sets obtained from state partners and public sources

SECTOR DATASETS

The data identification, collection, and coordination of this chapter was completed in coordination with the subcommittees of the Strategic 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 to 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. Table 5.5 summarizes the flood vulnerability point analysis. Locations for each sector are overlaid with flood inundation model data. The table summarizes the count of facilities with estimated flood depth of none, 6 to 12 inches, 1 to 2 feet, 2 to 3 feet, and greater than 3 feet under both current and future conditions. Sector specific maps are expanded upon later in this chapter. This broad view of how flooding puts South Carolina at risk is useful for planning purposes, but more specific analysis would be needed to comprehensively assess risk level at a specific facility, building, or campus.

Table 5.5: Summary Table of point count by inundation levels for each by sector.

Vulnerability by Sector		Flood Inundation Depths					
	Year	0 ft	6 inches	1 foot	2 feet	3 feet	> 3 feet
Residential							
Mobile Homes	2022	1,493	1	36	37	10	9
Mobile Homes	2052	1,487	1	29	40	10	19
Water Supply							
Surface Water Intakes	2022	57	1	1	1	2	25
Surface Water Intakes	2052	57	1	0	2	1	26
Groundwater Intakes	2022	688	1	30	23	17	56
Groundwater Intakes	2052	679	3	32	24	6	71
Hazardous Waste Locations							
NPDES Sewer System Discharge	2022	106	2	12	21	16	78
NPDES Sewer System Discharge	2052	102	4	10	16	16	93
Dry cleaners	2022	406	0	8	9	5	14
Dry cleaners	2052	396	2	11	13	1	19
Mines	2022	1,015	5	38	49	27	94
Mines	2052	1,002	5	35	56	28	102
Solid Waste Landfills	2022	105	0	1	2	1	2
Solid Waste Landfills	2052	105	0	1	2	1	2
Solid Waste Facilities	2022	1,199	2	43	42	21	67
Solid Waste Facilities	2052	1,183	2	40	45	25	79
Site Assessment, Remediation, and Revitalization Facilities	2022	5,529	15	46	86	44	139
Site Assessment, Remediation, and Revitalization Facilities	2052	8,482	14	53	92	46	172
Hazmat Treatment, Storage, and Disposal Facilities	2022	40	0	4	4	1	2
Hazmat Treatment, Storage, and Disposal Facilities	2052	39	0	4	3	1	4
Underground Storage Tanks Sites	2022	16,099	31	301	381	202	400
Underground Storage Tanks Sites	2052	15,856	38	344	401	215	560
Community Services							
Local Law Enforcement Offices	2022	308	0	4	6	3	6
Local Law Enforcement Offices	2052	308	0	4	3	3	9

Detention Centers	2022	81	0	1	0	0	2
Detention Centers	2052	79	1	2	0	0	2
Fire Stations	2022	1,080	2	7	16	11	18
Fire Stations	2052	1,064	2	14	13	8	33
EMS Station	2022	522	0	7	10	6	12
EMS Station	2052	511	0	10	11	7	18
K-12 Education							
Public Schools	2022	1,237	0	10	18	5	8
Public Schools	2052	1,229	1	5	15	8	20
Private Schools	2022	269	0	4	4	5	9
Private Schools	2052	267	0	2	4	1	17
Higher Education							
College and Universities	2022	99	0	1	4	0	1
College and Universities	2052	97	1	1	2	1	3
Health and Human Services							
Public Health Facilities	2022	2,461	0	43	51	18	39
Public Health Facilities	2052	2,426	5	43	59	27	52
Hospitals	2022	105	1	2	0	0	4
Hospitals	2052	104	0	1	0	2	5
Nursing Homes	2022	197	0	0	0	1	3
Nursing Homes	2052	194	0	0	3	1	3
Mental Health Offices	2022	75	0	2	0	0	2
Mental Health Offices	2052	75	0	2	0	0	2
Dialysis Centers	2022	159	0	1	2	0	1
Dialysis Centers	2052	156	0	3	3	0	1
Pharmacies	2022	986	1	16	15	7	23
Pharmacies	2052	971	2	18	18	12	27
Dept. of Health and Human Services	2022	84	0	0	1	2	0
Dept. of Health and Human Services	2052	82	0	2	1	1	1
Childcare Facilities	2022	2,048	2	23	55	23	27
Childcare Facilities	2052	2,025	3	29	48	25	48
Veterans' Affairs	2022	23	0	0	0	0	1
Veterans' Affairs	2052	23	0	0	0	0	1
Places of Worship	2022	5,432	4	160	139	97	77
Places of Worship	2052	5,361	9	171	146	96	126
Infrastructure							
Aviation Facilities (2022)	2022	180	0	3	5	2	6
Aviation Facilities	2052	180	0	3	5	1	7
Power Plants	2022	201	0	4	3	5	9
Power Plants	2052	200	0	5	2	6	9

Substations	2022	2,323	5	56	68	36	88
Substations	2052	2,289	5	66	72	37	107
Economic							
Public Refrigerated Warehouses	2022	8	0	0	0	0	0
Public Refrigerated Warehouses	2052	8	0	0	0	0	0
Manufacturing Accounts	2022	3,378	2	67	85	44	88
Manufacturing Accounts	2052	3,335	3	73	76	49	128
Industrial Buildings	2022	220	0	7	6	0	1
Industrial Buildings	2052	220	0	5	7	1	1
Industrial Sites	2022	474	0	16	27	12	60
Industrial Sites	2052	469	0	21	24	12	63

NATURAL SYSTEMS VULNERABILITY

South Carolina is rich in natural resources. The forests, rivers, lakes, beaches, marshes, mountains, and natural environments are critical resource to South Carolina's communities and economies. The landscapes of South Carolina are used by locals and visitors for recreation, hunting, fishing, and farming. South Carolina's economic drivers rely on these natural resources as a foundation. Coastal communities rely on the beaches and marshlands to draw tourists and for recreational and commercial harvesting of fish and oysters. Farmers rely on the soils and waters to grow crops and trees throughout the State.

These natural systems also provide hazard mitigation and protection benefits to the State. Marshes and beaches absorb storm surge, wetlands and soils absorb stormwaters and hold it in storage until the water can naturally drain into the rivers or groundwater systems. The vulnerabilities of South Carolina's natural systems have been assessed in order to protect the natural and economic value of these resources to the peoples of the State.

FORESTRY

South Carolina has approximately 12.8 million acres of forestland, 87% of which are privately owned (SC Forestry Commission, 2021). Forestry is the second largest manufacturing industry sector and provides approximately $23.2 billion to the State's economy each year (South Carolina Forestry Commission, 2022).

The South Carolina Forestry Commission (SCFC), established in 1927, is charged with protecting and managing the State's forests. Forests have additional economic, ecological, and aesthetic value as natural and recreational areas. Environmental change and natural hazards threaten forests with loss of overall productivity.

Forestland acts as a sponge, absorbing rainfall and then releasing it gradually. Canopy interception of rainfall is one of the primary mechanisms of reducing the amount of runoff. The forest soil absorbs the vast majority of rainfall and slowly releases it, reducing the peak flow following storm events and increasing base flow during drier periods

Depending on species, a mature tree retains 20 to 30% of annual rainfall (U.S. Department of Agriculture, 2020). Healthy forests help slow runoff from rain events in steep terrain, insulating creeks from scouring of the creek banks and beds. They ensure stable hydrology, low sedimentation rates, stable channels, moderate water temperatures (through shading), and woody debris for in-stream habitat.

The main impact from flooding on forest management is infrastructure damage, such as destruction of stream crossings on forest roads. Newly planted tree seedlings occasionally succumb to flooding, but forest stands beyond seedlings should survive short term flooding if they are not submerged for more than 7 to 10 days (SC Forestry Commission, 2015).

NATIVE PLANTS

Flooding can be exacerbated or mitigated by the type of vegetation that exists on a landscapeIn general, native plant species are more resilient and provide significantly more stormwater mitigation capacity. Turf grass roots are short and dense, resulting in sheeting water as storm water runs off instead of absorbing rainfall to allow infiltration back into the ground / aquifer (Selbig, 2010). Native grasses and plants slow down stormwater, their longer and more extensive root systems both absorb more water and create pathways for rainfall to infiltrate into the soil, and ultimately allowing for more ground water recharge and resulting in less erosion (WeConservePA, 2017). Utilizing native plants in flood prone areas allow for ground water infiltration as well as evapotranspiration during the growing season, reducing flood water and standing water more quickly (Davis & Scaroni, 2020).

Native plants have a multitude of co-benefitsNative bird and wildlife species are more likely to be able to use native plants for habitat and they are adapted to growing conditions, climate, and soils in South Carolina, making them low maintenance and saving resources related to mowing, fertilizers, pesticides, and irrigation (SC Native Plant Society, 2023)The long root systems of native grasses cause them to be more resilient both in regrowth and carbon storage in the instance of fires (Kerlin, 2018)Using native plants to divert and retain stormwater runoff allows for filtration and removal of pollutants (Massachusetts Office of Coastal Zone Management, 2023). Riparian buffers along water ways and retention ponds absorb more pollutants and excess nutrients and help to hasten water absorption and decrease runoff through evapotranspiration.

Clemson Extension maintains the Carolina Yards Plant Database containing nearly 300 plants suited to growing in South Carolina as well as several resources to guide landowners on strategies to use native plants to mitigate flooding, including rain gardensAdditionally, SCDNR has established Solar Habitat Guidelines to promote the use of native plants on solar developments, which provide benefits to pollinators and therefore neighboring agriculture, as well as flood mitigation.

BEACHES AND OCEANFRONT

South Carolina’s coastline measures 187 miles containing 98 miles of developed beaches (including public parks) and 89 miles of wilderness areas with limited public access. It should be noted that this figure does not include tidal shoreline, which totals 2,876 miles. The beach/dune system provides the basis for approximately two-thirds of South Carolina's annual tourism industry revenue (South Carolina Code Ann. § 48-39-250 *et seq.*, 2019), which is about $18 billion annually (SC Department of Parks, Recreation and Tourism, 2022). These systems also serve as a front line of defense to beachfront residents and businesses from wind, waves, and storm surge

The main risk from flooding to South Carolina beaches is exacerbated erosion due to sea level riseAs noted in the Coastal Flooding section above, beach and dune restoration (also known as nourishment) has reduced flood risk along much of the developed coastline but requires dedicated funding and planning to sustain. In policy, the Beachfront Management Reform Act of 2018 adopted a state policy of beach preservation. The Office of Coastal Resource Management of DHEC recently convened The South Carolina Beach Preservation Stakeholder Workgroup to make recommendations on how to implement the state policy. SCOR participated in this workgroup. The recommendations are as follows:

> Recommendation 1: Definition of Beach Preservation: The Workgroup recommends that the term “Beach Preservation” be defined as: “maintaining the natural processes and functionality and benefits of the beaches and the beach/dune system critical areas to support storm protection, habitat, tourism, public access, recreation opportunities, and aesthetics.”
>
> Recommendation 2: Establish a Beach Nourishment Technical Advisory Committee: The Workgroup recommends that a technical advisory committee be established to further investigate beach nourishment project specifications, including: Sand quality, Timing windows, Dredge type, Project footprint and borrow area flexibility, Long-term monitoring, Downdrift impact analysis, Bond requirement, Impacts to flora/fauna at beach and borrow sites (beach, benthic, threatened & endangered species).
>
> Recommendation 3: Establish A Pilot Project Ad Hoc Technical Advisory Committee: The Workgroup recommends establishing an Ad Hoc Technical Advisory Committee to evaluate pilot project study proposals, provide written comments and recommendations on project standards and success criteria, and evaluate the findings of such studies. Appointed by DHEC OCRM based on recommendations from stakeholders, this 7-member committee would be comprised of unbiased technical and scientific coastal experts from academia, state and federal resource agencies, coastal engineers, and other subject matter experts. The review and approval process should be rigorous and thorough.
>
> Recommendation 4: Enhance the Pilot Project Authorization Process: The Workgroup recommends that pilot project applications undergo a formal, prescribed process similar to other activities within the State’s critical area. This process would include internal and committee review, an opportunity for public comment, resource agency coordination, and an appeals process. The Workgroup recommends that process requirements include detailed study design, timeline, monitoring, demonstration of how the project will

address the erosional issue, criteria for success, bonding for removal and restoration, and no material harm to the beach environment, flora, or fauna.

Recommendation 5: Modify Pilot Project Statutory Language: The Workgroup recommends that the statutory language under S.C. Code Ann. § 48-39-320(C), *et seq.*, be amended to remove the wording: “Notwithstanding any other provision of law contained in this chapter” and include language in the statute to ensure that pilot projects do not cause material harm to the beach environment, flora, or fauna. The Workgroup also recommends revising the language from ‘the board, or the Office of Ocean and Coastal Resource Management’ to “the Department”.

SALT MARSHES

South Carolina is home to roughly 350,000 acres of saltmarsh, much of which is at risk from sea level rise and lack of management. Some sources estimate that 50% of the original salt marsh habitat in the U.S. has been lost due to human influence over the last century (Kennish, 2001)Globally, it is estimated that 85% of oyster reefs have been lost, with those remaining in poor condition (Beck, et al., 2011). Salt marshes provide essential habitat, wave attenuation, and water filtration. They provide a vital refuge, food supply and breeding grounds for fish, birds, and other wildlife, as well as a unique open space in a dense urban environmentThe associated estuaries are habitat for shellfish and are nursery habitat for juvenile fish species, many of which are economically important to the State. South Carolina marshes provide public and commercial fishing/oystering opportunities, as well as other recreational opportunities such as boating and bird watchingRecreational fishing is a $686 million annual industry (US Fish and Wildlife Service, 2014) in South Carolina. In 2012, commercial fishermen in South Carolina landed 12.3 million pounds of finfish (2.4 million pounds) and shellfish (9.9 million pounds), earning $24 million in landing revenue (National Marine Fisheries Service, 2014). To promote better management, the South Atlantic Salt Marsh Initiative (SASMI) brings together local, state, and federal partners along with community stakeholders to better manage marshes along the Atlantic Ocean from Florida to North Carolina. The SASMI Plan, published in 2023, lays out the framework to improve management and planning for future impacts to the approximately 1 million-acres of marsh along the South Atlantic coastline.

Salt marshes provide services for the State by reducing wave energy, absorbing flooding, and filtering debris and pollutants from the water. Despite decades of regulatory protection, salt marshes continue to be threatened by poor water quality, rising sea levels, encroaching development, illicit dumping, and erosion from boat wakes and flood events. This leaves marshes without adequate room for natural migration. Programs to restore the marsh (e.g., living shorelines) and oyster reefs have had success in increasing resilience along the coast. Figure 5.14 to Figure 5.16 show the projected marsh migration by 2050. Figure 5.17 to Figure 5.19 show projected marsh migration by 2100.

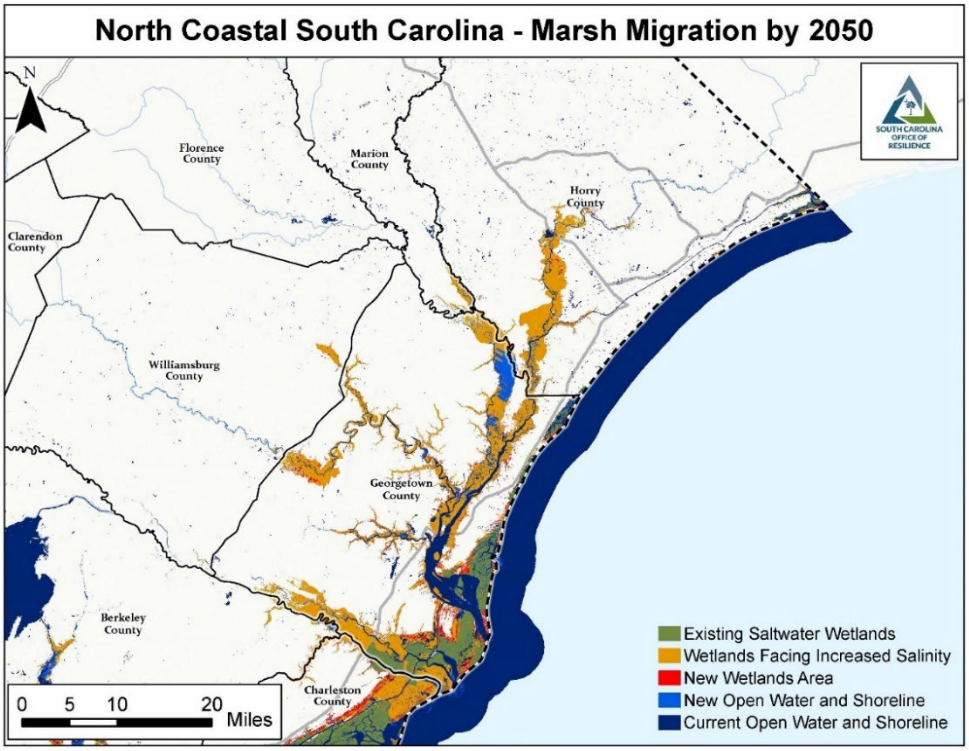


Figure 5.14: Marsh Migration by 2050 in the North Coastal Area of South Carolina

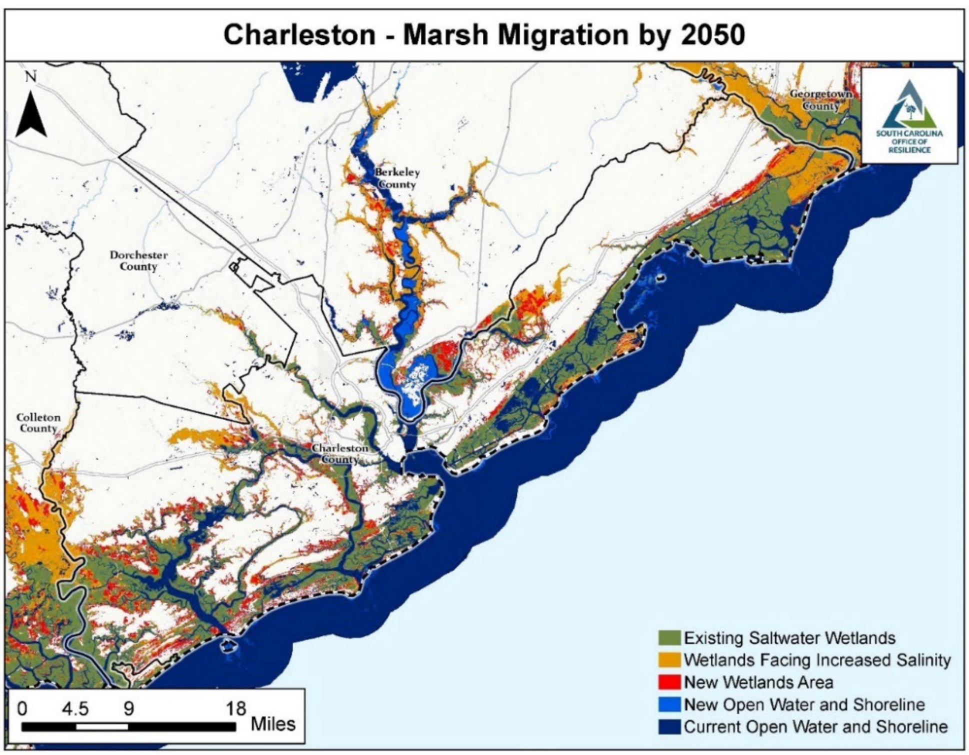


Figure 5.15: Marsh Migration by 2050 in the Charleston Area

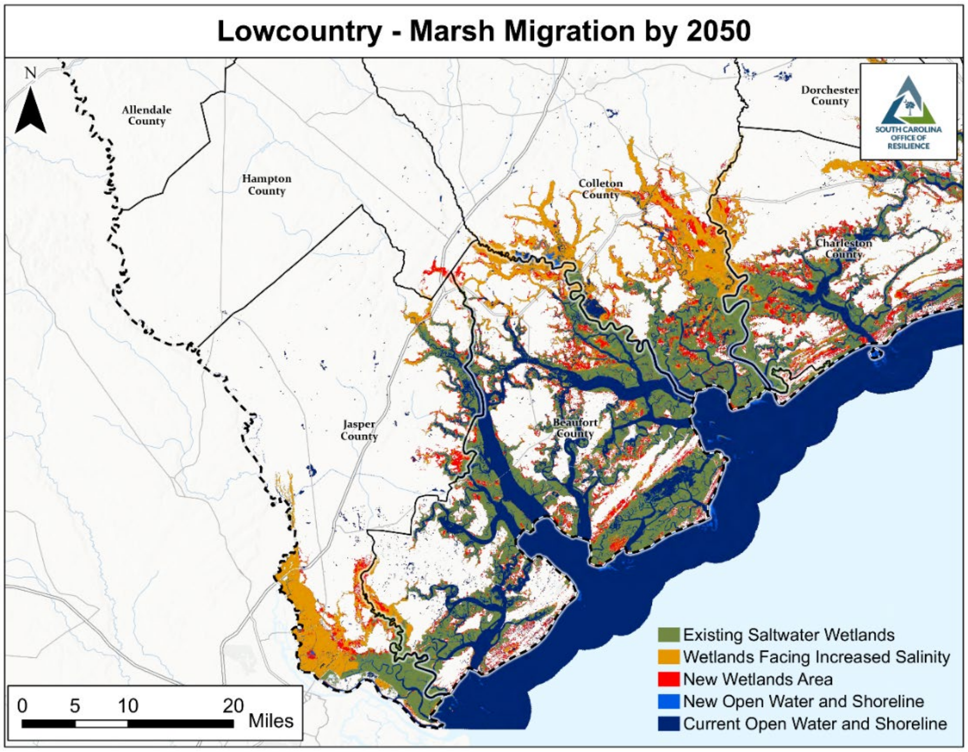


Figure 5.16: Marsh Migration by 2050 in the Lowcountry Area

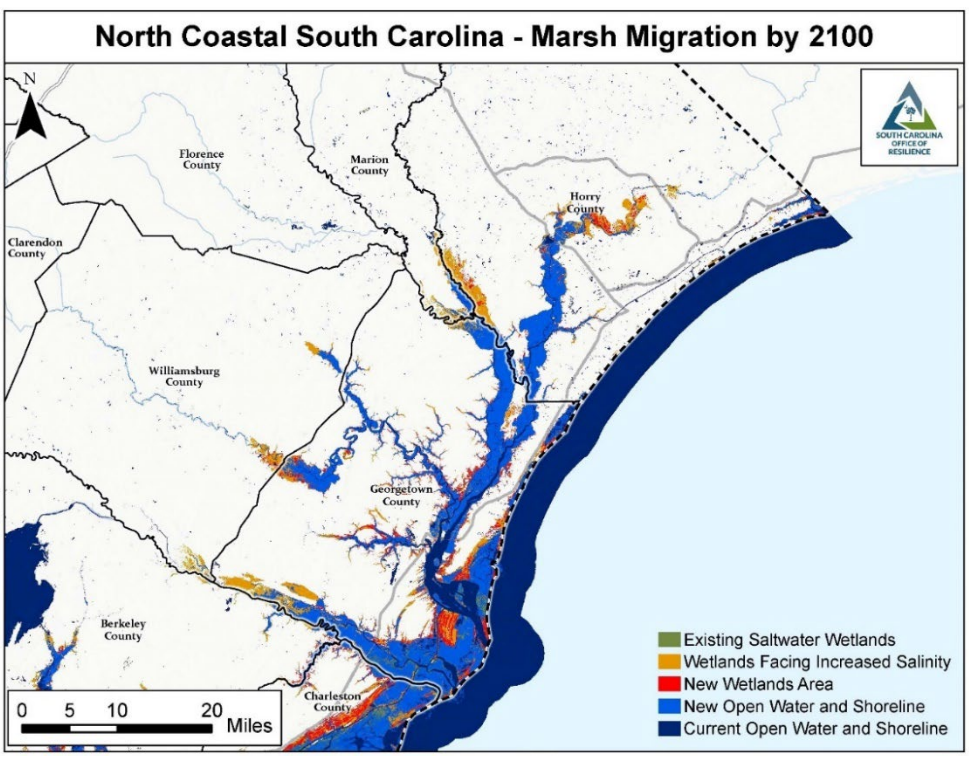


Figure 5.17: Marsh Migration by 2100 in the North Coastal Area of South Carolina

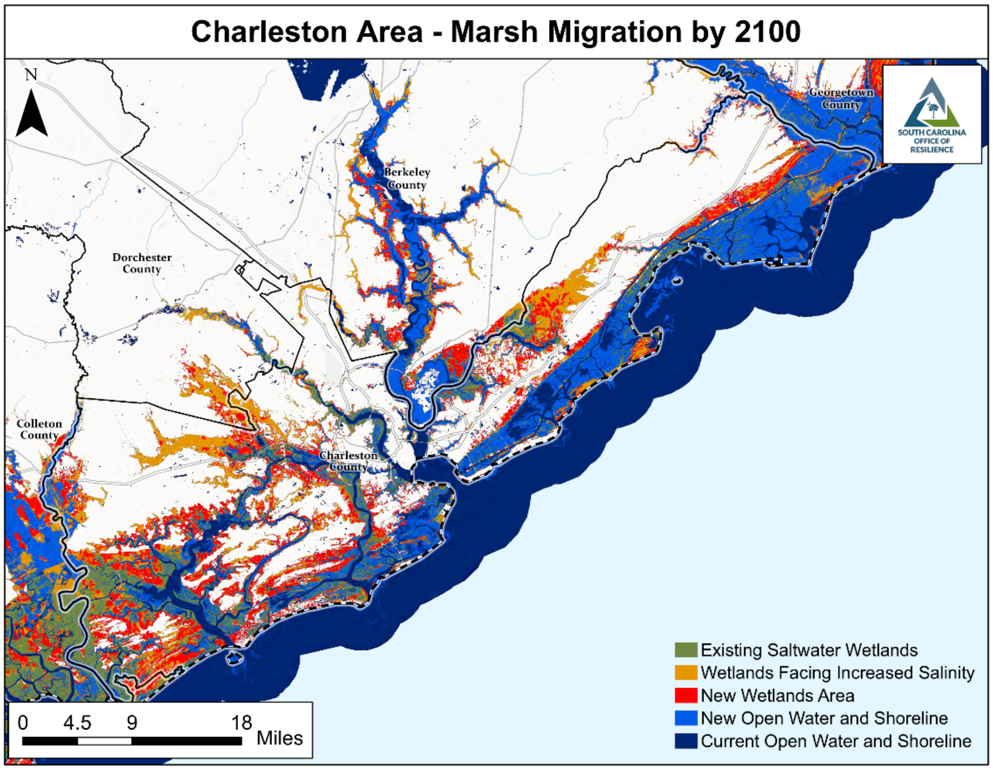


Figure 5.18: Marsh Migration by 2100 in the Charleston Area

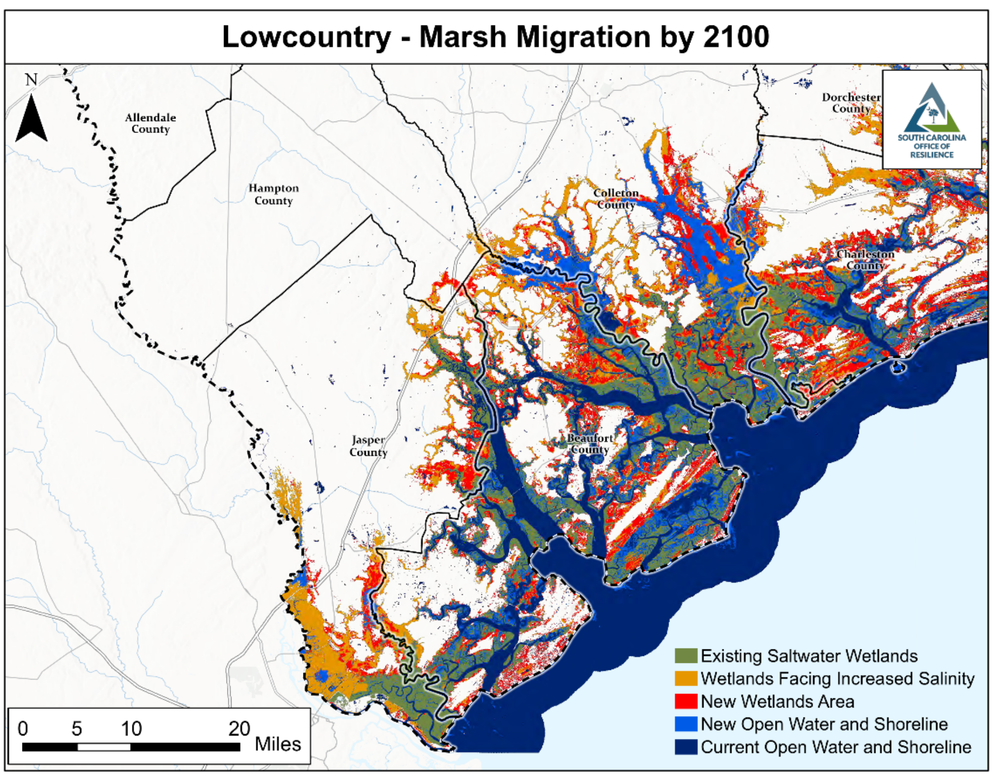


Figure 5.19: Marsh Migration by 2100 in the Lowcountry

WILDLIFE

THREATENED AND ENDANGERED SPECIES

Numerous state and federally Threatened and Endangered species, as well as species tracked in South Carolina's State Wildlife Action Plan (SWAP), depend on South Carolina's habitats for survival and recovery. The SWAP also focuses on priority species in 14 taxonomic groups, identifying 825 species of flora and fauna to include on the State's List of Species with the Greatest Conservation Need.

The plan notes several coastal, freshwater and land species and habitats that may be impacted by flooding. One of the major threats to species noted in the plan is the increase in impervious surfaces contributing to increased runoff. Runoff carries silt, chemicals, and nutrients into water and wetlands that can be lethal to aquatic life.

Along the coast, birds and sea turtles are particularly vulnerable. Least Tern and Wilson's Plovers are both beach-nesting species that are State Threatened. Red Knot and Piping Plover are federally Threatened and Endangered species that rely on South Carolina beaches as critical habitat throughout their life cycle (SC Department of Natural Resources, 2020). Loggerhead Sea Turtles commonly nest on South Carolina's beaches and rely on enough dune space to get beyond the high tide mark to deposit their eggs. The recently listed Black Rail has seen greater than 90% population decline since the 1990s due to sea level rise and its associated nest flooding (ACJV, 2020). In a recent study, 20,000 Whimbrel, almost 50% of the eastern population, were found to congregate on Deveaux Bank during spring migration (Weidensaul, 2021). Tidal marshes are vitally important feeding grounds for these species who breed in the Arctic tundra. Other shorebird species use Deveaux and other barrier islands for breeding. Dredge material has been put to good use building back up islands (i.e. Crab Bank Seabird Sanctuary in Charleston County) used by nesting shorebirds like Brown Pelicans, Black Skimmers, American Oystercatchers, and many more (SCDNR 2023). Marshes also support Seaside Sparrows, and moving further into the maritime forest community, Painted Buntings, Hummock Island Crayfish, and Diamondback Rattlesnakes find refuge (SCDNR, 2015). All of these species are Species of Greatest Conservation Need in South Carolina's SWAP. Protection of the State's beaches, marshes, maritime forests, and barrier islands is critical for the survival of multiple species of conservation concern and the buffering capacity of these landscapes (SCDNR, 2015).

In addition to these coastal vulnerabilities, the SWAP highlights threats to species statewide. The plan highlights the role increased impervious surface plays in increased flooding as well as the associated degradation and loss of habitat.

FEMA's Flood Risk and Endangered Species Habitat (FRESH) Mapping Tool, created in collaboration with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service, allows the user to visualize the ranges and critical habitats of species listed as threatened and endangered under the Endangered Species Act (Federal Emergency Management Agency (FEMA), 2022)

INVASIVE SPECIES

While threatened and endangered species are at additional risk due to flooding, several invasive species have been found to exacerbate flooding in addition to their negative impacts on people and ecosystems. Ineffective marsh protection and/or management, for example, can lead to the damage or destruction of native species that would otherwise provide important ecological benefits (from food sources to structural support to protect against flooding and storms), and the subsequent possible introduction or promotion of invasive species. Many invasive species become introduced into new habitats as a direct result of flooding either through movements to avoid the floodwaters or by being carried by the floodwaters.

> Phragmites: can invade freshwater marshes, outcompeting native vegetation and changing the organic composition of the ground cover. A once open marsh system may become too thick for birds and other wildlife to utilize effectively (K. Bradley, SCDNR Botanist, personal communication 2022). Other species include Chinese Tallow (Triadica Sebifera) which can damage wetlands by out-competing native plants, shading them out, and changing the hydrology of the wetland during the growing season (K. Brdaley. SCDNR Botanist, personal communication 2023).
>
> Feral hogs: can trample cordgrass as they forage for ribbed mussels, disrupting the mutualistic relationship between the bivalve and the grass as well as damaging the marsh ecosystem (Hensel, et al., 2021). Feral swine routinely undermine the integrity of dikes and levees leading to costly repairs. Some repairs have been estimated in excess of $100,000 to replace a single water gate (N. Myers, USDA APHIS WS SC State Director, personal communication 2022). In inland areas, feral hogs can foul waterways with their wallows, spread disease, and destroy sensitive habitats. They are omnivorous and consume plant and animal matter, including rare and declining species of conservation concern (West, Cooper, & Armstrong, 2009).
>
> Invasive zebra mussels (Dreissena polymorpha): have been known to block power intake pipes at power plants and water treatment facilities (Rosaen, Grover, & Spencer, 2016). In South Carolina, there is the potential for impact on storm water drainage pipe systems.

WILDLIFE VIEWING, HUNTING & FISHING

Wildlife and their associated habitat contribute to a significant portion of the state's economy. Fishing, hunting, and wildlife viewing are culturally important to South Carolina and contribute to almost $3 billion in economic value to South Carolina based on a 2017 study (Willis & Straka, 2017). Both local citizens and visitors come to South Carolina to experience natural places. More data can be found in the most recent report on SC's Ocean Economy (S.C. Sea Grant Consortium, 2020)

Hunting of many species is popular in the State and is particularly important to the state's economyThe hunting of deer, alligator, turkey, fur harvesting, small game, feral hog, coyote, armadillo, migratory birds, dove and waterfowls are regulated in the State, with SCDNR enforcing seasons, limits and methods of hunting statewide (SC Department of Natural Resources, 2020) SCDNR publishes harvest reports, which identify the number of over 20 species of waterfowl and migratory birds taken (South Carolina Department of Natural Resources, 2022). A 2001 report estimated $38 million was spent in the State by over 70,000 hunters on migratory bird hunting (International Association of Fish and Wildlife Agencies, 2002).

Coastal impoundments are managed wetlands that were former rice fields or built for protection of the coast from subsidence, high water levels, and high salinity. Although of anthropogenic origin, these impoundments have been a fixture on the landscape long enough to serve valuable ecosystem functions, including supporting wildlife and buffering the coast (Green, Carloss, Rader, & Brasher, n.d.). These areas are highly productive waterfowl and wading bird habitat and support a myriad of other wildlife species. Water levels are managed using gates and other water-control structures and pumps which replicate natural cycles. Some of these freshwater impoundments are threatened by sea level rise and storm surges that breach dikes and cause saltwater intrusion.

Recreation, competition, and commercial fishing are important across the State. Lakes and rivers are home to bass, bream, trout, and other species. The State's major marine fisheries are shrimp, shellfish, crabs, and offshore finish. Many more species are not harvested but are of importance to the ecological food chain, some of which are of conservation concern and listed in the SWAP. During flood events, fish populations can be impacted by the degradation of water quality with the increase of turbidity and runoff from surrounding land (bacteria, fertilizers and other nutrients, heavy metals, hazardous material, auto fluids, trash, and many others) (Clemson, 2022). With the influx of pollutants like nutrients and fertilizers, algal blooms can occur and cause fish kills when the algae growth consumes the oxygen in the water column, thus decreasing the available oxygen that other organisms need to live (Florida Fish and Wildlife

Conservation Commission, 2022). An additional source of oxygen demand placed on aquatic systems during and following flood events is the organic detritus that enters aquatic systems during and following flood eventsAs these materials break down, oxygen can be depleted, stressing aquatic organisms sometimes to the point of mortality

An even greater concern associated with flooding of small impoundments or ponds is the introduction of non-native species into public waters. During flood events, smaller water bodies, like ponds, that are normally isolated from other water bodies can overflow and allow for stocked fish to escape into nearby streams and rivers. Or a reciprocal problem may also occur, where invasive or other fish species that are not a part of the pond management plan may be introduced (Clemson, 2022)

COMMERCIAL & RESIDENTIAL PROPERTIES

The First Street Foundation parcel level data, described above, was paired with the estimated flood inundation levels associated with medium “100-year” flood event to assess the vulnerability of properties in the 2022 and 2052 scenarios. Although the chances of having a “100-year” (1% chance) flood event may seem small, they are significant when considering how risk accumulates over time. For example, a home at risk from flooding during a 1% annual flood event would have at least a 26% chance of flooding over the 30-year timeframe of the average mortgage. The figures below show the count and percentage of parcels, by HUC10 watershed, inundated greater than 6 inches, 1 foot, 2 feet, 3 feet and 6 feet in the 2022 (Table 5.6, Figure 5.20 through Figure 5.29) and 2052 (Table 5.6, Figure 5.30 through Figure 5.39) 1% annual chance flooding events. The flood damage associated with different inundation intervals are described by Risk Factor, a product of First Street Foundation, and presented in Table 5.7 (Risk Factor, 2022).

Table 5.6: Potential damage by flood inundation intervals (Risk Factor, 2022).

Flood Inundation Potential Damage		
	Interior (First Floor)	Exterior
>6 inches	Drywall, insulation, wallpaper, floors, carpets, appliances	Yard plants, root rot, standing water and bug attraction like mosquitoes, and vehicles exhaust could be under water and cause stalling
>1 foot	Electrical outlets 12-16 inch above floor and HVAC systems	Cars can float
>2 feet	Large appliances	Trucks can float
>3 feet	Building foundation and framework, severe damage	Lasting damage to water wells, sewage, plumbing, and septic tanks
>6 feet	Assumed total loss	Assumed total loss

Table 5.7: Number of noncommercial parcels estimated to see greater than 6 inches and greater than 6 feet of inundation in 1% annual chance flood event in 2022 and 2052 statewide. First Street Foundation identifies 2,334,328 parcels in South Carolina currently with their dataset.

Count of Potentially Inundated Parcels					
Year	>6 inches	>1 foot	>2 feet	>3 feet	>6 feet
2022	305,332	234,729	154,867	108,401	43,129
2052	340,038	276,459	187,066	141,040	63,546

2022 VULNERABLE PARCELS

An estimated count of properties impacted by 1% annual chance flooding event by county are listed in Table 5.8.

Table 5.8

County Name	2022					
	Above 0 Inches	Above 6 Inches	Above 1 Foot	Above 2 Feet	Above 3 Feet	Above 6 Feet
Abbeville	756	741	655	450	325	114
Aiken	6,772	6,758	5,635	3,336	2,001	695
Allendale	924	923	677	201	75	12
Anderson	5,045	5,017	4,288	2,645	1,691	534
Bamberg	1,565	1,551	1,119	350	130	3
Barnwell	984	984	737	307	115	8
Beaufort	44,834	43,830	39,173	30,828	24,020	10,924
Berkeley	9,044	8,838	5,730	2,348	1,170	143
Calhoun	1,355	1,343	1,011	534	304	83
Charleston	59,054	57,361	49,124	35,713	26,986	10,427
Cherokee	1,289	1,288	1,153	825	584	221
Chester	1,107	1,101	938	619	415	172
Chesterfield	1,817	1,816	1,469	787	426	129
Clarendon	3,357	3,334	2,011	541	206	12
Colleton	6,088	5,977	5,011	3,960	2,548	1,134
Darlington	4,744	4,705	3,227	1,038	392	41
Dillon	1,650	1,642	1,024	287	87	7
Dorchester	5,513	5,440	3,559	1,530	759	42
Edgefield	1,168	1,166	984	615	382	112
Fairfield	1,690	1,653	1,498	1,159	871	396
Florence	6,824	6,758	3,960	1,016	431	53
Georgetown	14,838	14,536	12,563	9,832	8,345	5,329
Greenville	15,311	15,232	13,174	8,783	5,756	1,832
Greenwood	2,185	2,118	1,806	1,127	644	162
Hampton	1,463	1,454	966	274	97	5
Horry	36,922	35,020	24,648	14,823	10,737	4,106
Jasper	2,993	2,917	1,953	1,185	948	486
Kershaw	2,699	2,654	2,132	1,197	789	350
Lancaster	2,199	2,167	1,859	1,215	765	232
Laurens	2,350	2,264	1,977	1,386	934	284
Lee	1,428	1,412	950	296	126	8
Lexington	6,979	6,843	5,447	2,876	1,565	374

Marion	2,742	2,687	1,686	509	233	33
Marlboro	2,427	2,369	1,665	657	214	18
McCormick	497	490	407	234	131	34
Newberry	1,802	1,709	1,434	880	549	154
Oconee	3,494	3,440	3,117	2,366	1,740	727
Orangeburg	6,066	6,019	3,981	1,367	534	72
Pickens	3,830	3,816	3,445	2,535	1,798	769
Richland	10,329	10,296	8,150	3,813	1,895	456
Saluda	1,264	1,206	983	551	303	53
Spartanburg	7,964	7,876	6,634	4,234	2,672	802
Sumter	6,105	6,062	3,849	1,142	538	67
Union	848	845	767	589	441	155
Williamsburg	4,931	4,809	2,853	820	421	57
York	5,727	5,651	5,002	3,646	2,711	1,419
Total	**312,973**	**306,118**	**244,431**	**155,426**	**108,804**	**43,246**

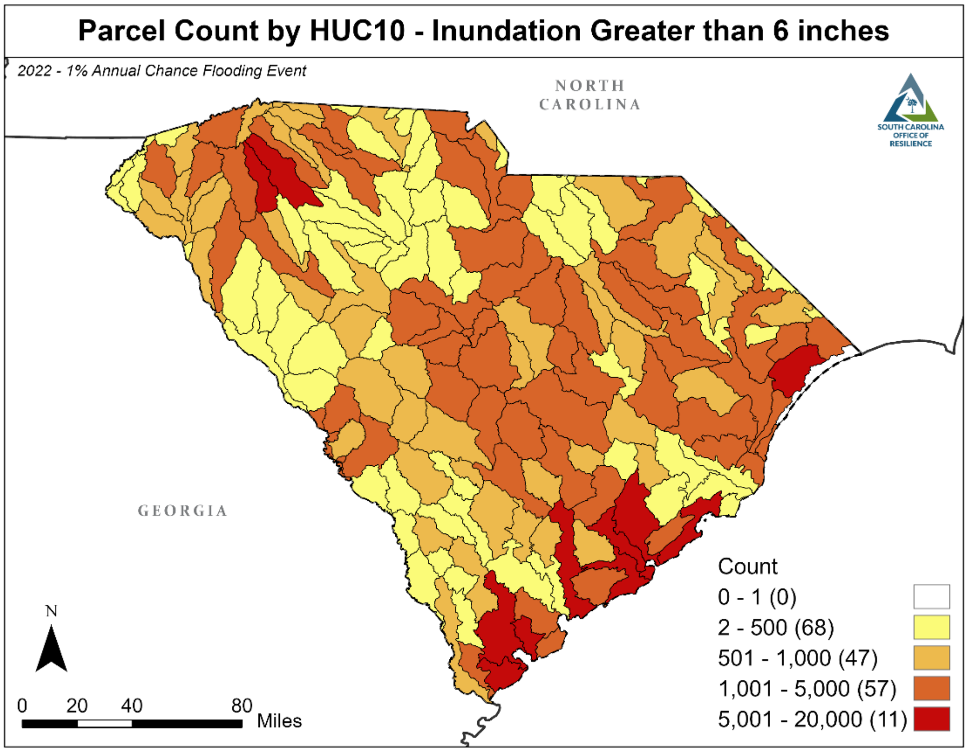


Figure 5.20: Count of parcels by HUC10 estimated to be inundated greater than 6 inches in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

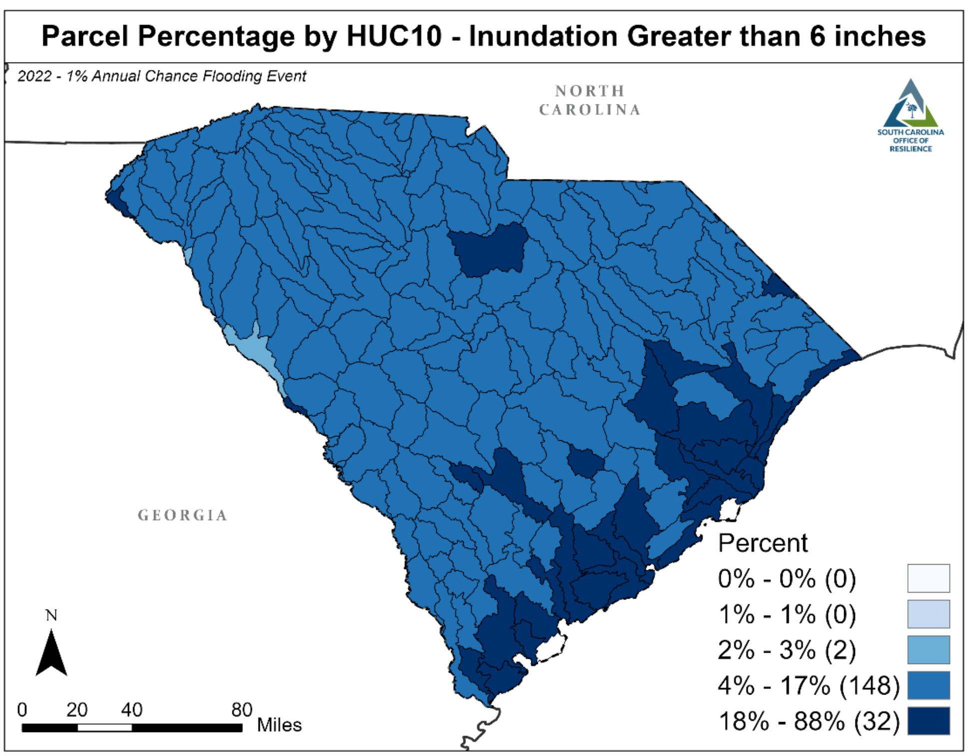


Figure 5.21: Percentage of parcels by HUC10 estimated to be inundated greater than 6 inches in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

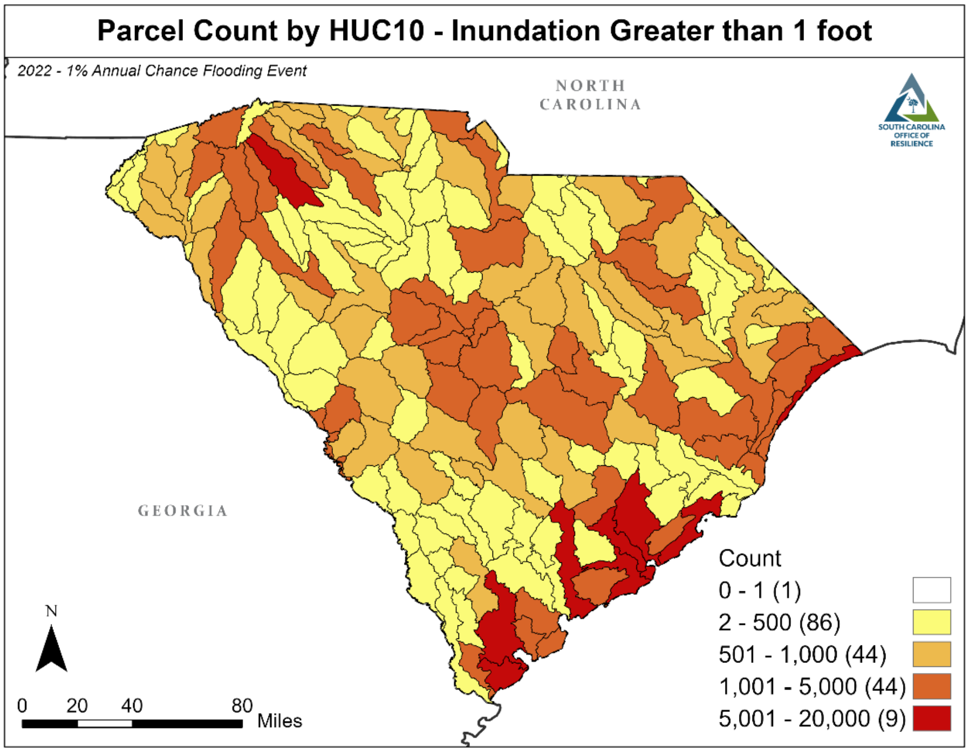


Figure 5.22: Count of parcels by HUC10 estimated to be inundated greater than 1 foot in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

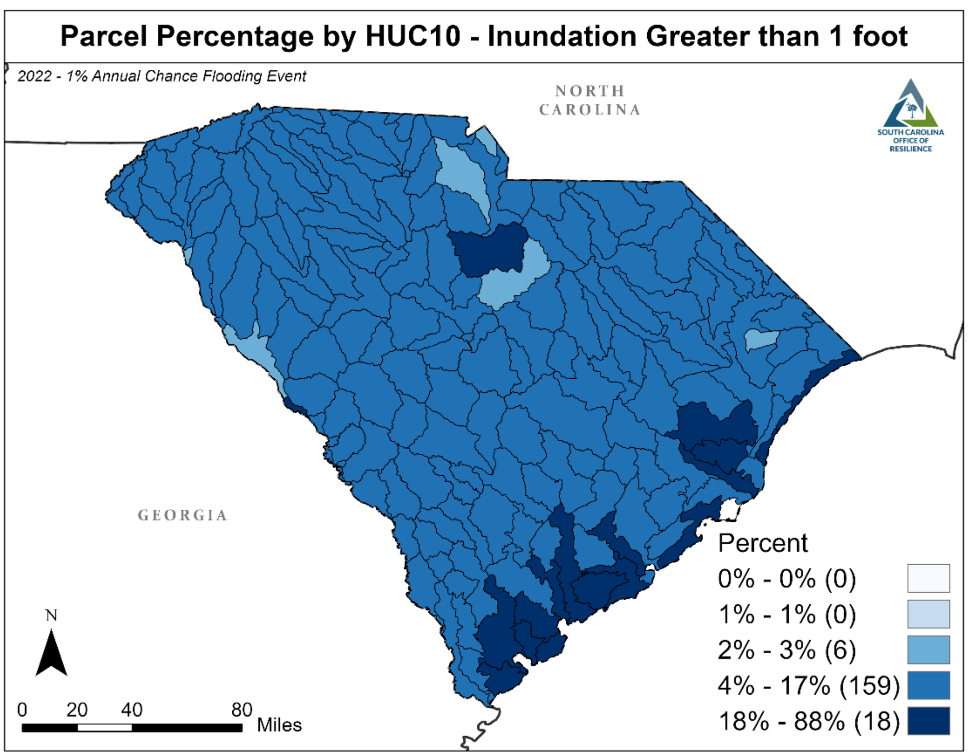


Figure 5.23: Percent of parcels by HUC10 estimated to be inundated greater than 1 foot in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

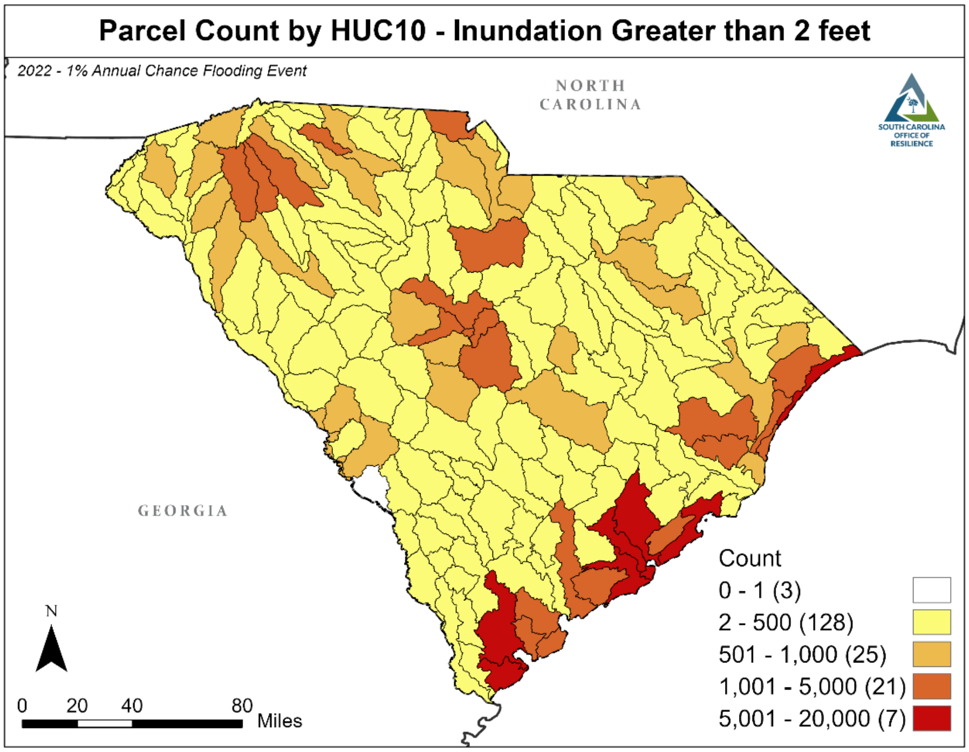


Figure 5.24: Count of parcels by HUC10 estimated to be inundated greater than 2 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

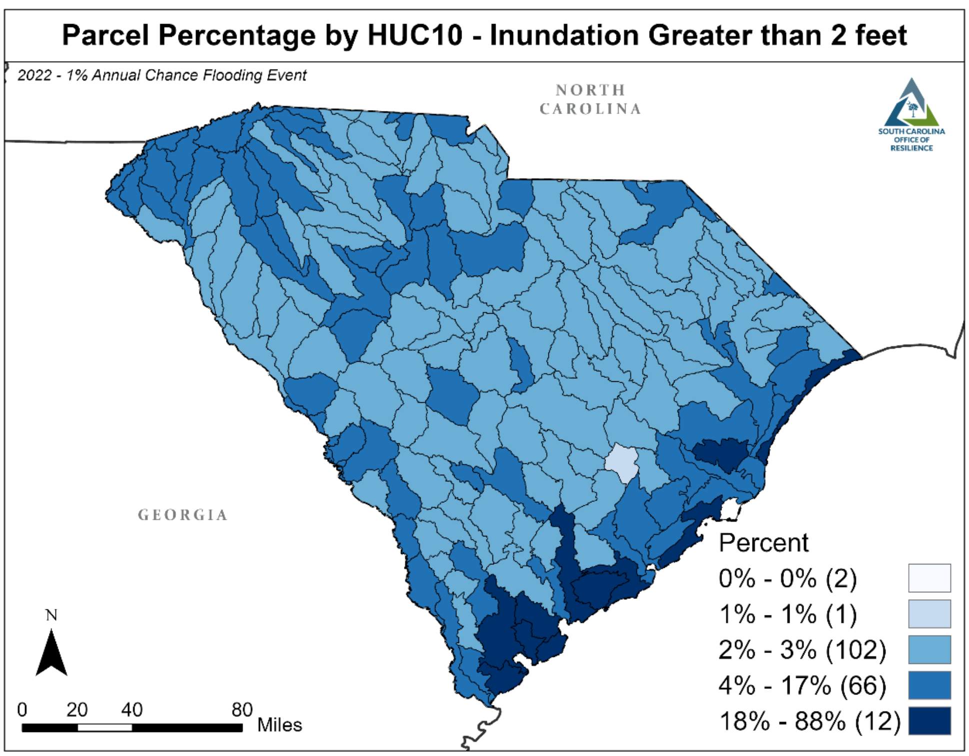


Figure 5.25: Percent of parcels by HUC10 estimated to be inundated greater than 2 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

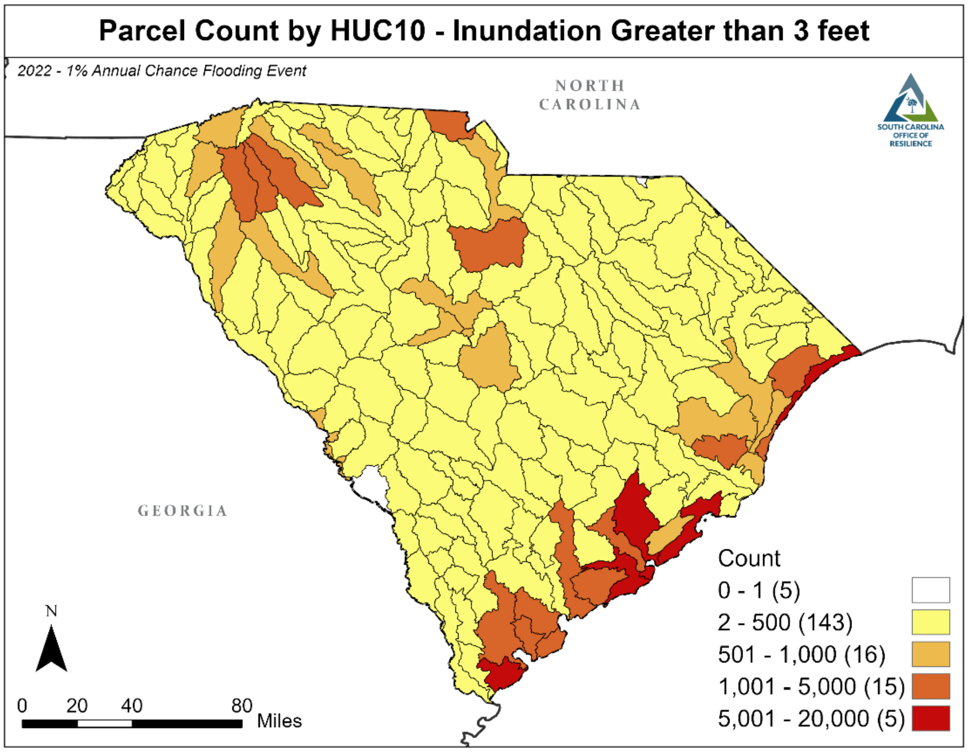


Figure 5.26: Count of parcels by HUC10 estimated to be inundated greater than 3 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

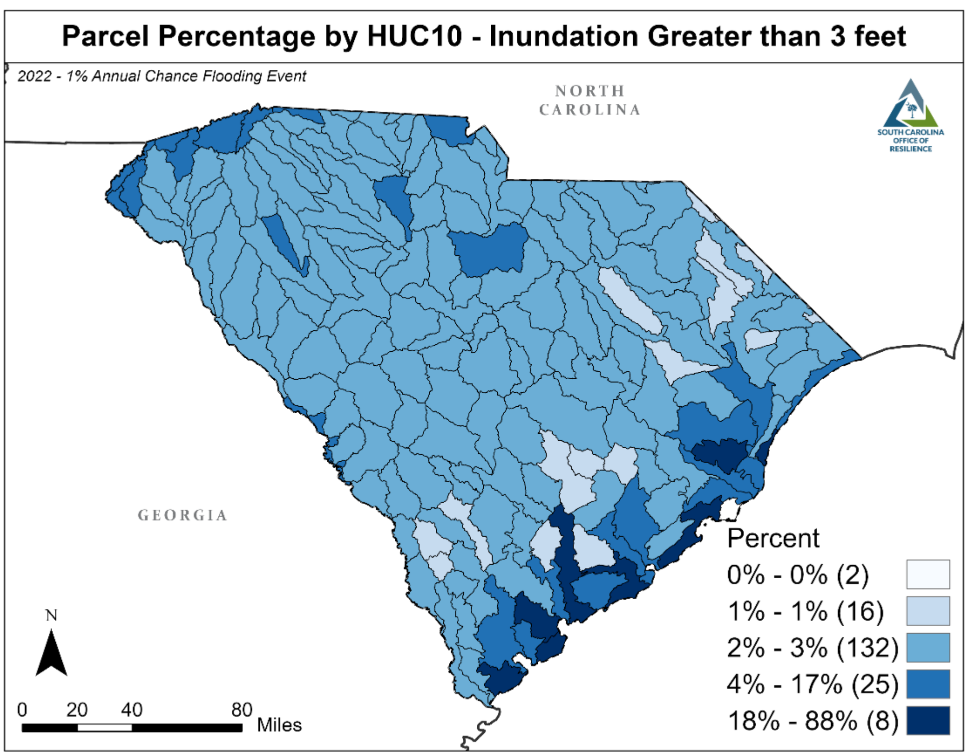


Figure 5.27: Percent of parcels by HUC10 estimated to be inundated greater than 3 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

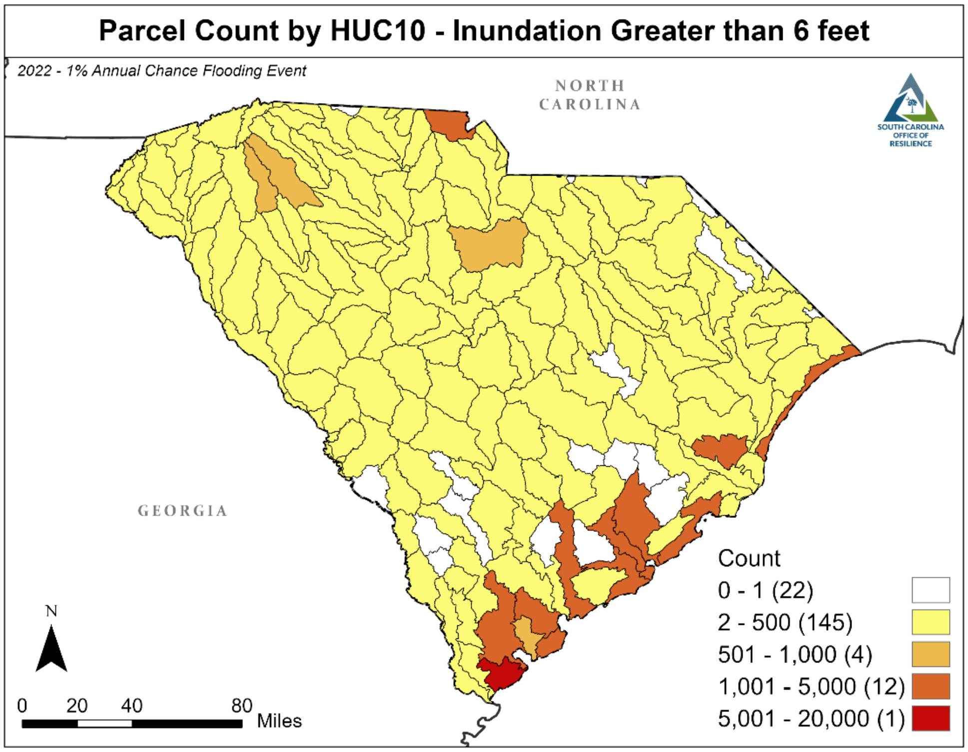


Figure 5.28: Count of parcels by HUC10 estimated to be inundated greater than 6 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

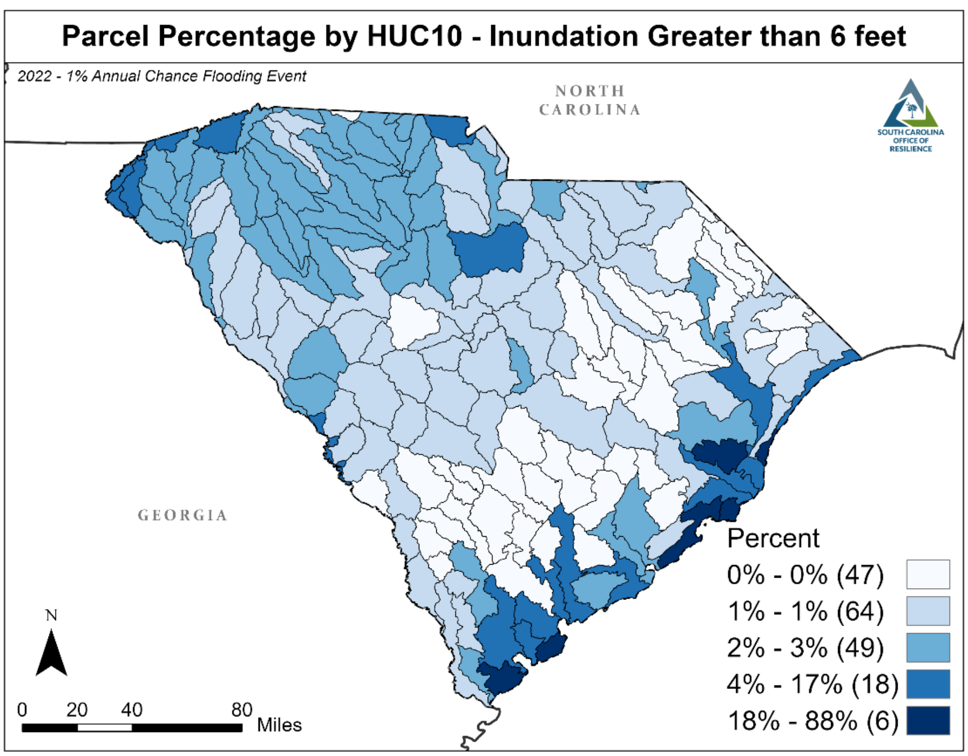


Figure 5.29: Percent of parcels by HUC10 estimated to be inundated greater than 6 feet in the 2022 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

2052 VULNERABLE PARCELS

An estimated count of properties impacted by 1% annual chance flooding event by county are listed in Table 5.9.

Table 5.9

County Name	2052					
	Above 0 Inches	Above 6 Inches	Above 1 Foot	Above 2 Feet	Above 3 Feet	Above 6 Feet
Abbeville	788	776	679	472	336	121
Aiken	7,137	7,132	5,962	3,532	2,148	776
Allendale	998	998	755	238	93	15
Anderson	5,289	5,261	4,492	2,788	1,783	568
Bamberg	1,678	1,663	1,245	406	149	4
Barnwell	1,049	1,049	796	354	131	10
Beaufort	49,968	49,201	45,195	38,051	33,163	16,956
Berkeley	10,903	10,665	7,247	3,544	2,085	417
Calhoun	1,403	1,389	1,054	565	325	94
Charleston	71,545	69,446	61,646	50,201	41,716	19,840
Cherokee	1,346	1,346	1,213	865	617	234
Chester	1,149	1,145	973	637	433	180
Chesterfield	1,894	1,890	1,525	824	463	142
Clarendon	3,635	3,615	2,215	599	236	14
Colleton	6,349	6,281	5,220	4,251	3,708	1,422
Darlington	5,111	5,076	3,530	1,154	452	46
Dillon	1,774	1,762	1,116	315	100	8
Dorchester	6,098	6,039	3,990	1,803	923	70
Edgefield	1,218	1,217	1,039	648	403	126
Fairfield	1,769	1,728	1,588	1,276	965	502
Florence	7,474	7,402	4,369	1,119	480	58
Georgetown	16,177	15,835	13,782	10,969	9,378	6,190
Greenville	16,242	16,156	13,981	9,324	6,138	1,965
Greenwood	2,338	2,260	1,951	1,217	701	183
Hampton	1,594	1,590	1,056	319	126	8
Horry	41,283	39,395	28,197	18,209	13,650	6,479
Jasper	3,491	3,432	2,356	1,539	1,188	717
Kershaw	2,894	2,854	2,285	1,275	860	374
Lancaster	2,283	2,258	1,942	1,284	794	251
Laurens	2,426	2,343	2,066	1,441	981	306
Lee	1,505	1,486	1,029	318	137	10
Lexington	7,555	7,397	5,872	3,123	1,696	423
Marion	2,941	2,887	1,846	577	269	43

Marlboro	2,530	2,472	1,752	707	242	23
McCormick	535	525	435	259	144	38
Newberry	1,963	1,855	1,553	956	585	159
Oconee	3,626	3,576	3,247	2,468	1,813	757
Orangeburg	6,471	6,427	4,306	1,491	632	86
Pickens	4,022	4,007	3,607	2,679	1,868	800
Richland	11,149	11,097	8,776	4,180	2,086	506
Saluda	1,323	1,260	1,032	614	333	56
Spartanburg	8,350	8,263	6,955	4,445	2,800	856
Sumter	6,526	6,476	4,167	1,244	591	71
Union	876	874	797	607	458	171
Williamsburg	5,227	5,117	3,093	896	458	69
York	6,059	5,978	5,292	3,899	2,948	1,618
Total	**347,961**	**340,901**	**277,224**	**187,682**	**141,585**	**63,762**

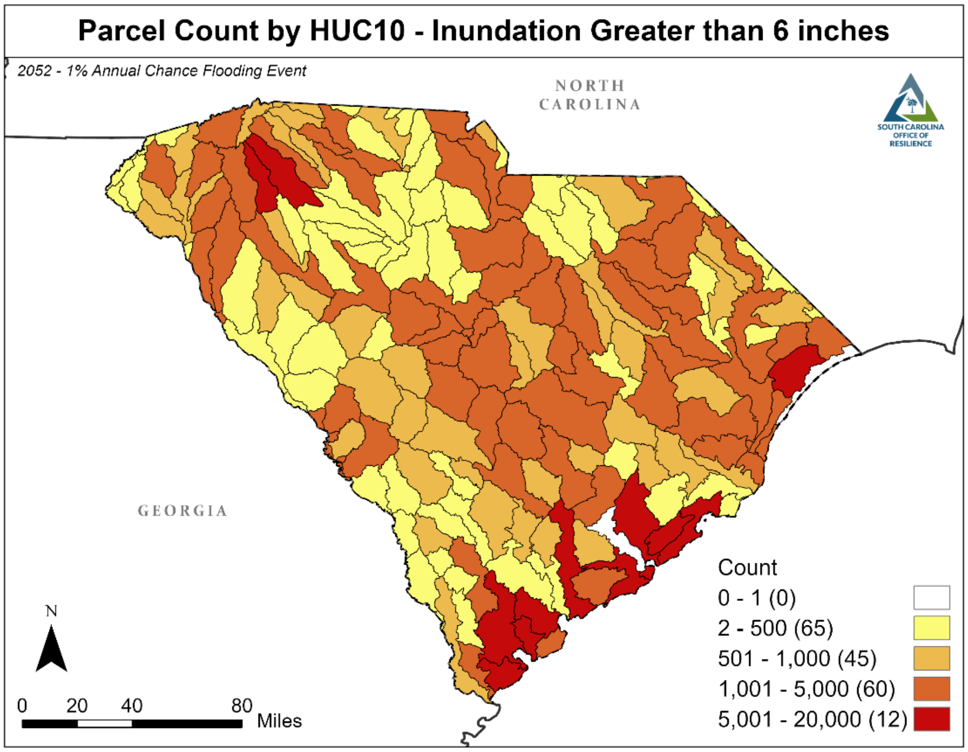


Figure 5.30: Count of parcels by HUC10 estimated to be inundated greater than 6 inches in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

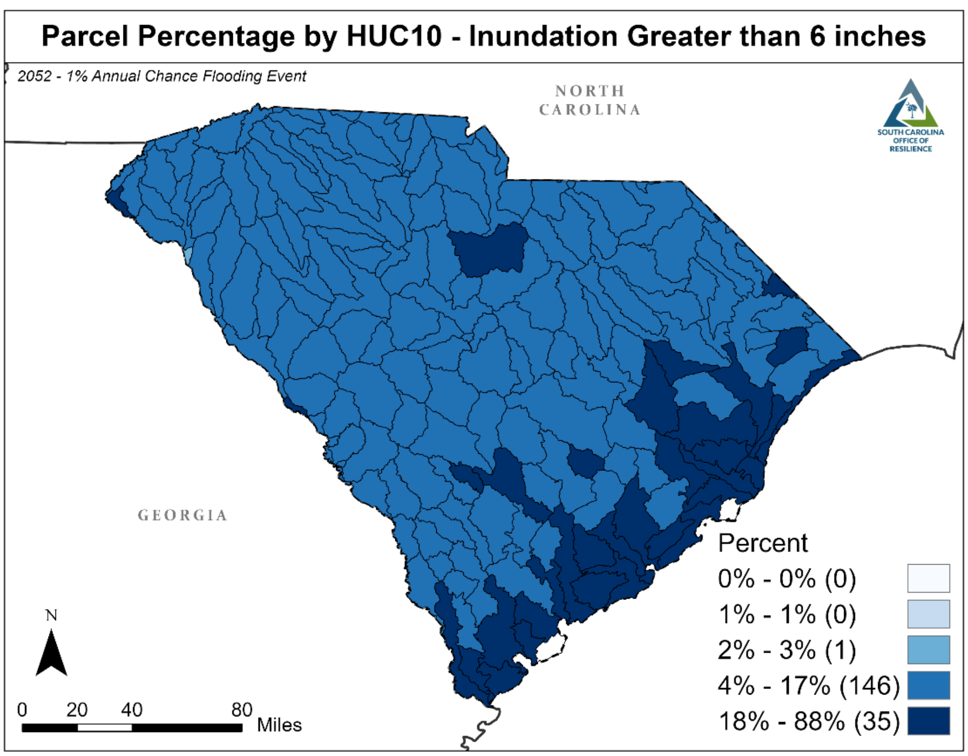


Figure 5.31: Percent of parcels by HUC10 estimated to be inundated greater than 6 inches in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

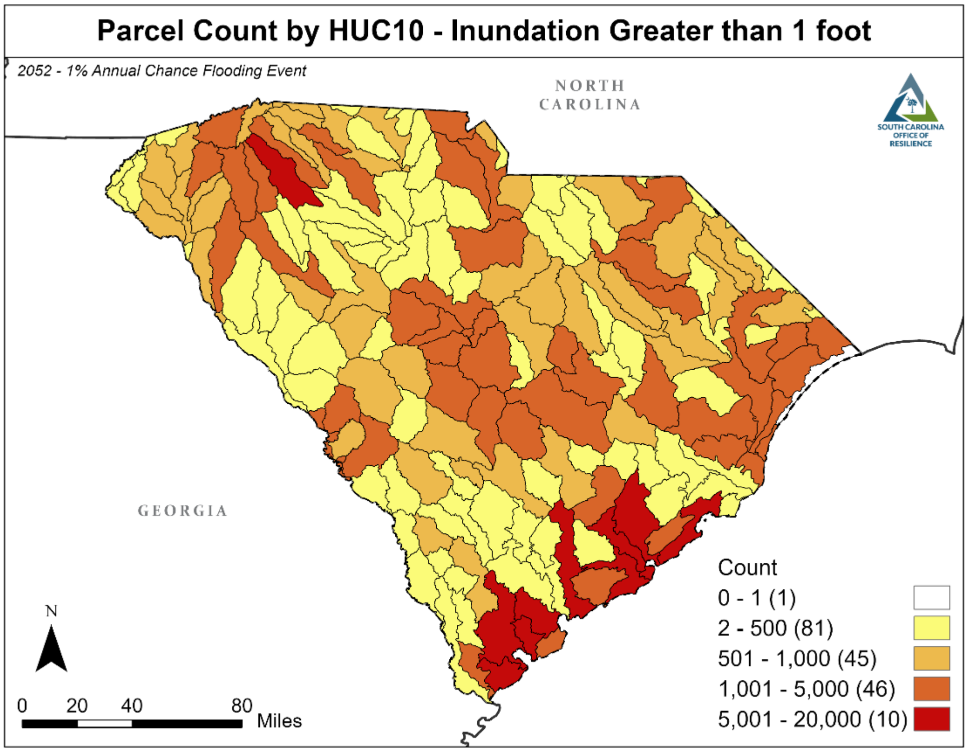


Figure 5.32: Count of parcels by HUC10 estimated to be inundated greater than 1 foot in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

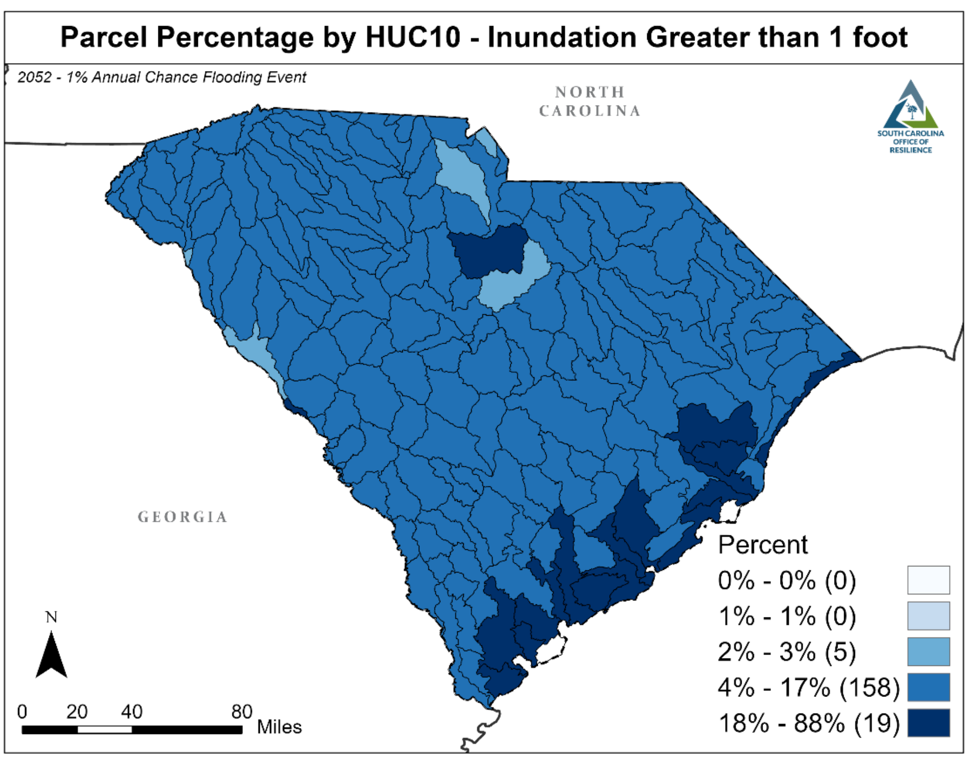


Figure 5.33: Percent of parcels by HUC10 estimated to be inundated greater than 1 foot in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

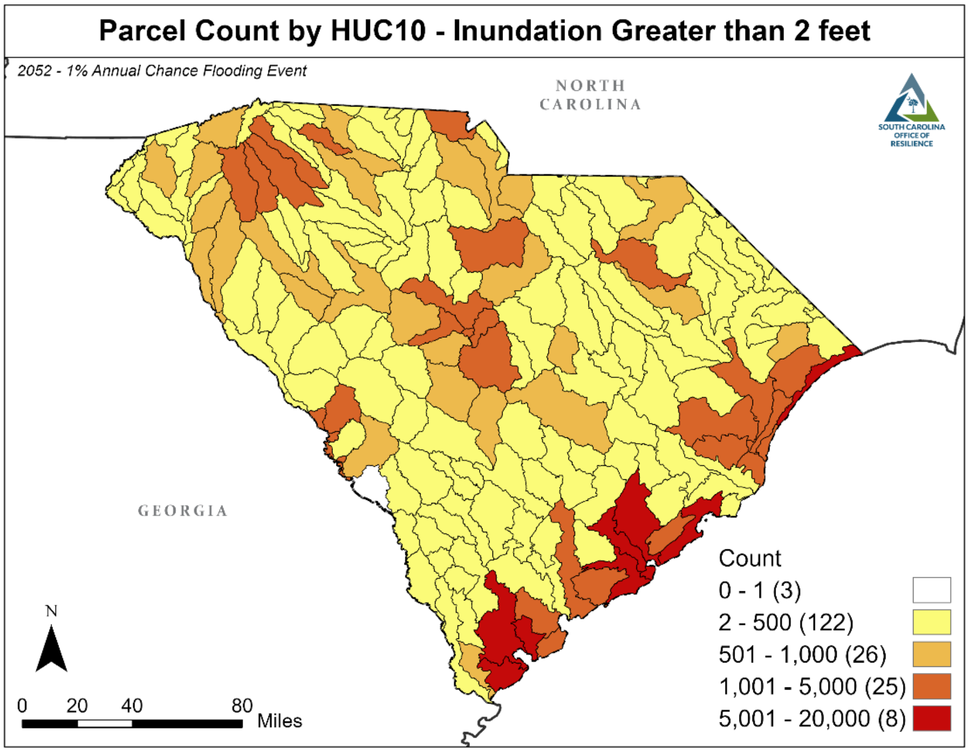


Figure 5.34: Count of parcels by HUC10 estimated to be inundated greater than 2 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

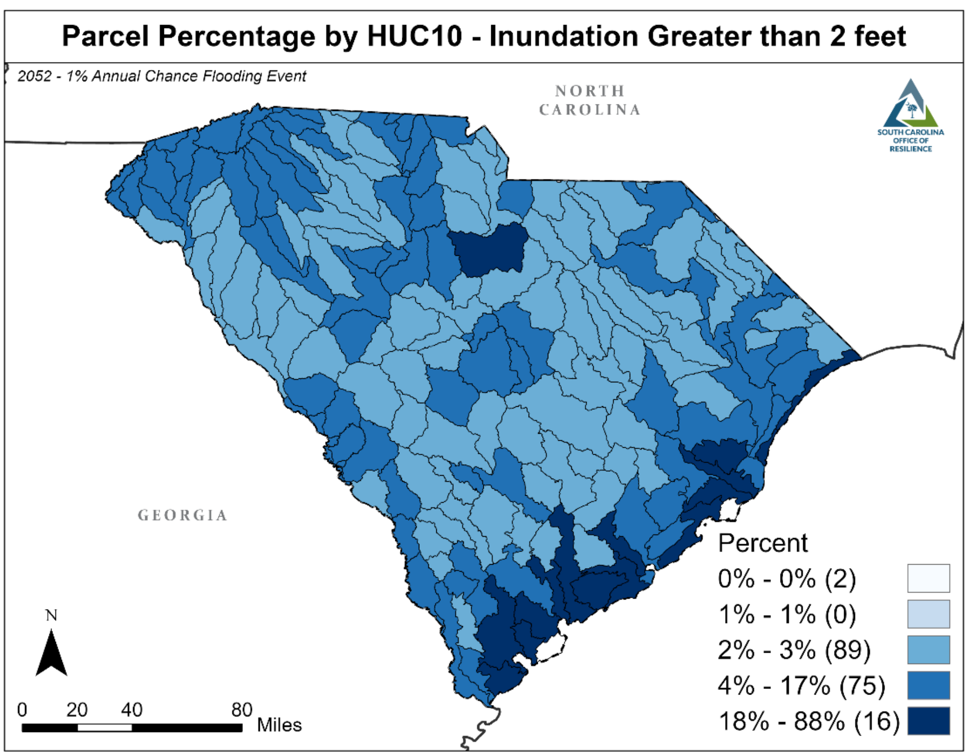


Figure 5.35: Percent of parcels by HUC10 estimated to be inundated greater than 2 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

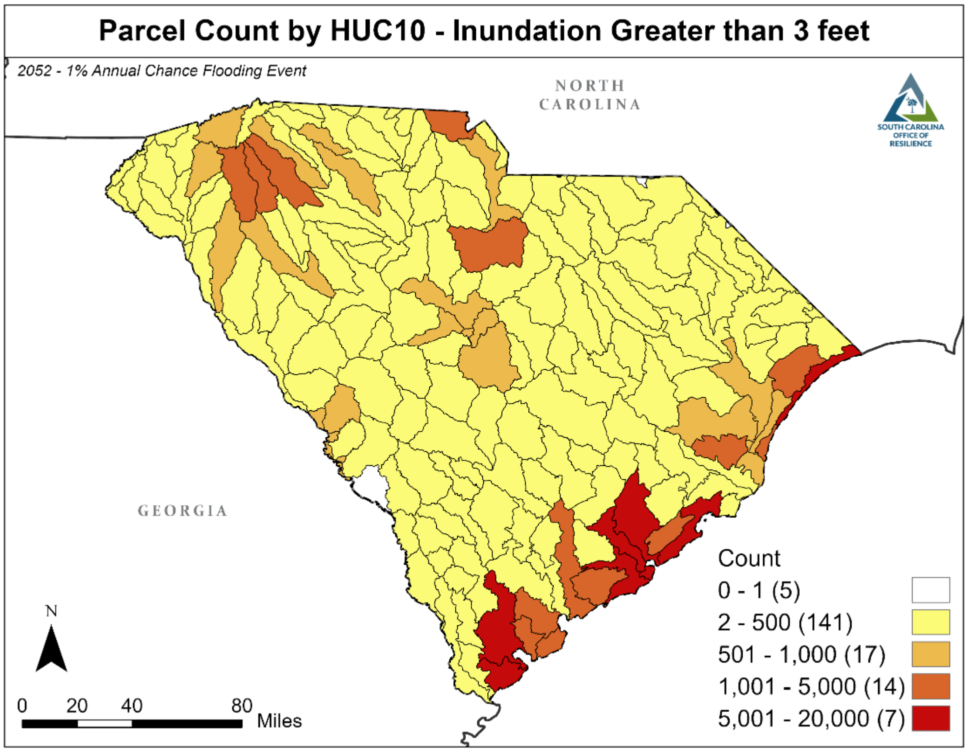


Figure 5.36: Count of parcels by HUC10 estimated to be inundated greater than 3 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

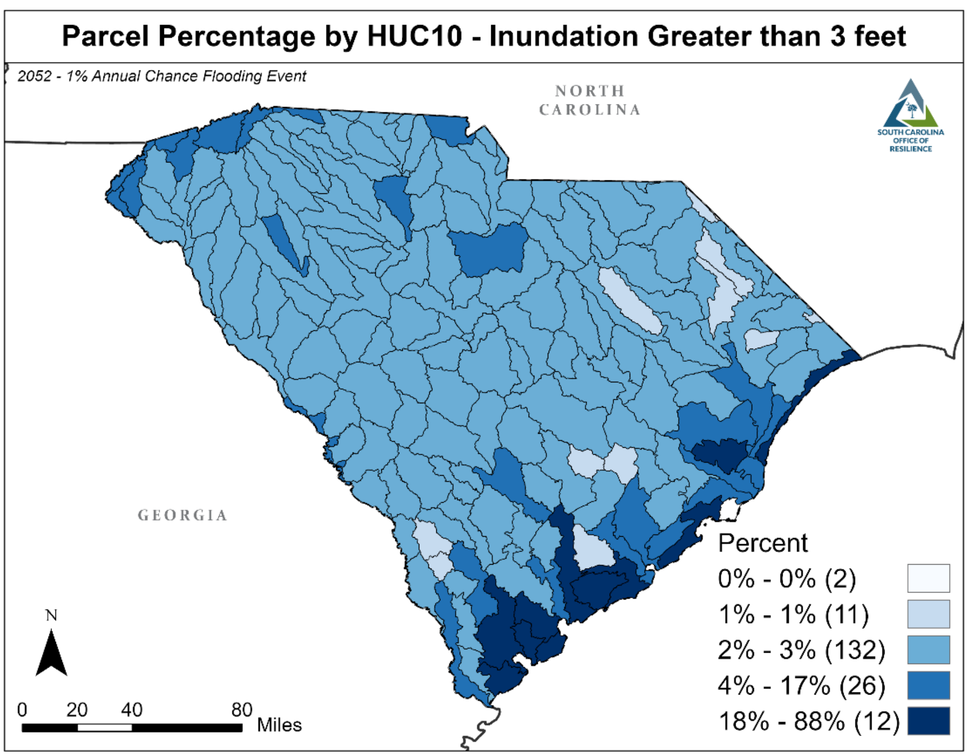


Figure 5.37: Percent of parcels by HUC10 estimated to be inundated greater than 3 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

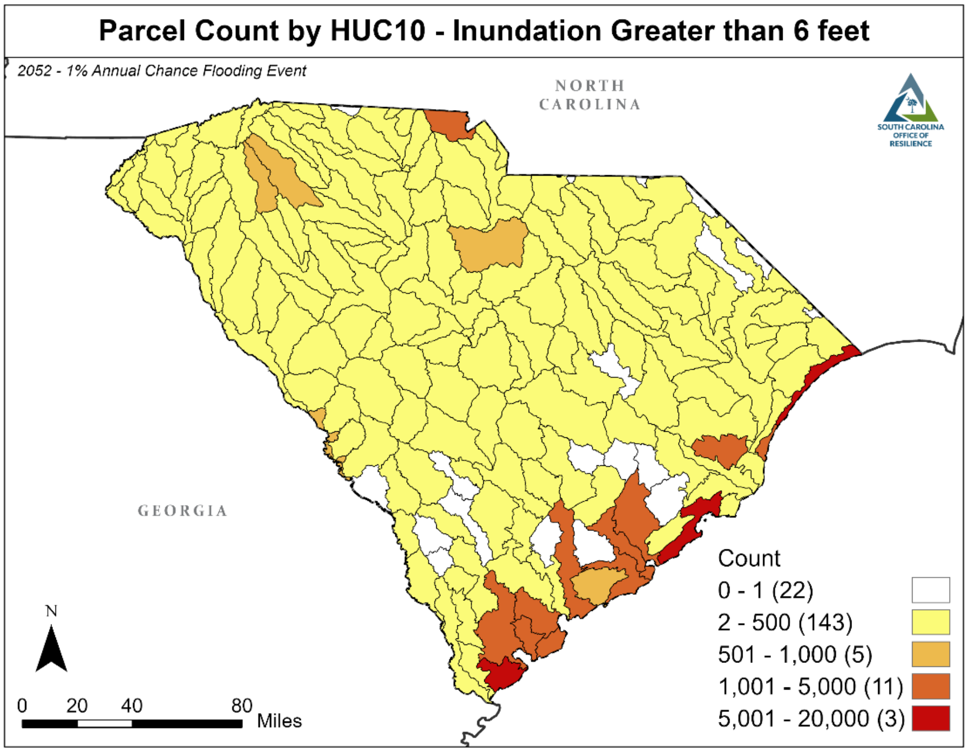


Figure 5.38: Count of parcels by HUC10 estimated to be inundated greater than 6 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

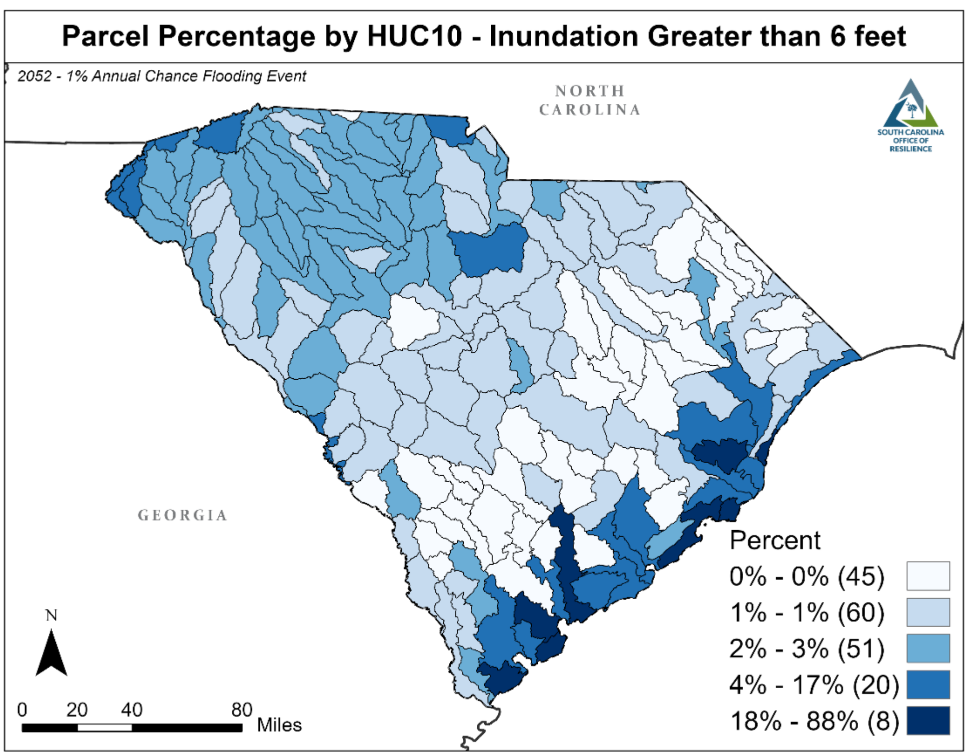


Figure 5.39: Percent of parcels by HUC10 estimated to be inundated greater than 6 feet in the 2052 1% annual chance flooding event. Flood risk data provided by the First Street Foundation Flood Risk Statistics, V2.0.

BUILDING CODES

To better understand the vulnerability of the buildings on these properties, the strength of South Carolina's building codes and enforcement was investigated. FEMA Region 4's 2021 Building Code Adoption Tracking Fact Sheet gives South Carolina a grade of 91.5% but states that the State is "not fully resistant because some jurisdictions with high flood risk do not participate in the NFIP" (Federal Emergency Management Agency, 2021).

The Building Code Effectiveness Grading Schedule is designed to assess building codes and their enforcement, with an emphasis on requirements designed to mitigate natural hazard losses. This grading scale can be used to lower insurance costs, which produces an incentive to rigorously enforce codes. With a raw score up to 100, and a possible rating class between 1 (exemplary commitment of building code enforcement) and 10, South Carolina has an average score of 4 for both the residential and commercial code (Figure 5.40). The residential classification addresses building code adoption and enforcement for 1- and 2-family dwellings. The commercial classification is for all other buildings. Community officials can get their local scores by emailing BCEGS_info@verisk.com (Insurance Services Office).

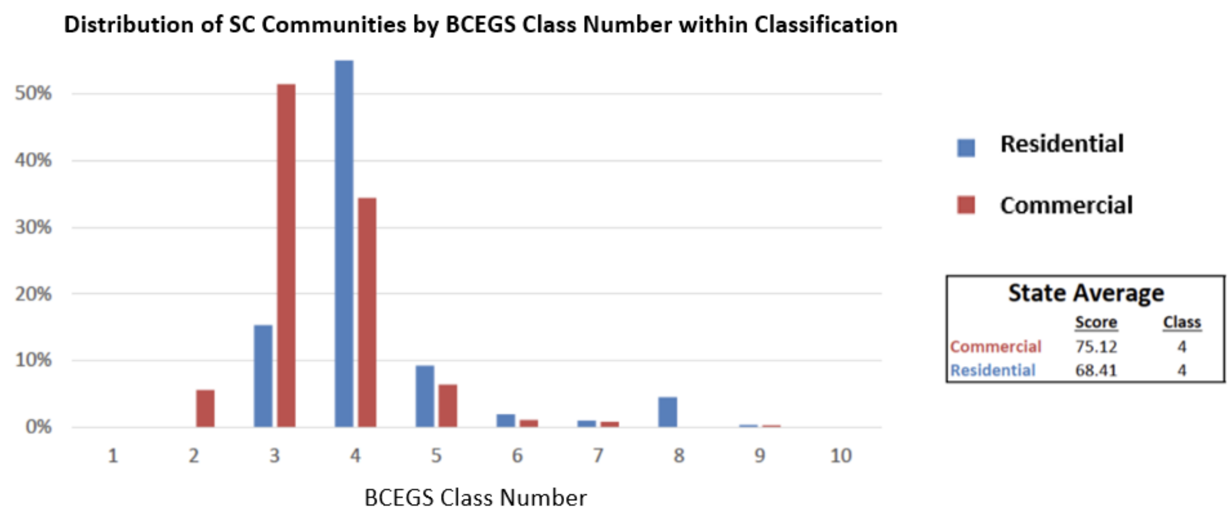


Figure 5.40: Average BCEGS Score for South Carolina (Insurance Services Office)

MOBILE HOMES

Mobile homes are considered one of the most vulnerable residential building types. The mobile or manufactured homes built today must meet the same general requirements as stick built or conventional housing. The vulnerability of these homes can depend on their age and anchoring. These homes can be used with or without a permanent foundation but should be elevated and anchored to a permanent foundation to resist flooding, collapse, or lateral movement (Federal Emergency Management Agency, 2020).

The vulnerability of mobile homes, and the recovery of those who live there, is complicated by arrangements where many residents own their individual homes but rent the land underneath (Rumbach, Sullivan, & Makarewicz, 2020). This often occurs in mobile home parks. While there is no statewide database of mobile homes, the Department of Homeland Security (DHS) maintains a database of mobile home parks, which represent communities where these homes are concentrated. The figures below quantify the number of mobile home parks impacted by the 2022 (Figure 5.41) and 2052 (Figure 5.42) 1% annual chance flood events.

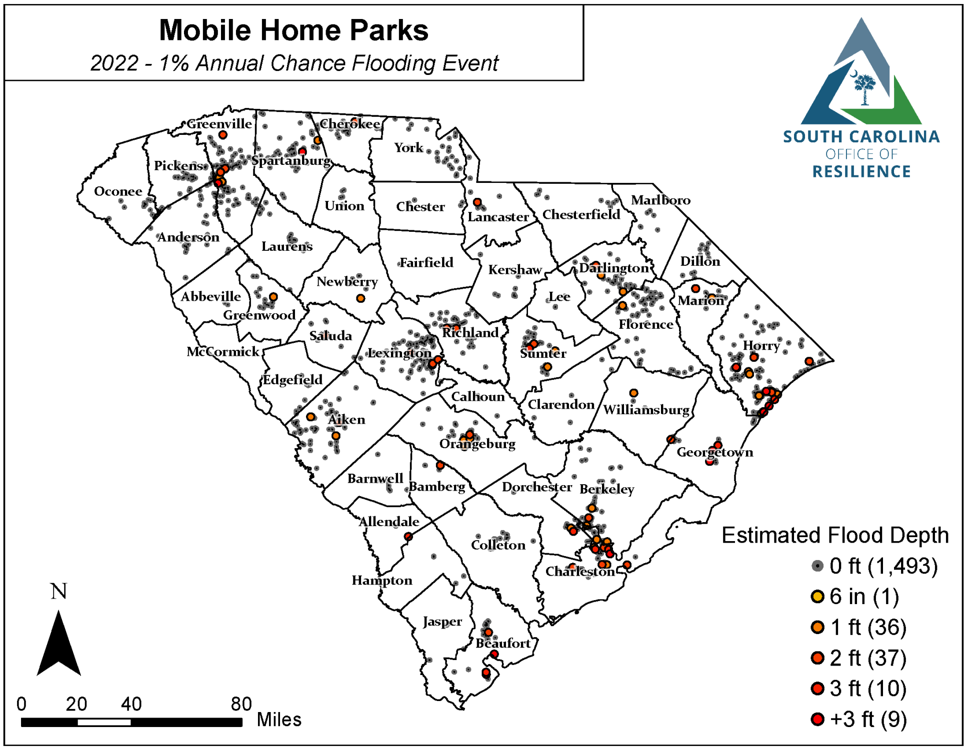


Figure 5.41: Estimated flooding of mobile home parks in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

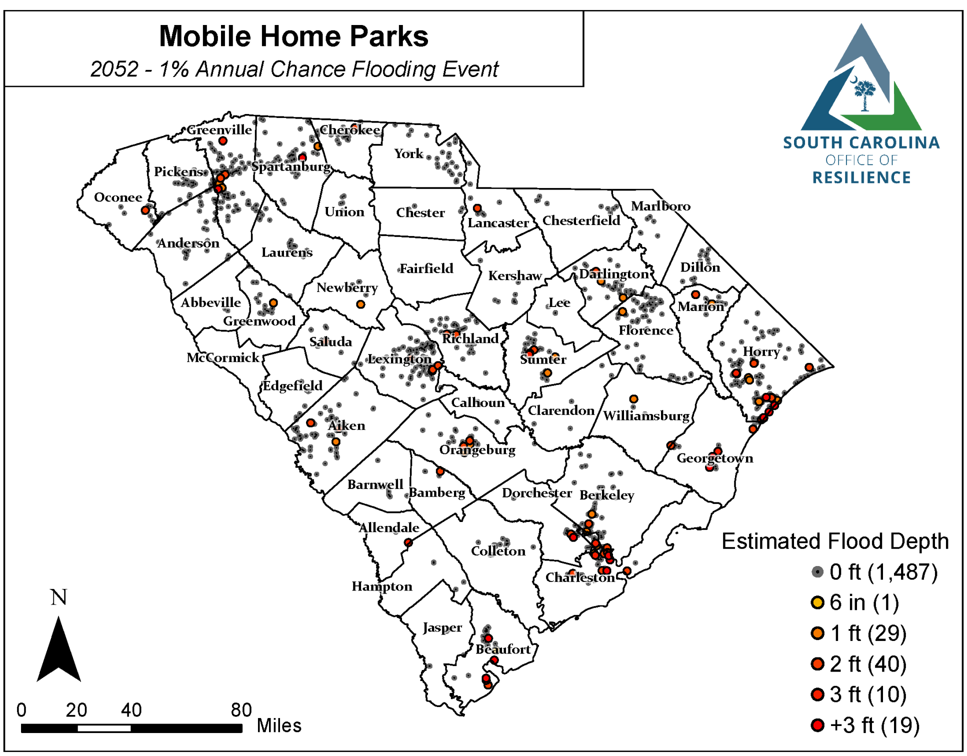


Figure 5.42: Estimated flooding of mobile home parks in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0

COMMERCIAL LOSSES

First Street Foundation applies their flood model to business locations and estimates the average time in days loss of productivity and the loss in dollars (First Street Foundation, 2021). Estimated loss in time and dollars are closely linked to the type of business and the size and characteristics of the building being used. This data is provided by a third party, Lightbox (First Street Foundation, 2021). Once the building characteristics and commercial type of the business is determined, estimated cost for building restoration, time loss, and revenue loss is calculated based on reported estimates to the Bureau of Economic Analysis in 2020 and then adjusted for region and time (First Street Foundation, 2021).

Table 5.10 summarizes the commercial loss by inundation level for a 1% annual chance flood event in 2022 and 2052 including the count of inundated commercial properties and loss in days and financial loss.

Table 5.10: Statewide summary of commercial loss by inundation level for a 1% annual chance flood event in 2022 & 2052

Count of Potentially Inundated Commercial Parcels						
	2022			2052		
	Count	Total Loss ($)	Avg Days Loss	Count	Total Loss ($)	Avg Days Loss
>6 inches	8,838	1,869,247,287	68	10,707	2,342,389,629	75
>1 foot	6,801	1,725,887,130	78	8,536	2,195,073,643	85
>2 feet	4,304	1,355,536,642	99	6,089	1,869,013,394	102
>3 feet	2,884	1,069,844,028	113	4,448	1,583,387,349	113
>6 feet	1,312	540,956,282	142	2,012	852,832,771	140

2022 COMMERCIAL AVERAGE ANNUAL LOSS

Table 5.11 summarizes the commercial loss by inundation level for a 1% annual chance flood event in 2021. Charleston County has the highest estimated impact with a potential of 4,000 commercial properties being impacted, with an approximate $660 million being lost from a 1% annual chance of flooding. Coastal counties, Beaufort, Charleston, Georgetown, and Horry are modeled to be the most impacted. Other counties with a high estimation of impact include Aiken, Dorchester, Florence, Greenville, Richland, and Spartanburg each having over 200 commercial properties with estimated flooding impact in a 1% annual chance event. All counties in South Carolina can be impacted by 1% annual chance of flood event, with a statewide average of 87 days of commercial downtime due to flooding and recovery and an estimated impact of $4,500,000,000 and an average economic loss of $393,021 per facility

Table 5.11: County summary for commercial parcels potentially inundated by a 1% flood event 2022.

County	Count	Count Any Inundation	Percent	Total Loss ($)	Average Downtime (Days)
Abbeville	1	-	0%	-	-
Aiken	5,961	365	6%	48,382,254	74
Allendale	206	10	5%	344,864	49
Anderson	4,188	157	4%	31,274,623	82
Bamberg	361	53	15%	1,673,037	47
Barnwell	451	24	5%	1,033,208	49
Beaufort	2,097	893	43%	360,815,317	97
Berkeley	1,735	146	8%	82,807,791	56
Charleston	11,186	4,010	36%	660,047,306	89
Cherokee	964	26	3%	2,139,694	118
Chester	608	22	4%	1,238,213	77
Chesterfield	1,043	27	3%	1,126,099	51
Clarendon	318	36	11%	15,561,262	44
Colleton	748	71	9%	14,251,803	104
Darlington	1,398	164	12%	16,387,504	50
Dillon	682	46	7%	1,548,884	45
Dorchester	3,890	377	10%	73,232,108	50
Fairfield	419	11	3%	630,314	92
Florence	3,007	229	8%	33,102,586	47
Georgetown	1,733	909	52%	232,631,159	195
Greenville	8,096	544	7%	50,515,530	98
Greenwood	1,857	53	3%	18,924,072	81
Hampton	432	18	4%	526,246	40
Horry	5,903	930	16%	265,051,199	55
Jasper	608	62	10%	2,004,537	67
Kershaw	867	44	5%	12,863,064	61
Lancaster	1,401	53	4%	26,247,813	75
Laurens	1,301	66	5%	4,345,907	108
Lee	1	1	100%	837,716	100
Lexington	4,332	189	4%	10,280,593	69
Marion	815	65	8%	2,070,790	50
Newberry	765	28	4%	5,202,465	70
Oconee	1,202	39	3%	2,608,103	111
Orangeburg	2,629	295	11%	45,517,805	51
Pickens	1,990	138	7%	65,598,562	107
Richland	6,755	478	7%	407,301,810	70
Spartanburg	5,472	270	5%	211,740,209	74

Sumter	2,653	284	11%	16,911,760	47
Union	695	21	3%	1,244,227	122
Williamsburg	827	150	18%	1,648,110,665	52
York	3,384	86	3%	100,971,614	62
Total	92,981	11,390	12%	4,477,102,712	87

Figure 5.43 shows the commercial properties estimated to be impacted by the 2022 1% annual flood event. Figure 5.44 shows the estimated count of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2021 in each HUC10 in South Carolina. Figure 5.45 then shows the estimated total dollars loss, by HUC10, of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022.

According to the First Street Foundation, there are 92,988 commercial parcels in South Carolina and of those, 11,395 are modeled to be impacted. Charleston County has the highest estimated impact with a potential of 3,600 commercial properties being impacted, with over $1 billion being lost from a 1% annual chance of flooding. Coastal counties, Beaufort, Charleston, Georgetown, and Horry are modeled to be the most impacted. Other counties with a high estimation of impact include Aiken, Dorchester, Florence, Greenville, Richland, and Spartanburg each having over 200 commercial properties with estimated flooding impact in a 1% annual chance event. All counties in South Carolina can be impacted by 1% annual chance of flood event, with a statewide average loss of 67 days to the impacted parcels and an estimated average economic loss of $393,021 per impacted commercial parcel.

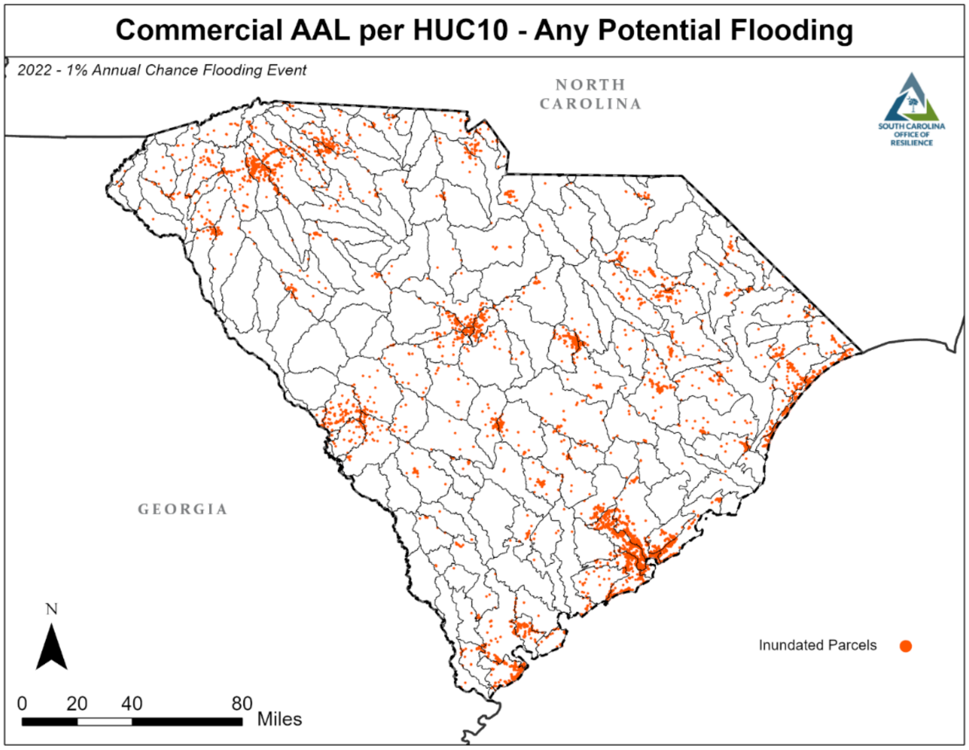


Figure 5.43: Estimated commercial properties with inundation by the 2022 1% annual chance flood event. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

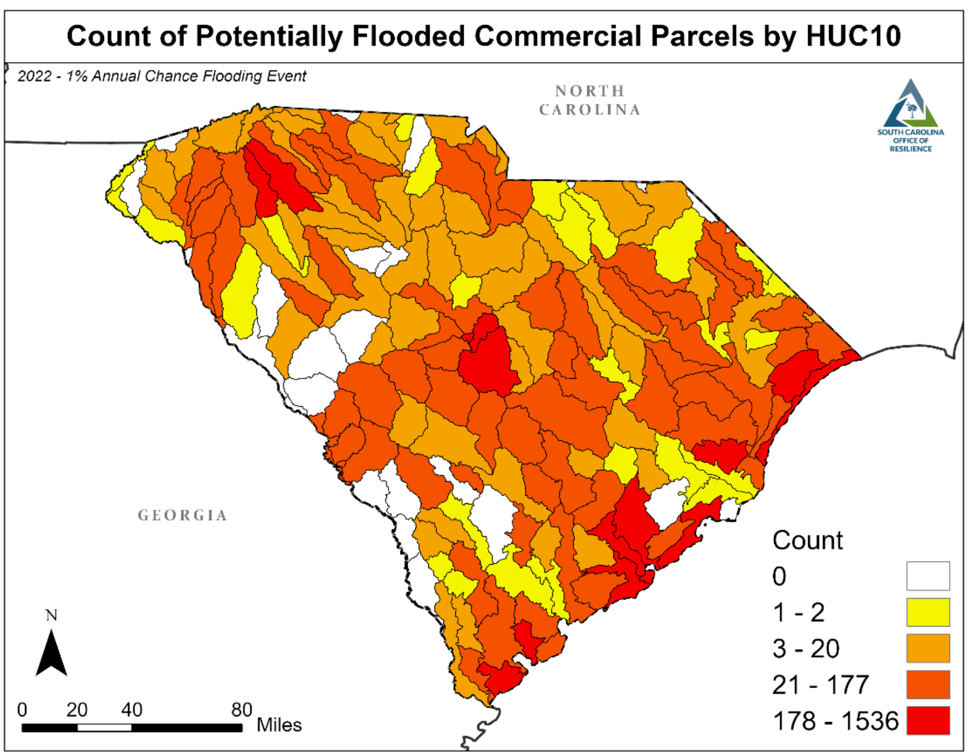


Figure 5.44: Estimated count of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022 in each HUC10 in South Carolina. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

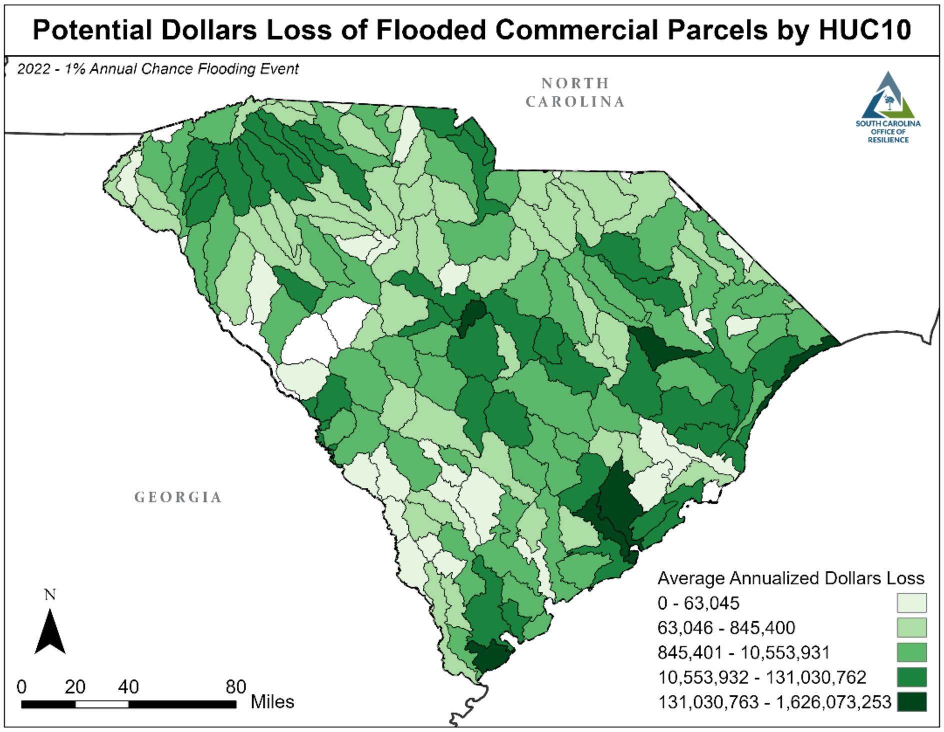


Figure 5.45: Estimated total dollar loss, by HUC10, of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

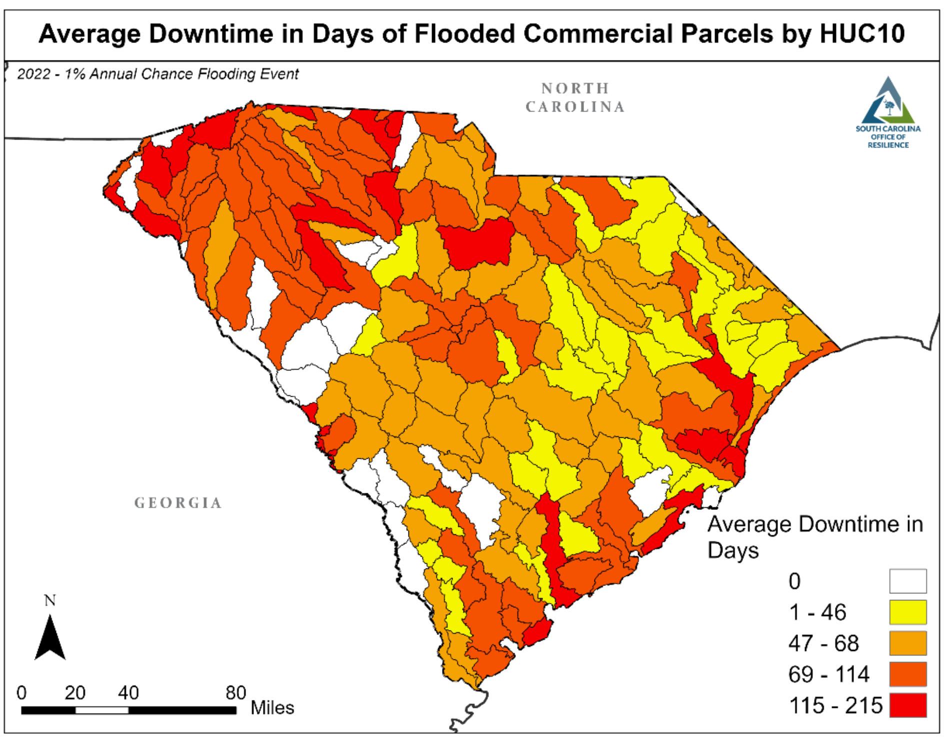


Figure 5.46: Estimated average days loss to flooding and reconstruction, by HUC10, of commercial facilities inundated by 1% annual chance flood event in First Street Foundation Flood Model Scenario mid-2022. Flood data provided by the First Street Foundation Flood Risk Statistics, V2.0.

2052 COMMERCIAL AVERAGE ANNUAL LOSS

Table 5.12 summarizes the commercial loss by inundation level for a 1% annual chance flood event in 2052.

Table 5.12: County summary for commercial parcels potentially inundated by a 1% flood event 2052.

County	Count	Count Any Inundation	Percent	Total Loss ($)	Average Downtime (Days)
Abbeville	1	-	0%	-	-
Aiken	5,961	384	6%	50,842,855	75
Allendale	206	10	5%	374,456	51
Anderson	4,188	168	4%	33,285,768	82
Bamberg	361	55	15%	1,838,997	49
Barnwell	451	27	6%	1,197,996	50
Beaufort	2,097	1,044	50%	441,904,141	110
Berkeley	1,735	198	11%	161,958,451	58
Charleston	11,186	4,976	44%	919,489,031	112
Cherokee	964	33	3%	2,462,623	110
Chester	608	22	4%	1,253,349	79
Chesterfield	1,043	31	3%	1,269,027	50
Clarendon	318	41	13%	16,695,282	44
Colleton	748	77	10%	16,950,125	116
Darlington	1,398	176	13%	17,544,018	51
Dillon	682	50	7%	1,695,694	45
Dorchester	3,890	424	11%	81,316,141	50
Fairfield	419	15	4%	988,504	82
Florence	3,007	255	8%	36,630,788	47
Georgetown	1,733	980	57%	286,038,298	206
Greenville	8,096	570	7%	53,509,800	98
Greenwood	1,857	55	3%	19,282,671	82
Hampton	432	21	5%	641,316	41
Horry	5,903	1,034	18%	332,090,277	59
Jasper	608	82	13%	2,959,060	70
Kershaw	867	50	6%	14,179,801	61
Lancaster	1,401	58	4%	28,743,124	75
Laurens	1,301	71	5%	4,748,178	107
Lee	1	1	100%	865,776	101
Lexington	4,332	216	5%	11,725,186	68
Marion	815	73	9%	2,332,843	50
Newberry	765	30	4%	5,494,845	70
Oconee	1,202	39	3%	2,713,467	113

Orangeburg	2,629	316	12%	51,199,259	52
Pickens	1,990	143	7%	67,118,840	107
Richland	6,755	516	8%	438,894,712	70
Spartanburg	5,472	291	5%	224,174,209	74
Sumter	2,653	306	12%	19,208,180	48
Union	695	26	4%	1,475,201	123
Williamsburg	827	160	19%	1,672,451,485	53
York	3,384	93	3%	124,015,230	61
Total	92,981	13,117	14%	5,151,559,002	87

CRITICAL INFRASTRUCTURE

While the natural systems above are in many ways naturally resilient, many of our vulnerabilities to hazards come at the intersection of critical infrastructure and environmental change and natural hazards. This section includes the vulnerability of systems that are essential to human health, safety, and welfare including the need to maintain a clean water supply and protection against harmful substances, materials, and waste.

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). 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 the delivery of longer-term recovery resources.

The impacts of floods to roads and bridges include direct damages to the roadway and barriers to access, as well as indirect impacts due to ongoing repairs and re-routing that impacts communities and economies. In South Carolina's coastal areas, hundreds of miles of roads are at risk of high-tide flooding. As the number of high-tide flooding days increase with sea level rise, the miles impacted will also increase.

Currently, there is no statewide road elevation data set. SCEMD, in conjunction with Clemson University, is working to develop a dataset that may be used for vulnerability analysis. A test version of this analysis was completed for Dillon County (Figure 5.45).

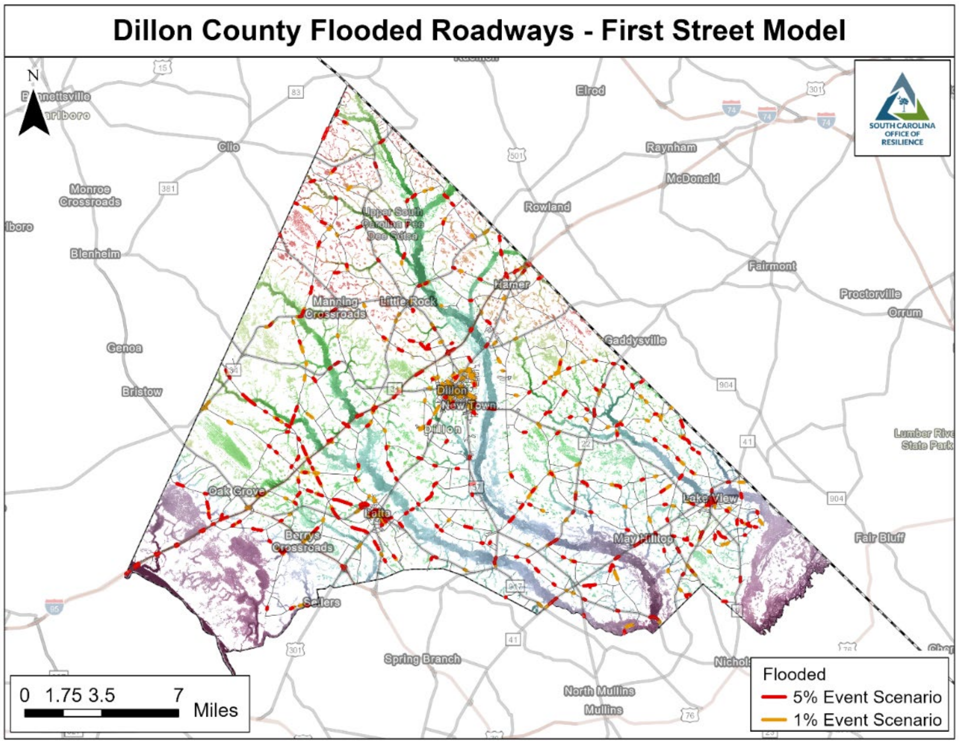


Figure 5.47: Analysis of locations where the roadway centerline elevation is lower than the elevation of a modelled flood scenario. Roadway elevations are provided by Clemson University, and flood data is provided by the First Street Foundation's Flood Hazard Layers, V2.0.

AVIATION 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 figure includes the economic impact of Boeing, which has a large presence in Charleston, the location of final assembly for the Boeing 787 Dreamliner (South Carolina Aeronautics Commission, 2018).

The maps below show the vulnerability of these aviation facilities to flooding in the 2022 (Figure 5.48) and 2052 (Figure 5.49) 1% annual chance flood event.

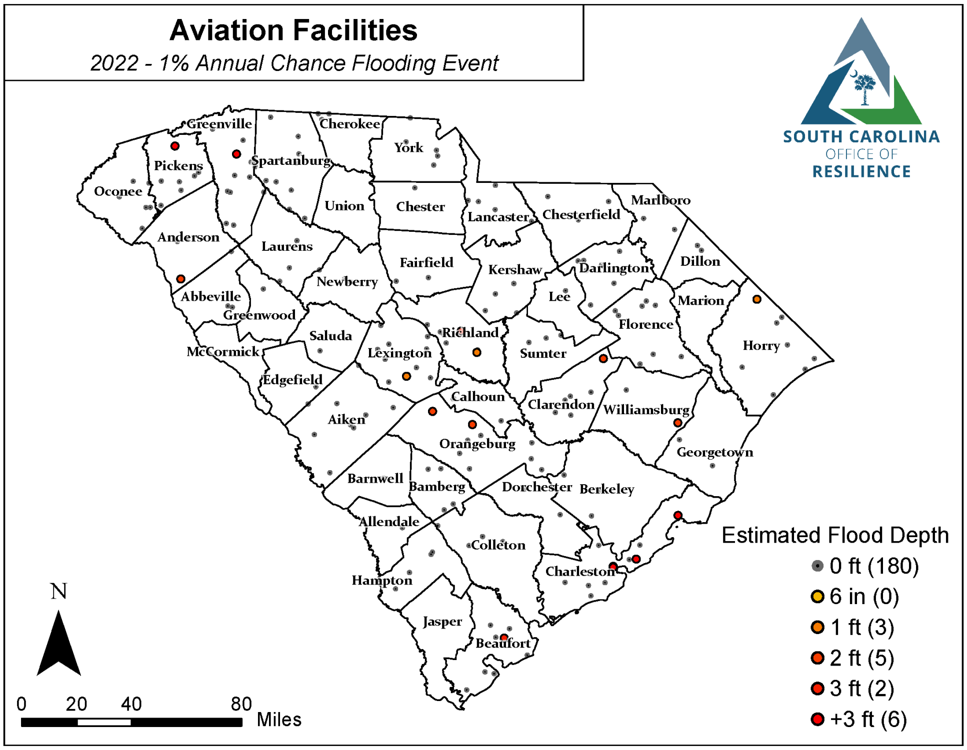


Figure 5.48: Estimated flooding of aviation facilities in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

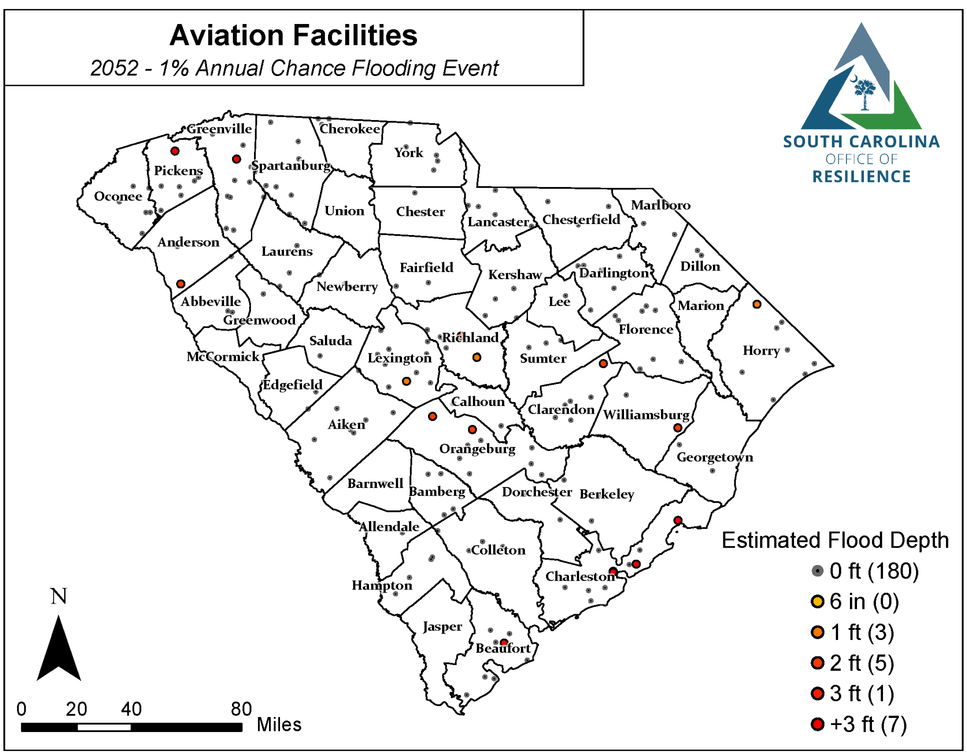


Figure 5.49: Estimated flooding of aviation facilities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PORTS

South Carolina Ports Authority (SCPA) owns and operates the Port of Charleston, Port of Georgetown, Inland Port Greer, and Inland Port Dillon, ensuring the efficient movement of cargo between South Carolina and global markets, generating a $63.4 billion economic impact in South Carolina each year (SC Ports Authority, n.d.).

Sea level rise poses risk to ports across the United States because mitigation measures are capital intensive. Ports plan for sea level rise contingencies, but the effects of storm surges and flooding could extend to complementary supply chain infrastructure on the landside and transportation sector. In the event of a massive hurricane or other disaster that leaves roads impassable. Ports would likely be a vital resource for delivery of supplies and movement of goods. Interruption of supply chain can be disastrous. Port equipment could be damaged along with cargo. Hurricanes could cause shipping channels and berths to shoal in from increased sediment load.

Historically, South Carolina’s wharves have progressively been elevated, and sea level rise is factored into Ports Authority’s design. However, older terminals have much older wharf structures that are more vulnerable to storm surge and sea level rise.

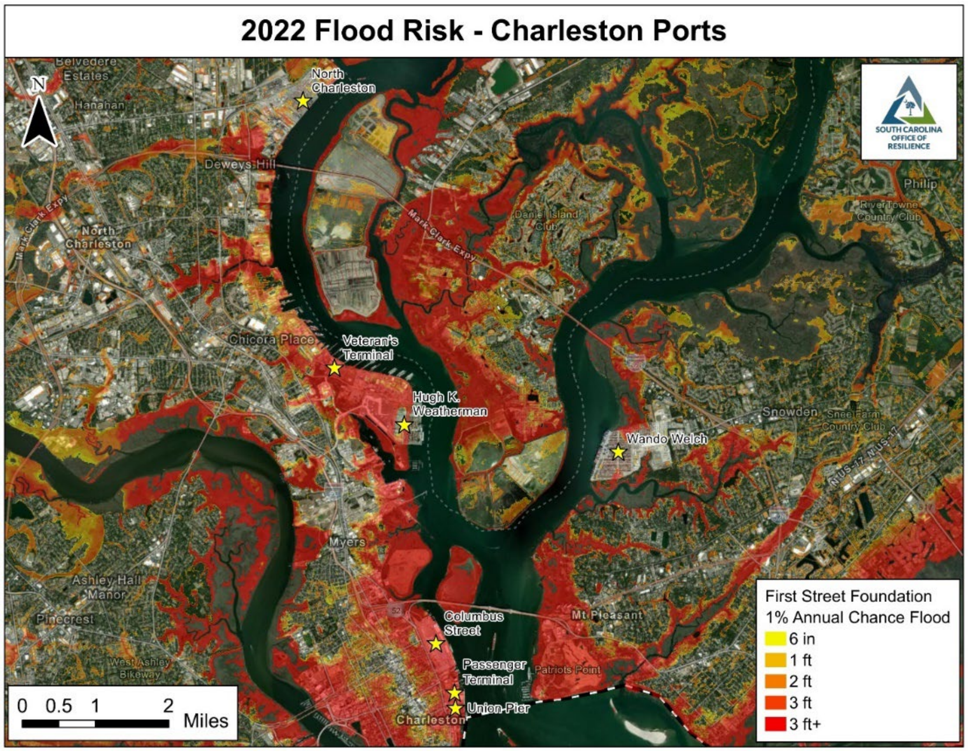


Figure 5.50: Estimated flooding of the Charleston Ports in the 2022 1% annual chance flooding event

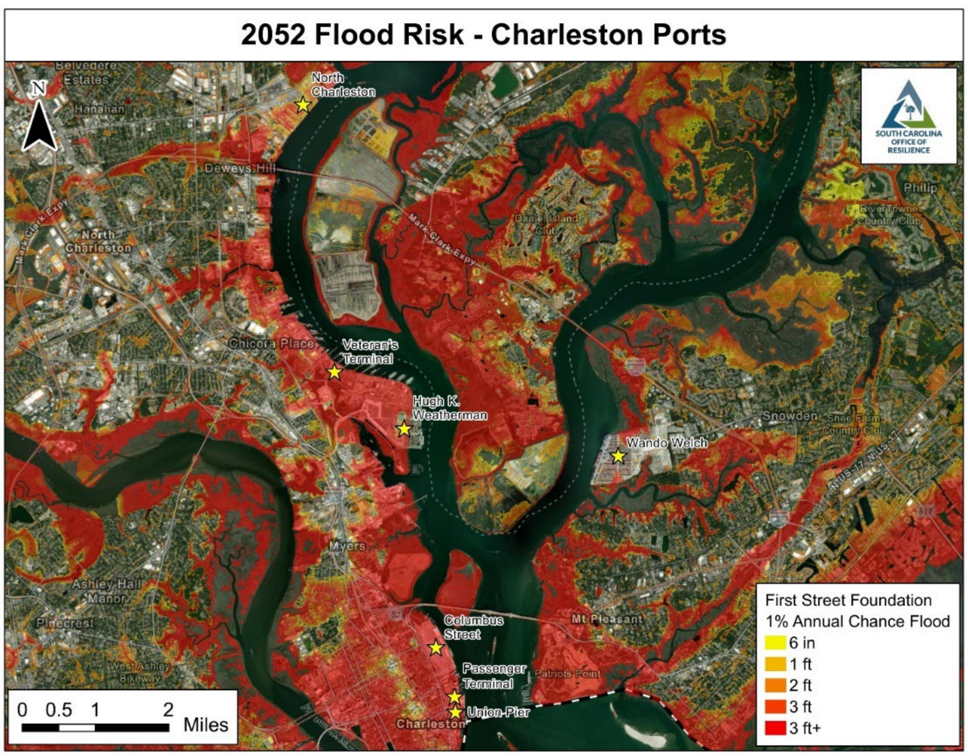


Figure 5.51: Figure 107: Estimated flooding of the Charleston Ports in the 2052 1% annual chance flooding event

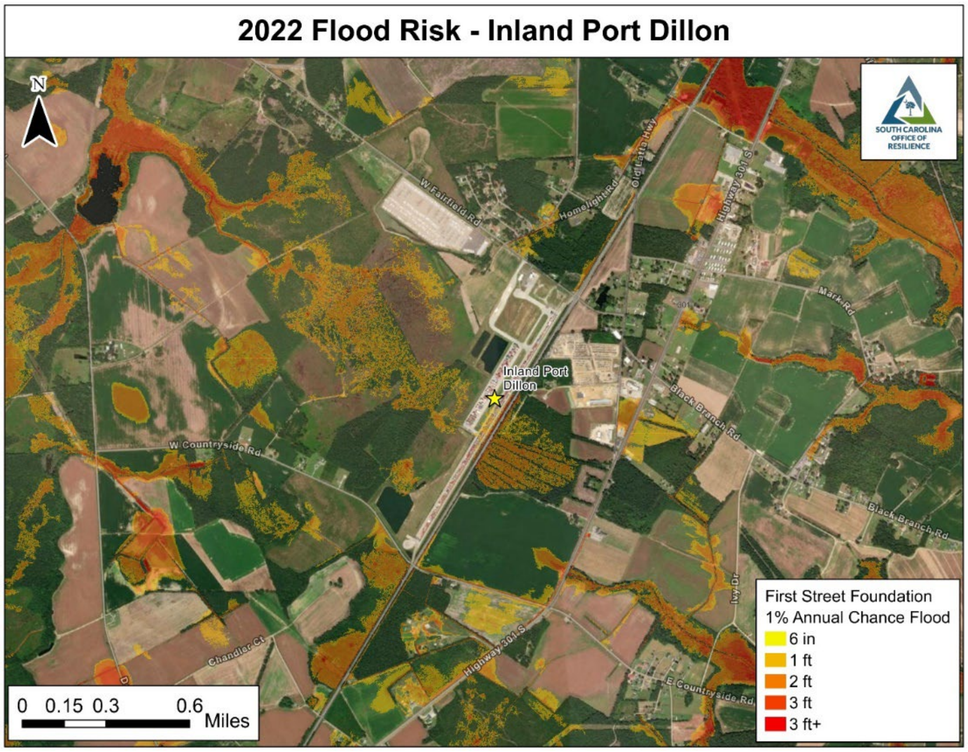


Figure 5.52: Estimated flooding of Inland Port Dillon in the 2022 1% annual chance flooding event

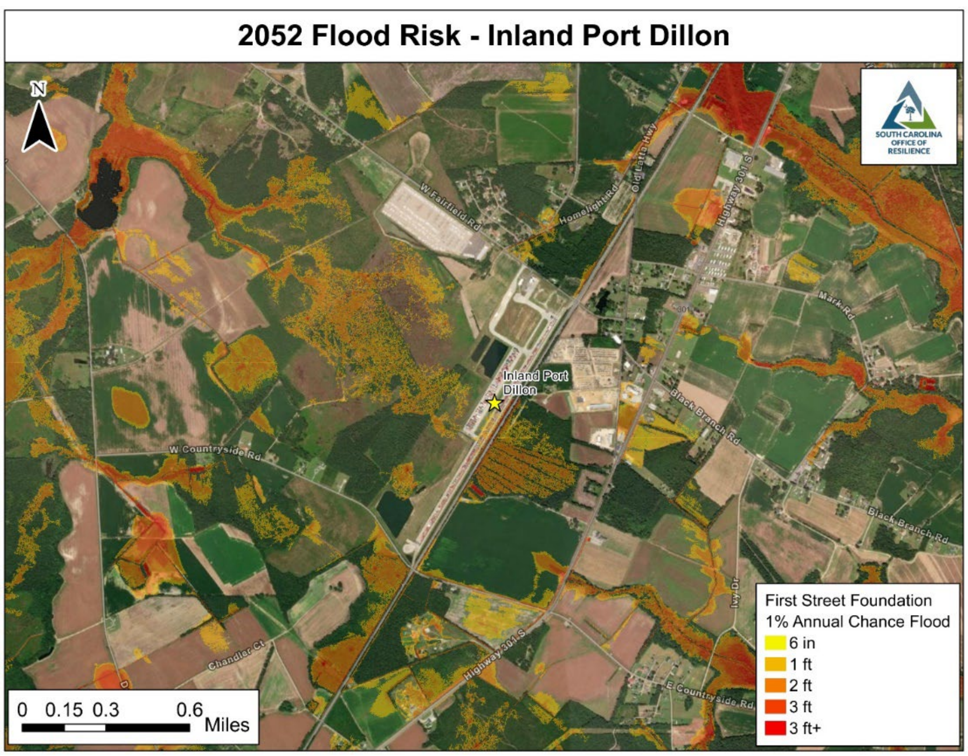


Figure 5.53: Estimated flooding of Inland Port Dillon in the 2052 1% annual chance flooding event

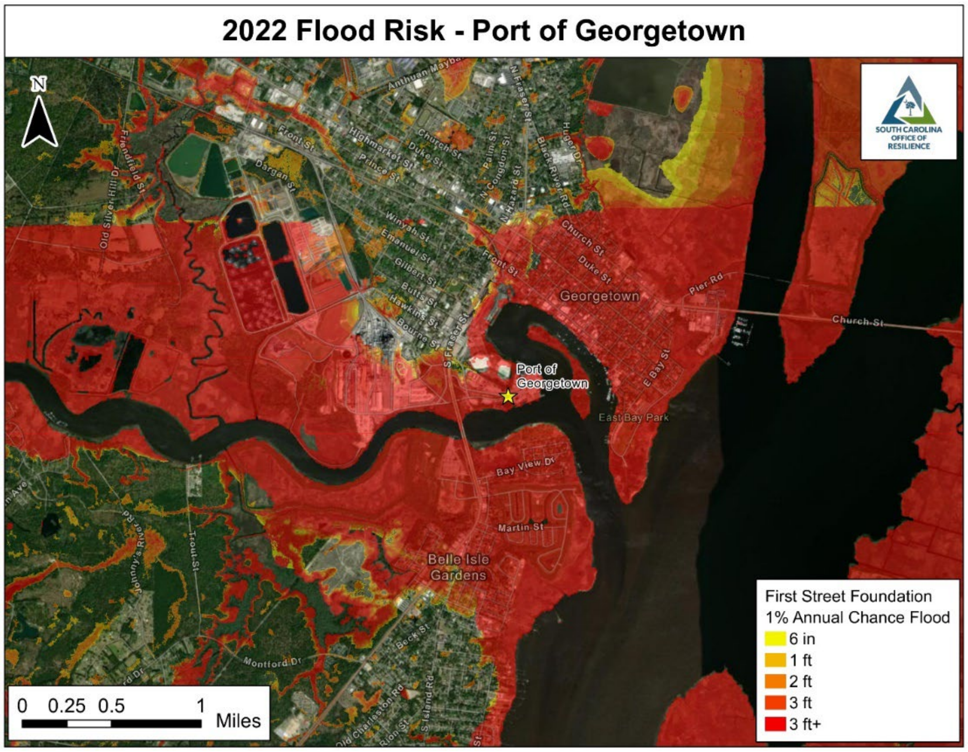


Figure 5.54: Estimated flooding of the Port of Georgetown in the 2022 1% annual chance flooding event

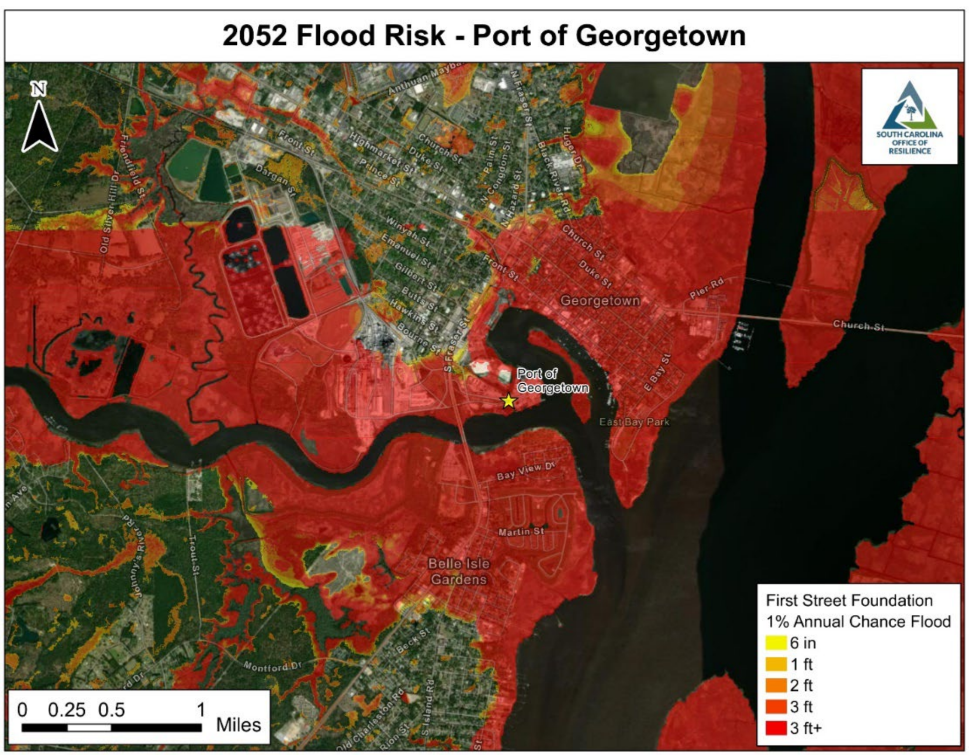


Figure 5.55:Estimated flooding of the Port of Georgetown in the 2052 1% annual chance flooding event

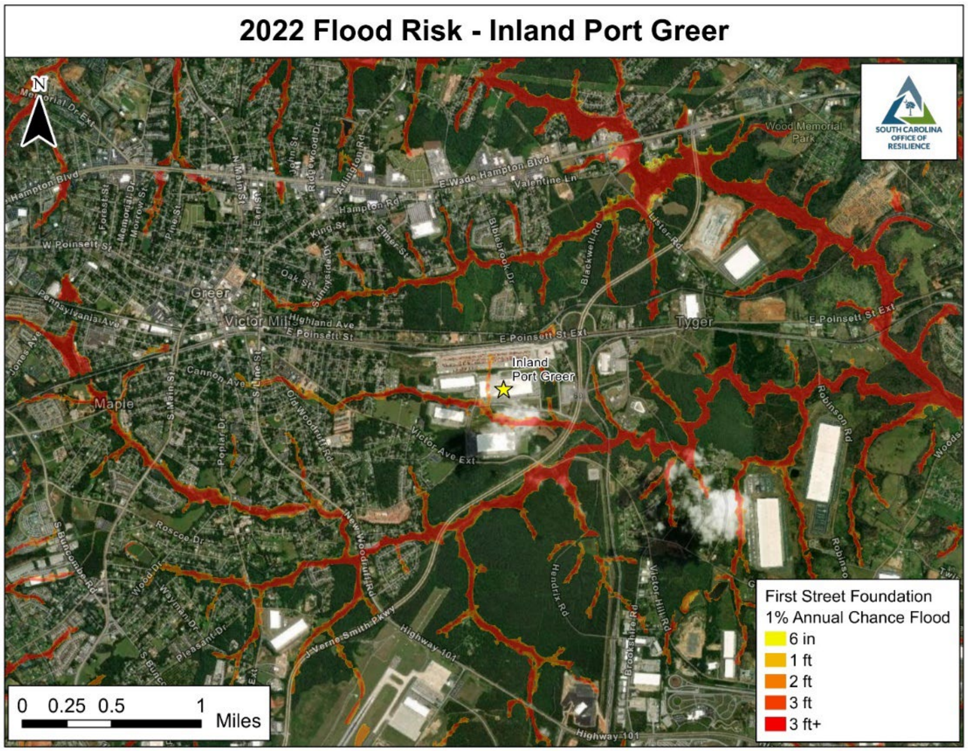


Figure 5.56: Estimated flooding of Inland Port Greer in the 2022 1% annual chance flooding event

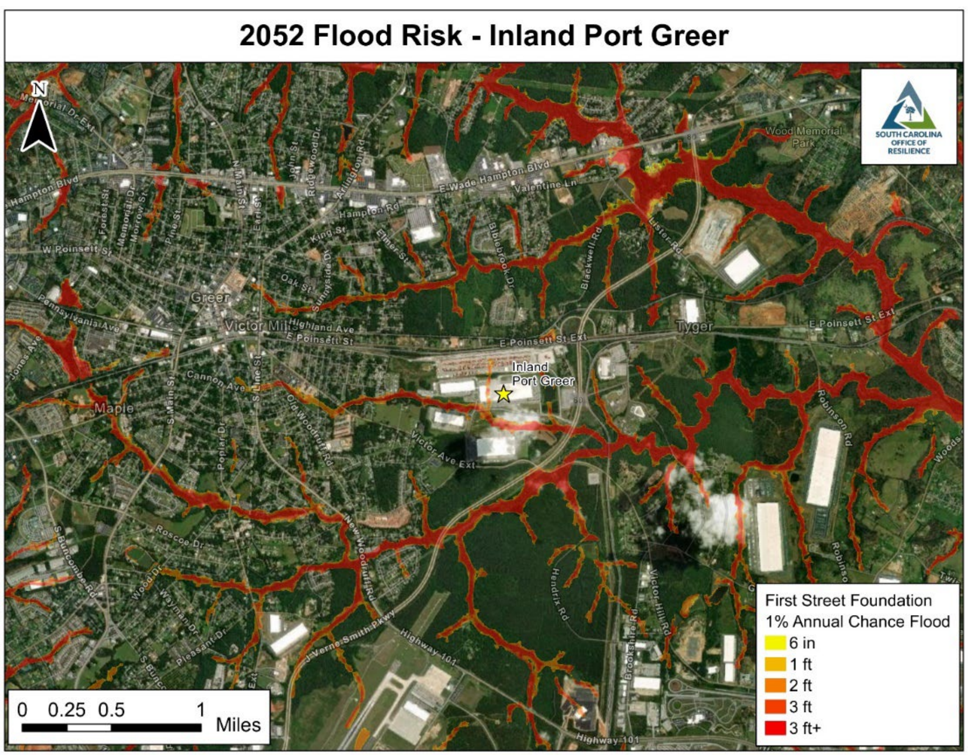


Figure 5.57: Estimated flooding of Inland Port Greer in the 2052 1% annual chance flooding event

RAIL

Rail freight is essential to the state's economy by providing efficient transportation of raw materials and goods for industries and businesses located here, as well as a distribution channel for products exported to other states and countries. Rail services are provided by 11 railroads, including two Class I railroads (CSXT and Norfolk Southern). Palmetto Railways, a branch of the South Carolina Department of Commerce, operates four railroad subdivisions. Additionally, Amtrak provides passenger service in South Carolina, with four Amtrak services passing through 11 stations in the State (SC Department of Transportation, 2020)

Currently, there is not a publicly available statewide dataset of railways with elevations on which to base a mapping analysis of flood risk.

ELECTRIC POWER GENERATION AND DISTRIBUTION

Electric generation and distribution require a complex system of power plants, substations, transmission lines, and other critical infrastructure that make up the power grid (Kern & Miranda, 2021). This section considers the impacts of hazards through the mapping of 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, 2022)Power distribution includes electric power substation facilities and equipment that switch, transform, or regulate electric power at voltages equal to, or greater than, 69 kilovolts. This permits export onto the wider state grid and for distribution into homes and businesses (Department of Homeland Security).

Electric power systems are particularly vulnerable to flooding. The maps below show the vulnerability of power plants to flooding in the 2022 (Figure 5.58) and 2052 (Figure 5.59) 1% annual chance flood event.

The vulnerability of substations to flooding in the 2022 (Figure 5.60) and 2052 (Figure 5.61) 1% annual chance flood event. Repairing flooded substations can take much longer than repairing distribution lines because of the time needed to allow waters to recede (Kern & Miranda, 2021).

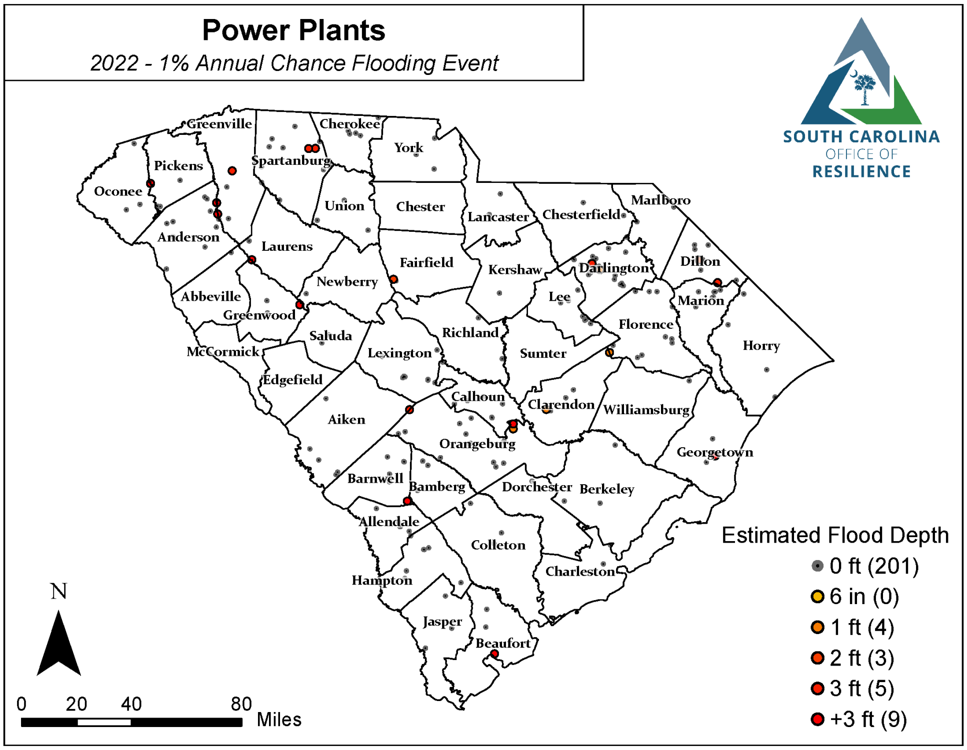


Figure 5.58: Estimated flooding of power plants in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

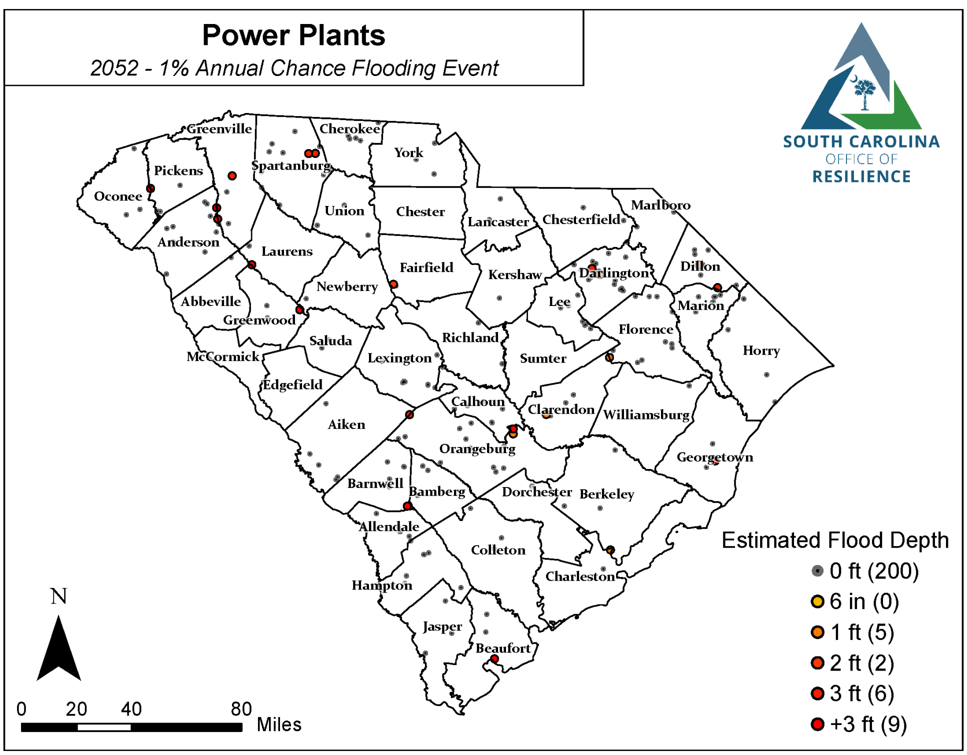


Figure 5.59: Estimated flooding of power plants in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

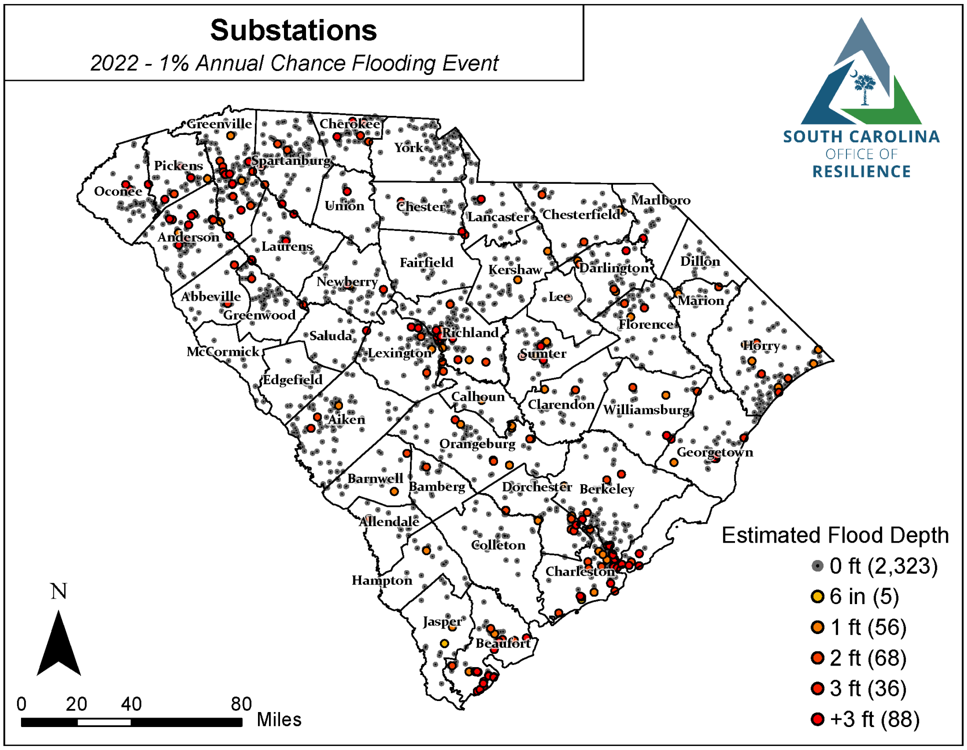


Figure 5.60: Estimated flooding of power substations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

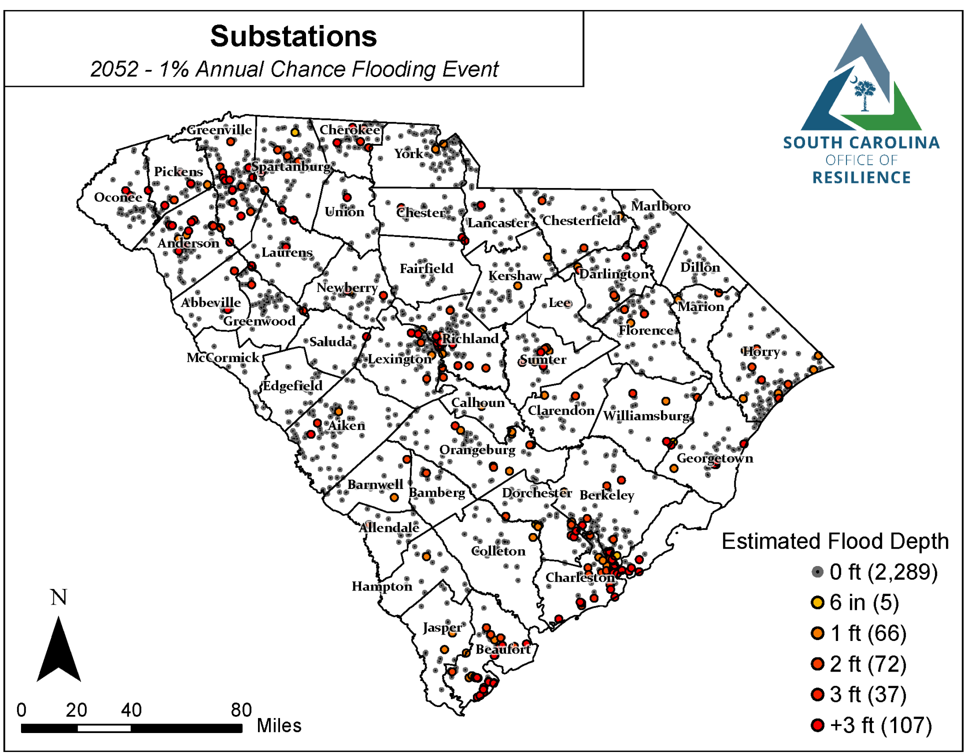


Figure 5.61: Estimated flooding of power substations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

INTERNET AND BROADBAND

Flooding can have a significant impact on internet cables, especially those that are underground or located near bodies of water. When flooding occurs, water can seep into the protective casing surrounding the cables and cause damage to the wires inside. This can lead to electrical shorts, corrosion, and even complete failure of the cables. Furthermore, if the water level rises above ground level, it can also damage above ground cables, which can disrupt internet and other communication services. Flooding can also cause physical damage to the infrastructure that supports internet cables, such as poles and equipment boxes. This damage can lead to service disruptions and potentially lengthy repair times.

Broadband infrastructure is difficult to capture on a statewide basis, as this data is often either not publicly available, incomplete, disorganized, outdated, not digitized, or held in disparate formats (National Telecommunications and Information Administration, 2022). Without a centralized asset map held at the state or local level, it is difficult to assess how specific assets and infrastructure supporting South Carolina’s broadband network are vulnerable to flooding or other hazards. SCOR will work with the South Carolina Broadband Office on identifying vulnerabilities and developing resilience strategies.

WATER SUPPLY

The state's freshwater resources sustain human life as well as support the state's economy for everything from agriculture to industry and power generation. Increasing population and development impact water demand. South Carolina DHEC Bureau of Water maintains an extensive dataset that includes the location of water suppliers in the State. Public water suppliers retrieve the water from surface water and groundwater. Surface water intakes can be fixed pipes or soft hoses in the water source with the pump station nearby, with larger municipalities using canals to divert water or locating their intakes on reservoirs to ensure a stable water source. Water supply groundwater wells are more likely to be found in the coastal plain of South Carolina due to access to availability of productive aquifers. Pump station and well locations are reported to SCDHEC during the permitting and registration process.

An example of how flooding can impact water supplies is the breaching of the Columbia Canal in the 2015 flooding event. The Columbia Canal originally opened in 1824 as a transportation alternative to the railroads to connect the upstate to the port in Charleston. Additions of water supply and power came in the later 19th and early 20th century (Marsh, 2015). During the historic 2015 flooding in Columbia, a 60-foot wide breach occurred, emptying into the Congaree River, compromising the primary water supply to the roughly 400,000 people (Underwood, 2021; Marsh, 2015). The City of Columbia, Columbia Water, and FEMA began repairs of the canal, with agreements announced in 2020 and the construction starting in 2022 (Columbia Water, 2022; Underwood, 2021).

The figures below illustrate the number of public water supply facilities vulnerable to flooding in the 2022 (Figure 5.62) and 2052 (Figure 5.63) 1% annual chance flood events.

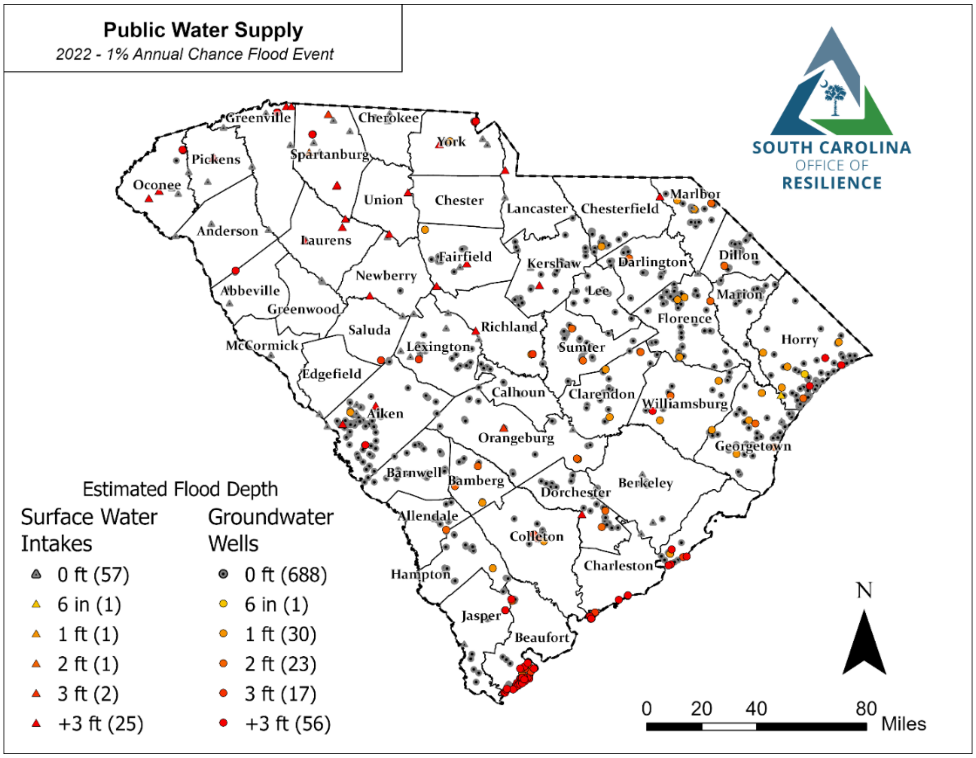


Figure 5.62: Estimated flooding of Public Water Supply in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

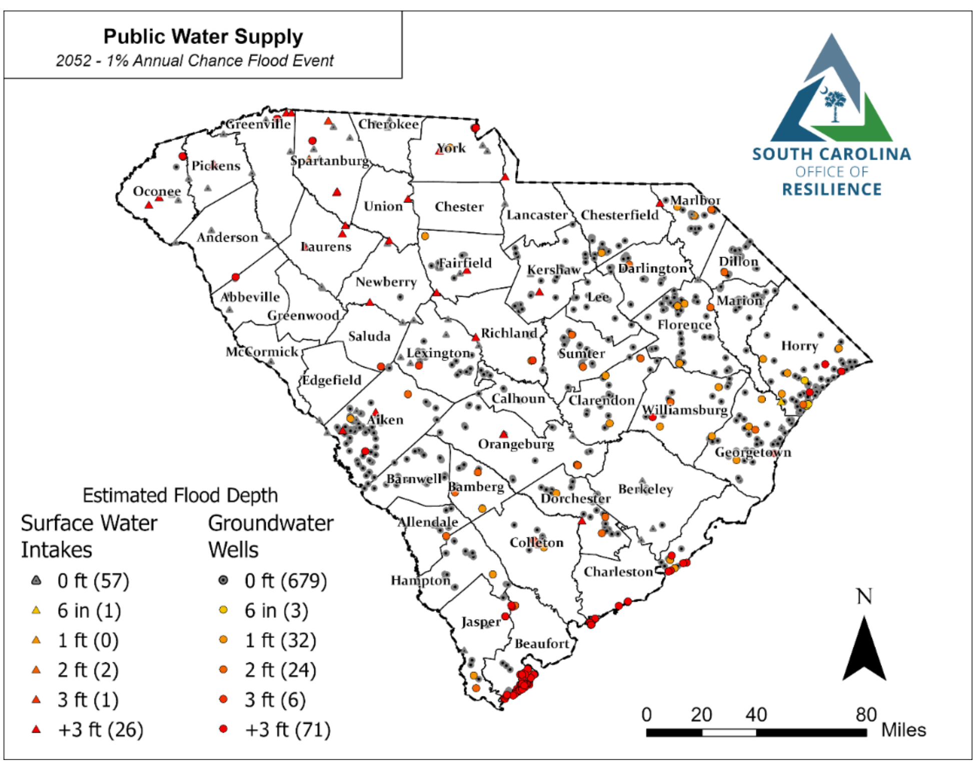


Figure 5.63: Estimated flooding of Public Water Supply in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

HAZARDOUS WASTE LOCATIONS

During flood events hazardous materials may be mobilized and cause impacts to downstream properties. By identifying facilities at potential risk from flooding, communities can better plan for potential impacts. Understanding which facilities may be at risk also allows for closer examination of onsite practices to mitigate potential off-site releases

SEWER SYSTEM DISCHARGE

It is essential to maintain sewage system function to protect human and environmental health, safety, and welfare. Both on-site septic systems and sewer systems are vulnerable to hazards.

The National Pollutant Discharge Elimination System (NPDES), administered by DHEC, regulates potential discharge of pollutants into the waters across the nation and in South Carolina. Using the system user type in the NPDES permits, supplied by DHEC, the location of the discharge pipe can be used as a proxy for the potential vulnerability of the facility discharging the sewage.

The figures below illustrate the number of sewer system discharges vulnerable in the 2022 (Figure 5.64) and 2052 (Figure 5.65) 1% annual chance flood events. Wastewater systems in coastal areas are vulnerable to infrastructure damage and disruption resulting in public health issues from heavy rainfall events, high-tide flooding, and sea level rise.

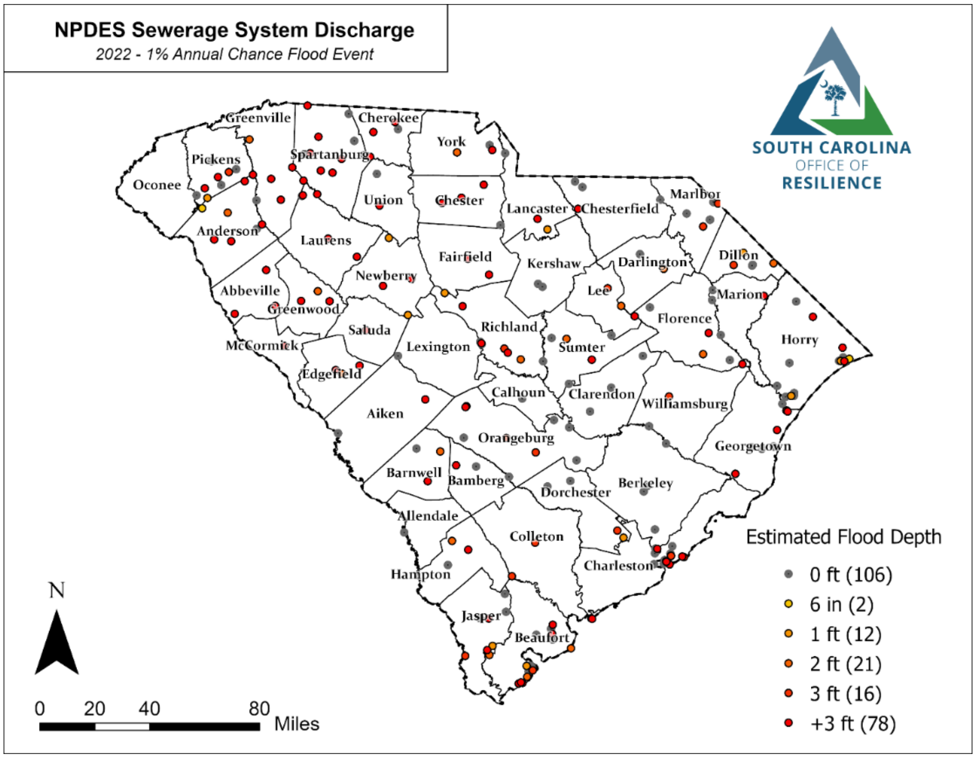


Figure 5.64: Estimated flooding of NPDES sewerage system discharge in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

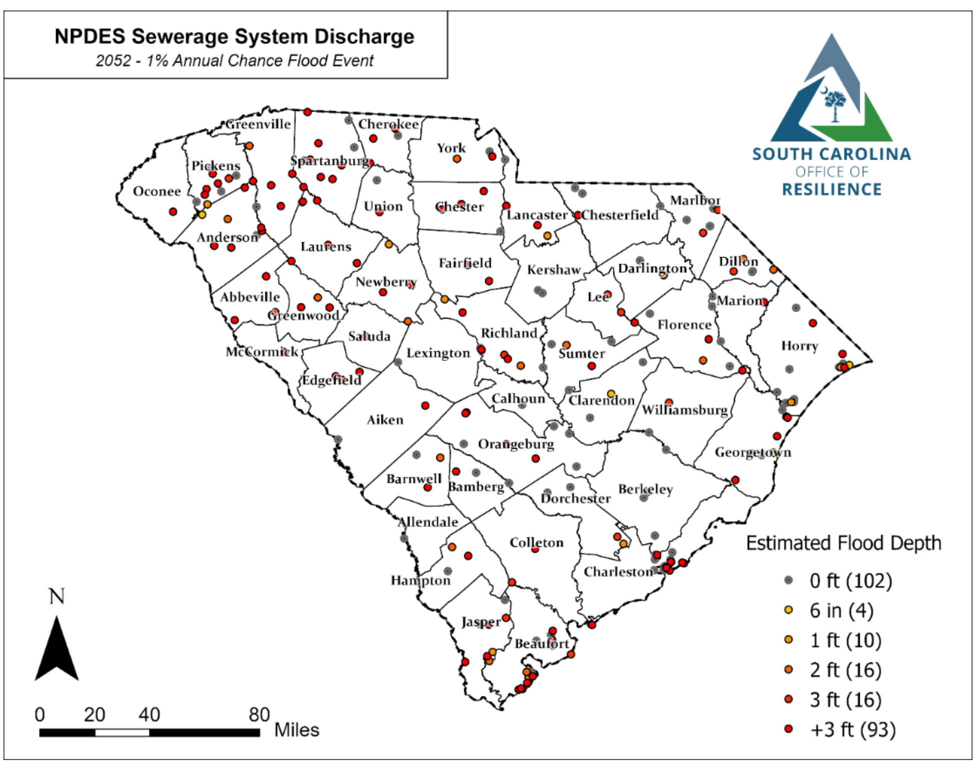


Figure 5.65: Estimated flooding of NPDES sewerage system discharge in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 contaminate water or soil if released. Despite containment measures, many small solvent releases occur during normal operations. State environmental regulatory standards only allow a few parts per billion of the solvent to be present in the ground or groundwater under a facility (SC Department of Health and Environmental Control, n.d.).

Contamination has the potential to be even more widespread if solvent comes in contact with flood water. The figures below illustrate the number of dry cleaners vulnerable in the 2022 (Figure 5.66) and 2052 (Figure 5.67) 1% annual chance flooding event.

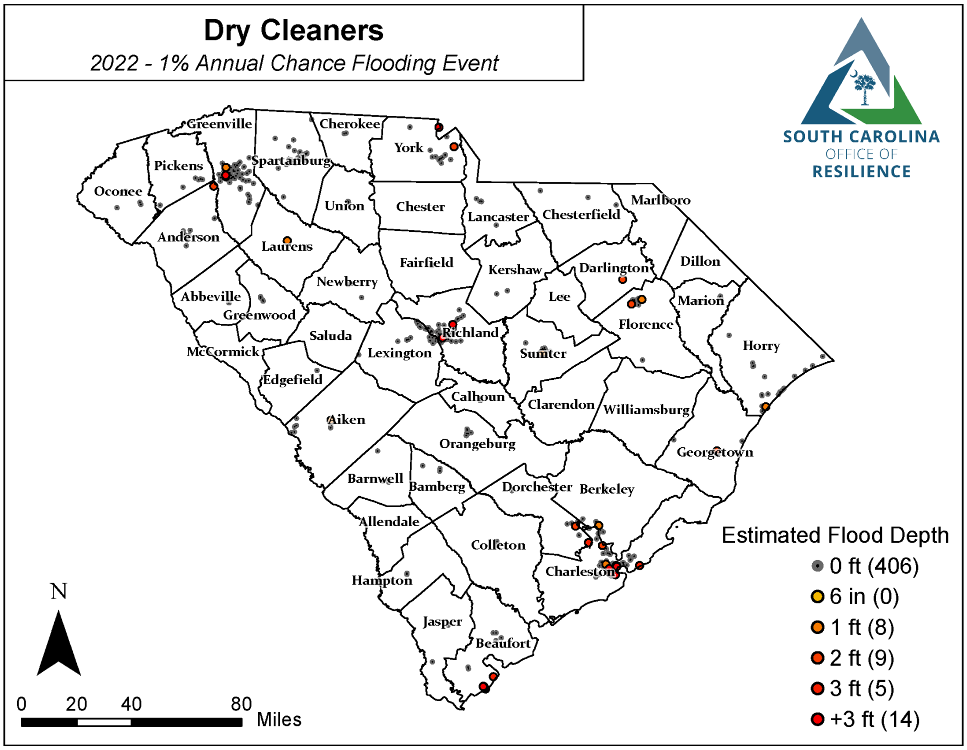


Figure 5.66: Estimated flooding of dry cleaners in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

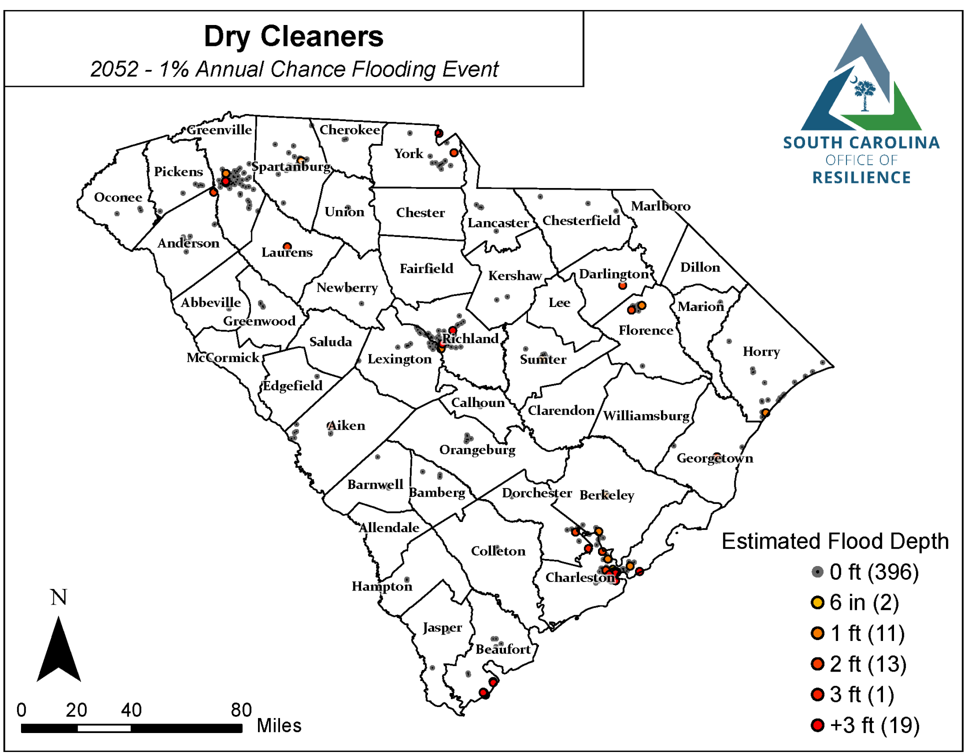


Figure 5.67: Estimated flooding of dry cleaners in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

MINES

Approximately 500 mines are actively operating with DHEC permits. Mines are regulated through the SC Mining Act (1974). There are several types of surface mining 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.).

DHEC Regulation 89-10 through 89-350 states that all overburden and spoil shall be placed so as not to result in deposits of sediment in streams, lakes or on adjacent property and that permanent overburden piles shall not be placed in or infringe on natural drainageways of floodways, and that temporary piles should not be placed there unless proper designs are utilized (SC Department of Natural Resources, 2003). The figures below show the number of mines vulnerable under the First Street Foundation's current (2022) and future (2052) scenario outside of these regulated areas (Figure 5.68 and Figure 5.69).

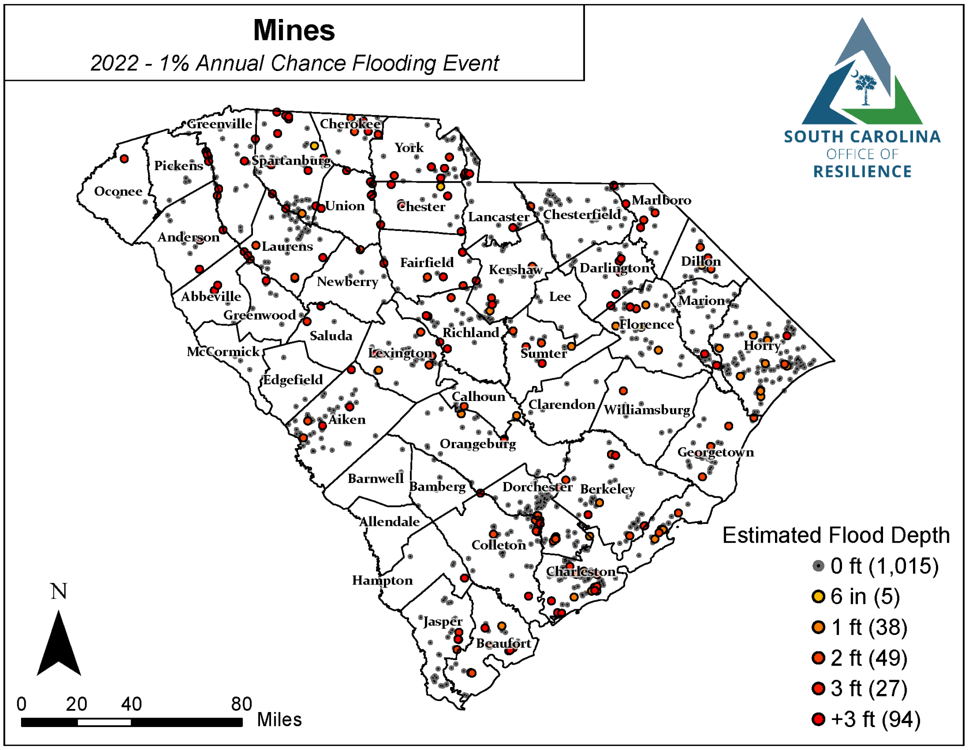


Figure 5.68: Estimated flooding of mines in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

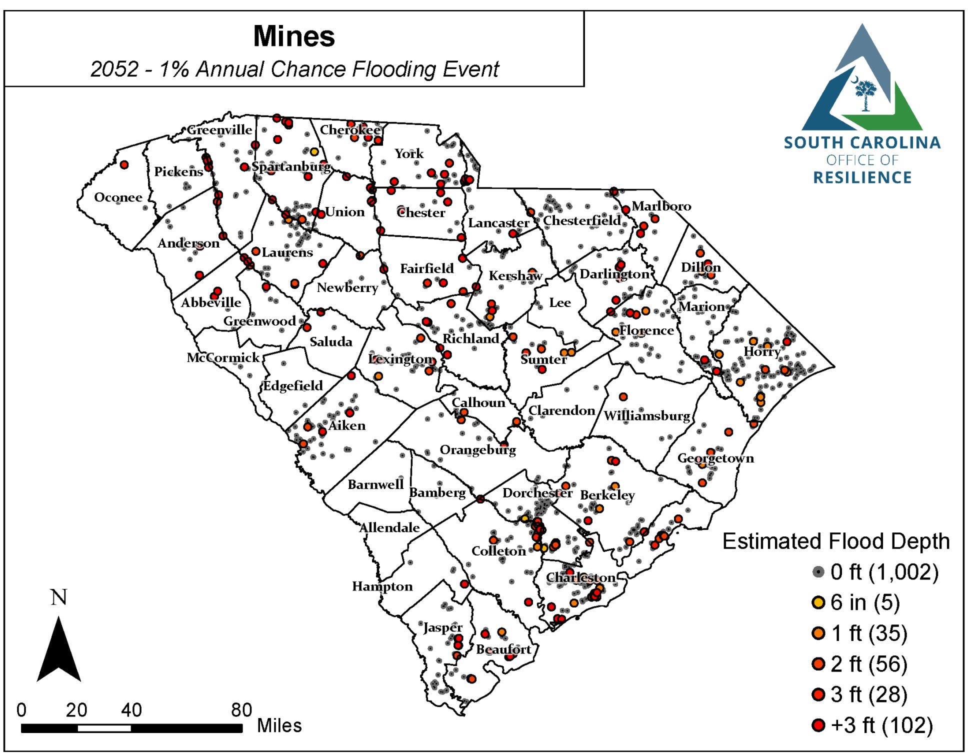


Figure 5.69: Estimated flooding of mines in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

SOLID WASTE FACILITIES

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.

Washout of solid waste and leachate by floodwater poses a hazard to human health and the environment. The South Carolina Solid Waste Policy and Management Act states that landfills shall not be located in the one hundred year floodplain unless it can be demonstrated "that engineering measures have been incorporated into the landfill design to ensure the landfill will not restrict flow of the one hundred year base flood, reduce the temporary water storage capacity of the flood plain, or result in the washout of solid waste". Figure 5.70 and Figure 5.71 show the number of solid waste landfills vulnerable in 2022 and 2052 1% annual chance flooding event while Figure 5.72 and Figure 5.73 show the vulnerability of all solid waste facilities.

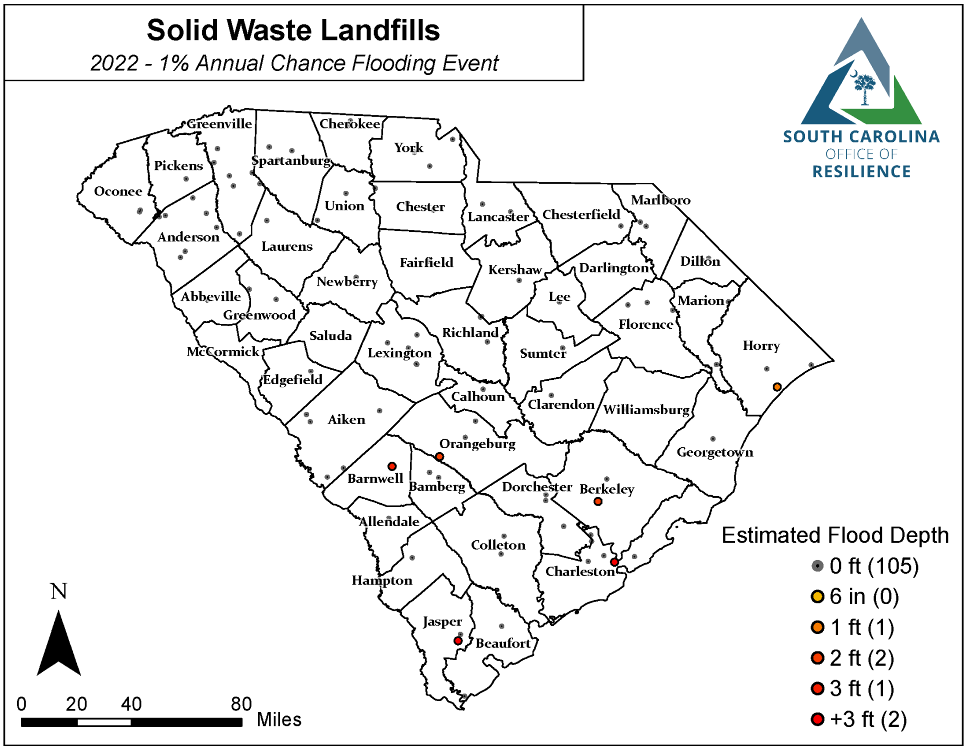


Figure 5.70: Estimated flooding of solid waste landfills in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

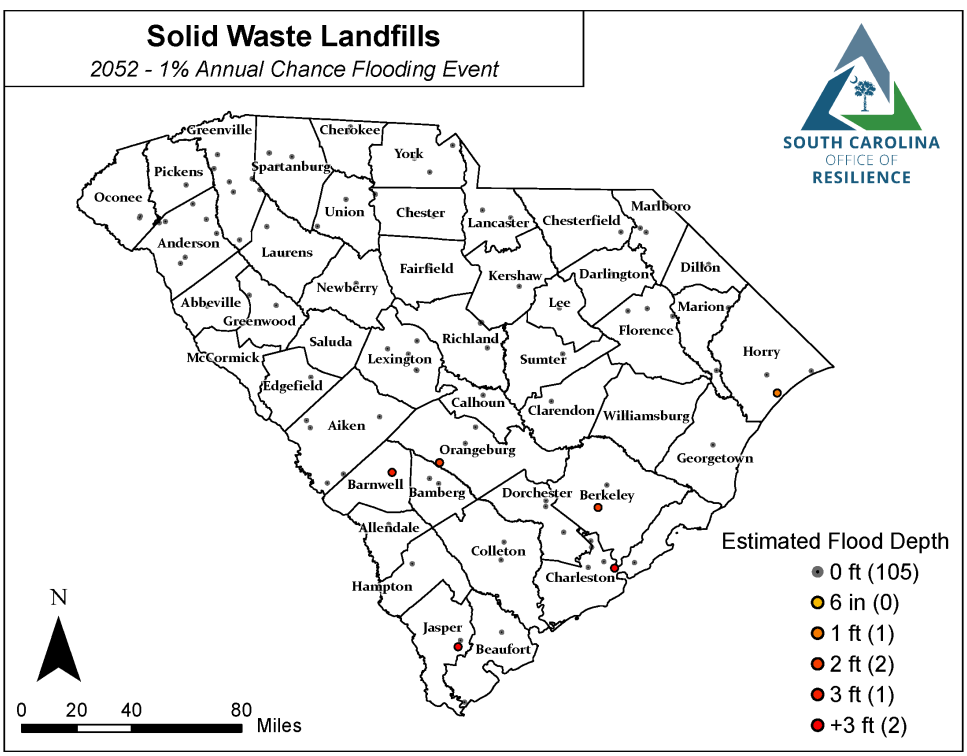


Figure 5.71: Estimated flooding of solid waste landfills in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

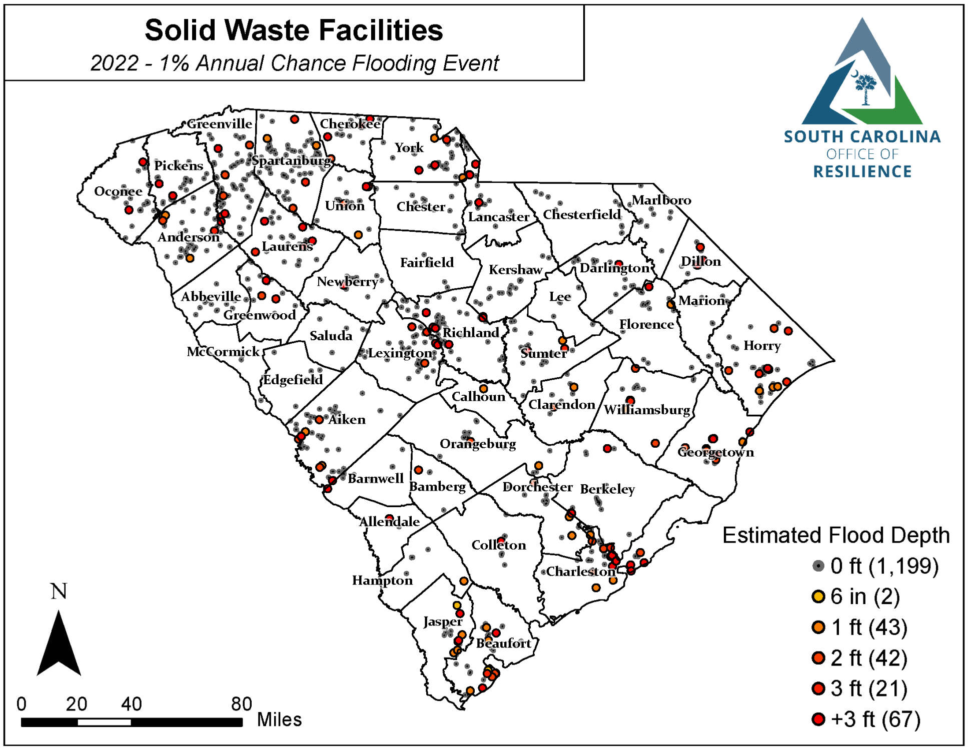


Figure 5.72: Estimated flooding of solid waste facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

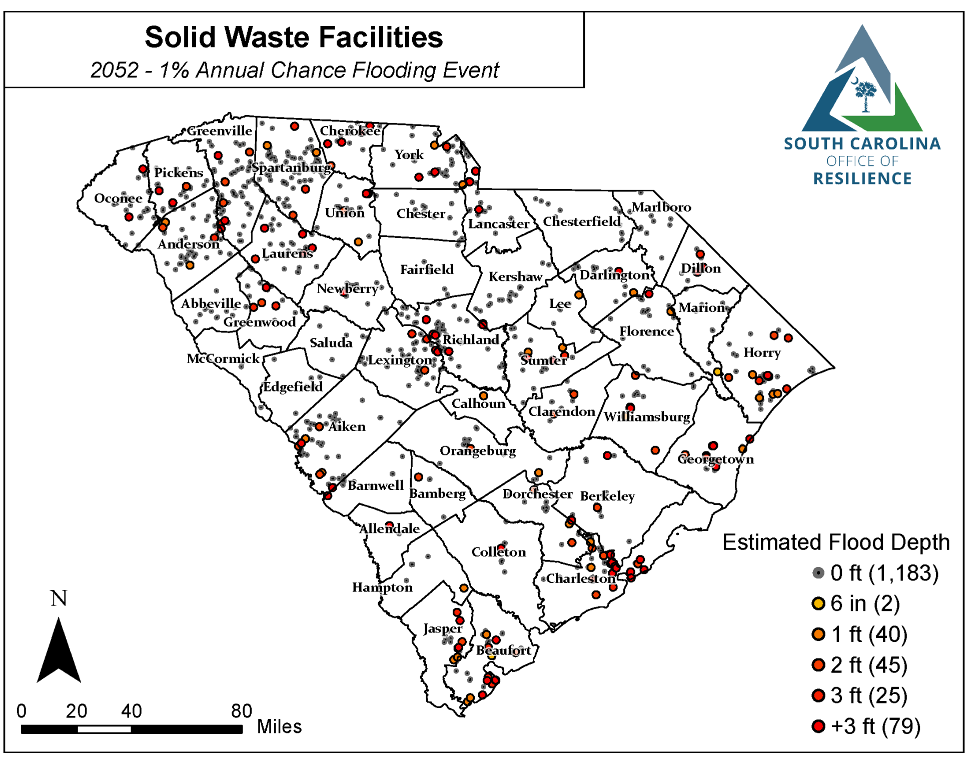


Figure 5.73: Estimated flooding of solid waste facilities in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

SITE ASSESSMENT, REMEDIATION AND REVITALIZATION (SARR)

DHEC's Site Assessment, Remediation and Revitalization (SARR) Division manages the evaluation and restoration of sites where hazardous waste has polluted the environment. These sites include Brownfields, Superfund, and State Voluntary Cleanup locations. According to preliminary data from DHEC, there are over 5,800 sites across the state. Locations are not displayed at the request of DHEC.

Table 5.13 shows the estimated flood depth of these sites under both the 2022 and 2052 1% annual chance flooding event.

Table 5.13: Estimated flooding of DHEC Site Assessment, Remediation and Revitalization sites in the 2022 & 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

Estimated Flood Depth	2022 1% Annual Flooding Event Number of Sites	2052 1% Annual Flooding Event Number of Sites
0 ft	5529	5482
6 inches	15	14
1 ft	46	53
2 ft	86	92
3 ft	44	46
+3 ft	139	172

HAZMAT TREATMENT, STORAGE AND DISPOSAL

DHEC permits active hazmat 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.).

The figures below show the number of these facilities vulnerable in the 2022 (Figure 5.74) and 2052 (Figure 5.75) 1% annual chance flooding event.

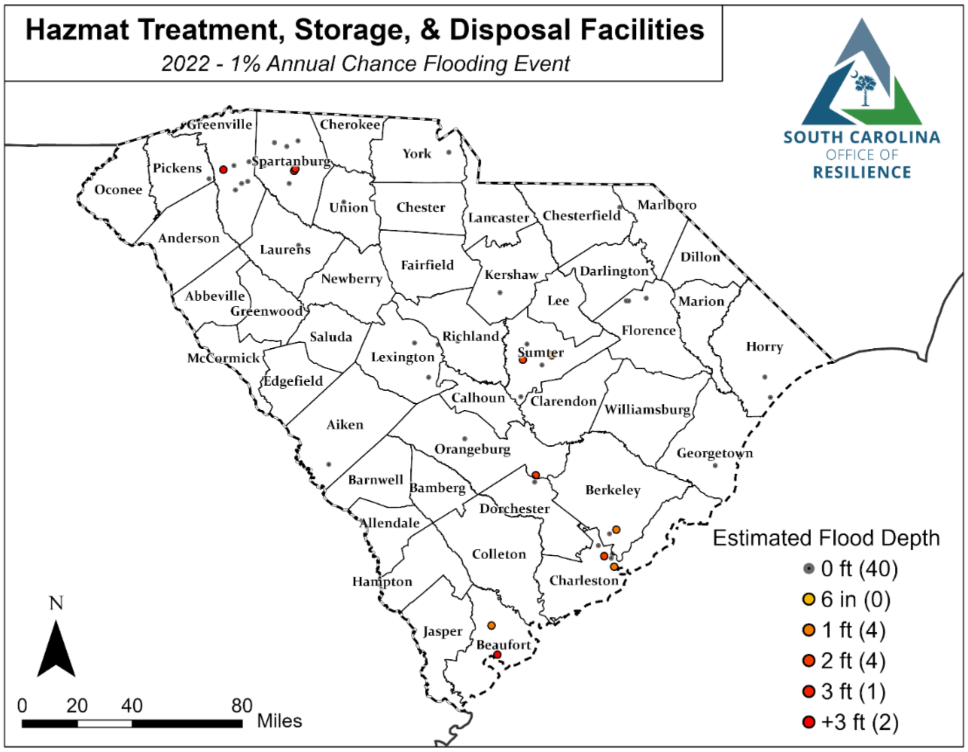


Figure 5.74: Estimated flooding of Hazmat Treatment, Storage and Disposal Facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

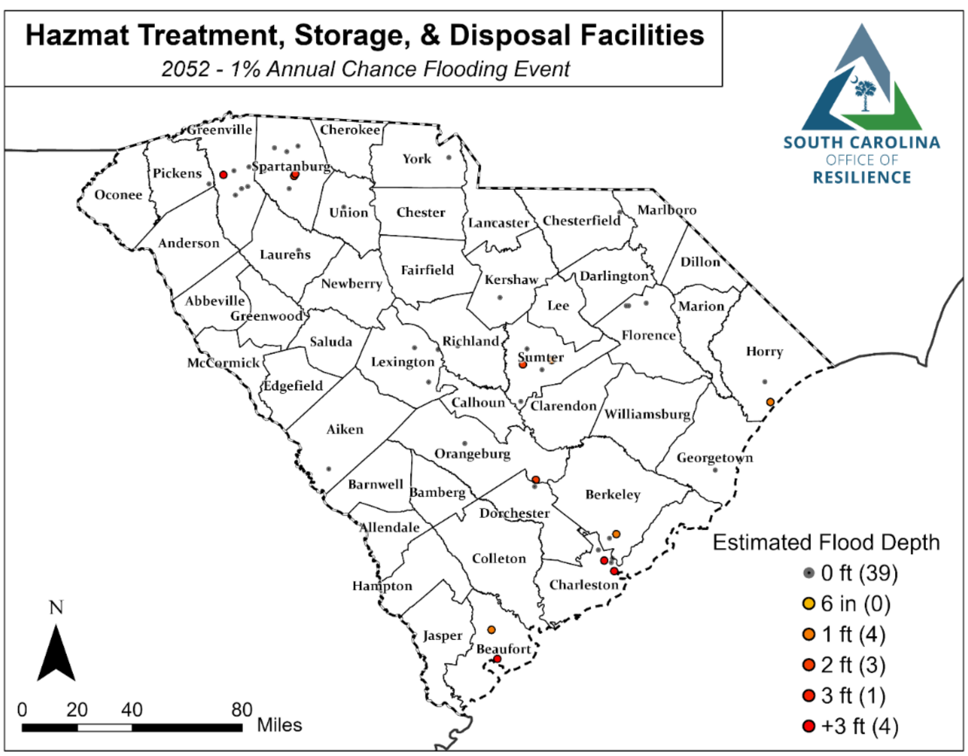


Figure 5.75: Estimated flooding of Hazmat Treatment, Storage and Disposal Facilities in the 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

UNDERGROUND STORAGE TANKS (UST)

Underground storage tanks are used across the State to store vital fuel but pose a risk if not properly contained. Regulation 61-92, Underground Storage Tank Control Regulations, defines underground storage tanks as any single or combination of tanks, including underground pipes connected to it, which is used to contain an accumulation of regulated substance, and the volume of which is ten percent or more beneath the surface of the ground.

The EPA Underground Storage Tank Flood Guide describes the effects flooding can have on underground storage tanks such as buoyancy, erosion and scour, and product displacement. The guide outlines actions to decrease risks to the system and environment. Preliminary data from DHEC shows over 17,000 underground storage tanks across the State, with Table 5.10 showing the estimated flood depths under both the 2022 and 2052 1% annual chance flooding event. Locations not displayed at the request of DHEC

Table 5.14: Estimated flooding of Underground Storage Tanks in the 2022 & 2052 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

Estimated Flood Depth	2022 1% Annual Flooding Event Number of Sites	2052 1% Annual Flooding Event Number of Sites
0 ft	16,099	15,856
6 inches	31	38
1 ft	301	344
2 ft	381	401
3 ft	202	215
+3 ft	400	560

OTHER IDENTIFIED AND UNIDENTIFIED HAZARDOUS WASTE

In addition to those identified hazardous waste sites analyzed above, there are many other sites that contain known and unknown contaminants that may be at risk to spreading during a flood event. Examples of this include hazardous waste found in marine debris such as ships as well as hazardous materials found in sediment behind dams, that if compromised, can leach into water bodies or floodwaters. Below are examples of locations with identified hazardous materials. There is a need to study sites with known or potential contaminants to understand the risk of contamination with flooding.

DAMS/SEDIMENT (LAKE CONESTEE)

Dams are structures built across rivers or streams to control and manage water flow. One of the significant effects of dams is their ability to interrupt the natural flow of sediments downstream. The slowing of water in the river allows for sediments and contaminants from upstream to fall out of suspension. Contaminants from upstream activities such as industry, agriculture, and other development often accumulate in the sediment trapped behind dams.

An example of this issue is the dam at Lake Conestee. The dam is located on the main stem of the Reedy River in Greenville County. It is a stone masonry dam constructed in the late 1880s to power Conestee Mill. This dam is now in deteriorating condition, and many harmful materials have been found in the sediment behind itWhile the dam breaking or being otherwise compromised would not cause a catastrophic level of flooding, such an event would release the wide range of contaminants down the system. The dam is classified as Significant Hazard Potential as it has been determined that failure would cause drinking water interruption based on drinking water intakes downstream, including Lake Greenwood. There is a need to stabilize the structure and the contaminants behind the dam (SCDHEC , 2023).

USS YORKTOWN

In 2022, the Governor signed Executive Order No. 2022-20, directing the SC Office of Resilience to address the potential environmental hazards associated with the USS Yorktown, directing SCOR to study, and obtain approval and funding for to perform any necessary and appropriate activities identified or recommended by the study to address legacy contaminants currently contained within the USS Yorktown. The study directed by the Executive Order is currently underway.

In 1975, the U.S. Navy donated the World War II Essex-class aircraft carrier USS Yorktown to the state of South Carolina to become a museum ship at Patriots Point in Charleston Harbor. Executive Order 2022-20 directed the SCOR to begin the process of removing hundreds of thousands of gallons of toxic pollutants from the USS Yorktown by commissioning an updated cost study for the project. This project is aimed at protecting the Charleston Harbor and the surrounding area from hazardous materials with the potential to harm the economy, natural resources, and communities.

At the time of the USS Yorktown's deactivation, the extensive procedures prescribed by the Navy today, S9086-BS-STM010 [0910-LP-104-3949, rev 3] were not in place. Consequently, the USS Yorktown still contains significant quantities of potentially hazardous materials. The USS Yorktown environmental assessment project involves the identification of all contaminants and design of a mitigation plan for the estimated 100,000 gallons of fuel in approximately 129 tanks and compartments. In many of the compartments, the fuel is combined with water. There is an estimated 1.75 million gallons of contaminated water. In addition, 3,000 gallons of hydraulic and lubricating oils have been identified throughout the ship. Other known contaminants on the vessel include, but may not be limited to, the polychlorinated biphenyls (PCBs) in some of the hydraulic fluids, lubricating oils, caulks, greases, electrical wiring, and in a large portion of the wooden flight deck.

The USS Yorktown is currently moored in the Charleston harbor with the keel buried to a depth of approximately 28 feet in soft bottom silt. Above the silt line, there is open water on the port side and tidal marsh on the starboard side that allow the ship's hull to be subjected to tidal ebb and flow. Localized areas of the ship's hull, particularly in the tidal splash zone, have experienced extensive corrosion with significant through hull penetration. It is anticipated that the USS Yorktown will require significant repairs for it to remain a viable museum for the foreseeable future.

CULTURAL RESOURCES

South Carolina's history is rich with the diversity of traditional communities, including many tribal nations, that trace their roots to the landscape. While the Catawba Indian Nation is the only federally recognized resident tribe in South Carolina, many sovereign tribal nations were forcibly removed from South Carolina and still maintain strong cultural ties to the landscape

The State currently recognizes nine tribes and four tribal groups (South Carolina Commission for Minority Affairs, 2022). State recognized tribes include: Beaver Creek Indians, Edisto Natchez-Kusso Tribe of South Carolina, Pee Dee Indian Nation of Upper South Carolina, Pee Dee Indian Tribe, Piedmont American Indian Association, The Santee Indian Organization, Sumter Tribe of Cheraw Indians, The Waccamaw Indian People, The Wassamasaw Tribe of Varnertown Indians. State recognized tribal groups include: Chaloklowa Chickasaw Indian People, Eastern Cherokee, Southern Iroquois and United Tribes of South Carolina, Natchez Tribe of South Carolina, Pee Dee Indian Nation of Beaver Creek.

Federally recognized tribal nations with ties to South Carolina include: Absentee-Shawnee Tribe of Indians of Oklahoma, Alabama-Quassarte Tribal Town, Catawba Nation, Cherokee Nation, Eastern Band of Cherokee Indians, Eastern Shawnee Tribe of Oklahoma, Kialegee Tribal Town, Miccosukee Tribe of Indians of Florida, Muscogee Nation, Poarch Band of Creek Indians, Santee Sioux Nation (Santee Sioux Tribe of the Santee Reservation of Nebraska), Shawnee Tribe, Thlopthlocco Tribal Town, Tuscarora Nation, United Keetoowah Band of Cherokee Indians of Oklahoma.

Additionally, the Gullah/Geechee warrant special consideration given their national cultural significance and ties to the Lowcountry's environmental and cultural landscape (National Park Service, 2005).

These historically marginalized communities have been overlooked as key stakeholders in the region's ability to absorb and recover from environmental change and natural hazards. Cultural assets – archives, libraries, museums, historic buildings, archeological sites, historic neighborhoods and communities, and cultural landscapes – throughout South Carolina have a vested interest in the state's resilience efforts. Cultural custodians and representatives can offer critical insight to the specific threats experienced in their communities and provide valuable historic context for land and resource use important for resilience planning solutions (National Park Service, 2005).

Intangible cultural heritage such as oral traditions, performing arts, social practices, rituals, festive events, knowledge, and practices (UNESCO, 2022) also deserve special consideration and are often tied to a physical place (Feary, 2015).

Cultural resources are increasingly threatened both by development and by climate driven impacts, especially in coastal zones (Dawson, Hambly, Kelley, Lees, & Miller, 2020). On the southeastern Atlantic Seaboard, nearly 20,000 known archaeological sites are at risk of damage or destruction due to forces related to sea level rise (Anderson, et al., 2017). Assuming current projections hold, and the sea level rises approximately one meter by the end of the century, a total of 19,676 currently recorded archaeological sites will be submerged. Since survey coverage is incomplete, the numbers of actual sites impacted will be much higher (Anderson, et al., 2017). Many additional archaeological sites will be lost before they are discovered due to the current methodologies of archeological survey. These sites are damaged most severely by the persistent wave and tidal energies generating erosion that precedes permanent sea level rise.

Additionally, portions of the southeastern coastline are experiencing sea level rise at rates three times the global average (Valle-Levinson, Dutton, & Martin, 2017). The ways in which we are addressing the impacts of climate to cultural heritage in the United States is a patchwork of partial solutions driven largely by state budgets and to a lesser extent by federal support for specific weather events for which funding often comes years later (Beavers, et al, 2016; Newland, et al, 2017). Furthermore, siloed cultural resource management practices operating within state borders have led to divergent and imperfect responses to environmental changes and natural hazards. Currently, no laws associated with resilience and mitigation provide funding for cultural resources that are increasingly threatened by environmental processes.

Federal, state, and local laws and regulations define what typically makes a cultural resource or historic property “significant”. For example, for buildings, structures, sites, objects, and districts, their inclusion in the National Register of Historic Places (NRHP), or a determination of eligibility for inclusion in the NRHP can make them significant. This is different however from how resources are designated at the local level, which are less quantifiable due to the number of entities involved or due to their sensitive nature.

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 12,000 to 15,000 properties are included in the National Register. Charleston County has the most listings followed by Richland, Greenville, Beaufort, Spartanburg, Lexington, York, and Darlington Counties.

In addition to these NRHP listings, 76 South Carolina properties are recognized as National Historic Landmarks (NHLs), including four historic districts - Beaufort, Charleston, Graniteville in Aiken County, and Penn School on St. Helena Island. Of the NHLs, 42 are in Charleston County, including the USS Yorktown, and the remainder are scattered across the state.

Over 83,000 above-ground historic and architectural resources have been recorded by surveys of historic properties since the early 1970s. An average of 1,800 properties are added annually to the Statewide Survey collection that is maintained by the SC Department of Archives and History (SCDAH). Additionally, nearly 37,000 archaeological sites are in the state archaeological site files maintained by the SC Institute for Archaeology and Anthropology (SCIAA). Over the past decade, almost 700 new sites were added to the inventory annually, primarily through cultural resources surveys to comply with federal and state laws. Counties with the most recorded sites include Beaufort, Berkeley, Charleston, and McCormick, each with over 2,000 sites.

Regarding tangible collections, heritage custodians are overburdened and focused on triage and mitigating active instances of damage and loss rather than planning for the long-term needs of collections. According to the 2014 Heritage Health Information Survey (HHIS) conducted by the Institute of Museum and Library Services (IMLS), 76% of organizations do not have both a written institutional emergency plan and staff trained to carry that plan out - a statistic that was unimproved from the 2004 HHIS (Institute of Museum and Library Services, 2019). As a result, time and resources are directed to mitigating internal impacts on collections such as improper packaging and storage, obsolete and out of date equipment, water damage, and pest infestations rather than looking toward future impacts. The potential impact of future climate conditions on tangible collections has not been thoroughly investigated beyond the monetary impact of rising temperatures, humidity, and natural weather events on collection storage environments and the acknowledgement that most collections are greatly unprepared to respond to any emergency (International Institute for Conservation of Historic and Artistic Work, 2008).

Of primary concern is the lack of up-to-date documentation and assessments of State cultural assets. Over half of collecting organizations nationally have not completed a condition assessment of their collection, and nearly all do not regularly assess the entire collection (Institute of Museum and Library Services, 2019). Furthermore, volunteer-run sites and assets not listed on official registers will easily slip through the cracks. The level of preparedness was demonstrably worse for small collections compared to large ones with greater resources at their disposal.

The cultural heritage sector in South Carolina is largely unprepared to absorb adverse impacts, let alone adapt, thrive, or demonstrate resilience at this time. A long-term, sustainable investment in funding, time, and people (e.g., cultural resource managers, community members, members of sovereign tribal nations) is required to allow the cultural resources sector to become resilient.

ArchSite, the South Carolina Institute for Archeology and Anthropology (SCIAA) and the South Carolina Department of Archives and History's (SCDAH) online cultural resources information system, is used in the maps below to show physical vulnerability to properties that are individually listed in the NRHP or historic structures that have been determined eligible for listing in the NRHP. In the following maps, this data is not represented by individual points to protect the security of the properties while allowing for statewide analysis. Figures 5.76 through 5.79 display the number of sites or structures at the HUC-10 level that will be impacted by a 1% annual chance flooding event.

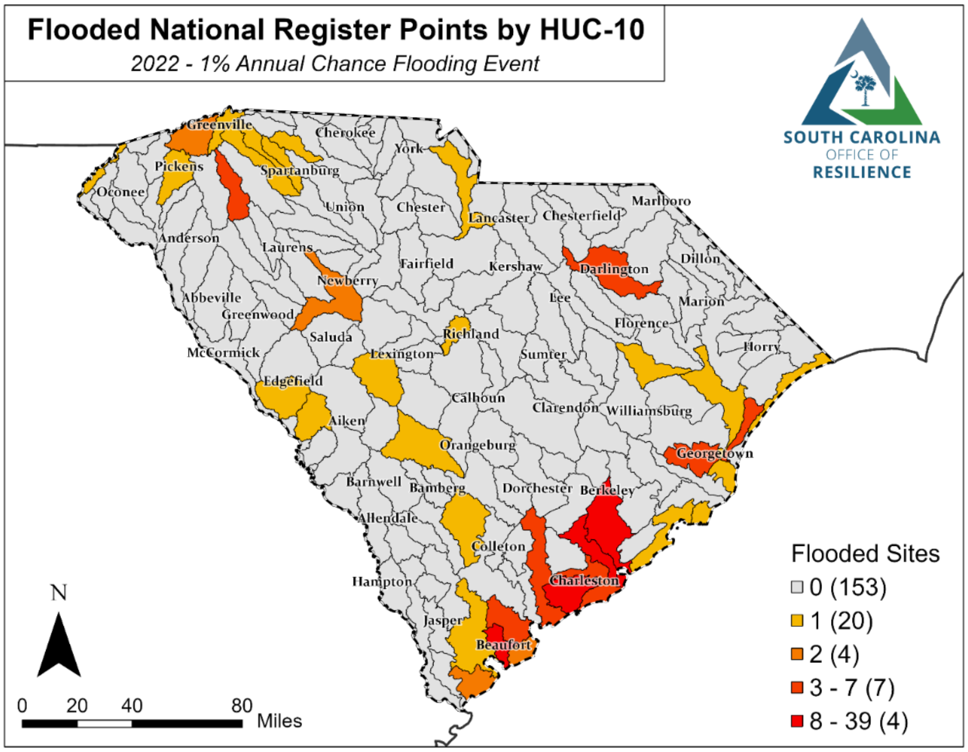


Figure 5.76: Estimated flooding of National Register Locations in the 2022 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

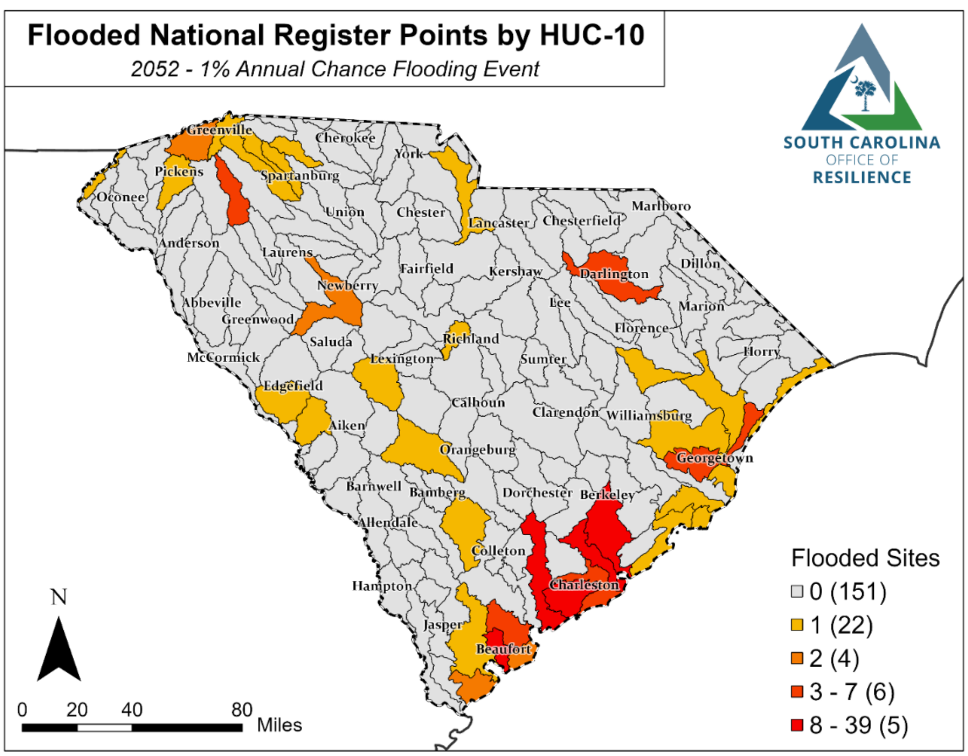


Figure 5.77: Estimated flooding of National Register Locations in the 2052 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

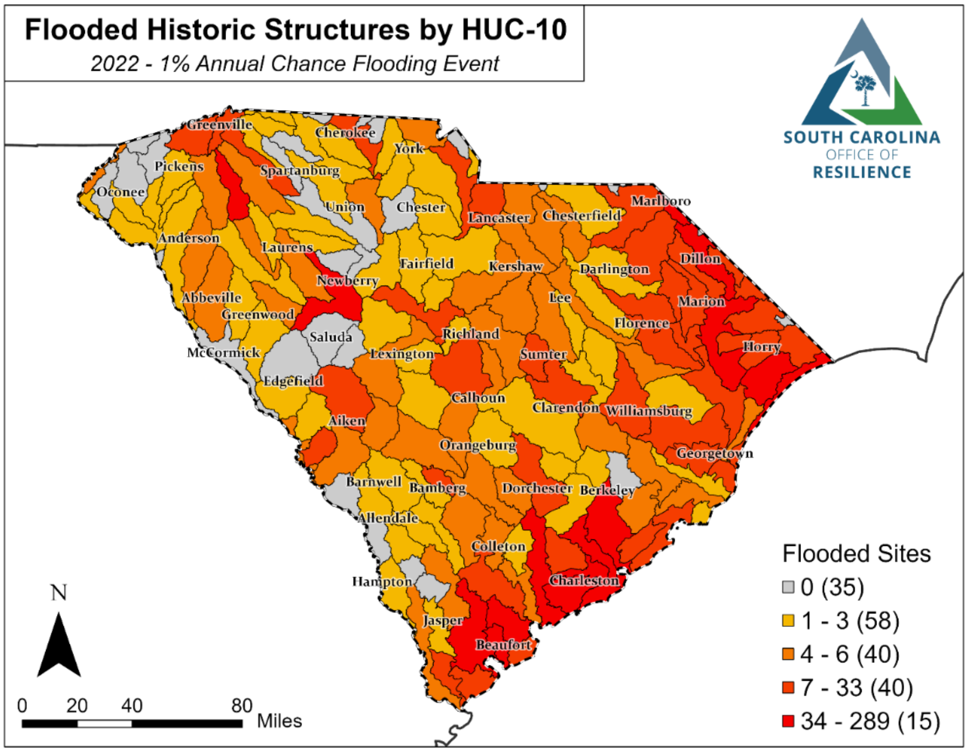


Figure 5.78: Estimated flooding of Historic Structures in the 2022 1% annual chance flooding event by local watershed (HUC-10)(ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

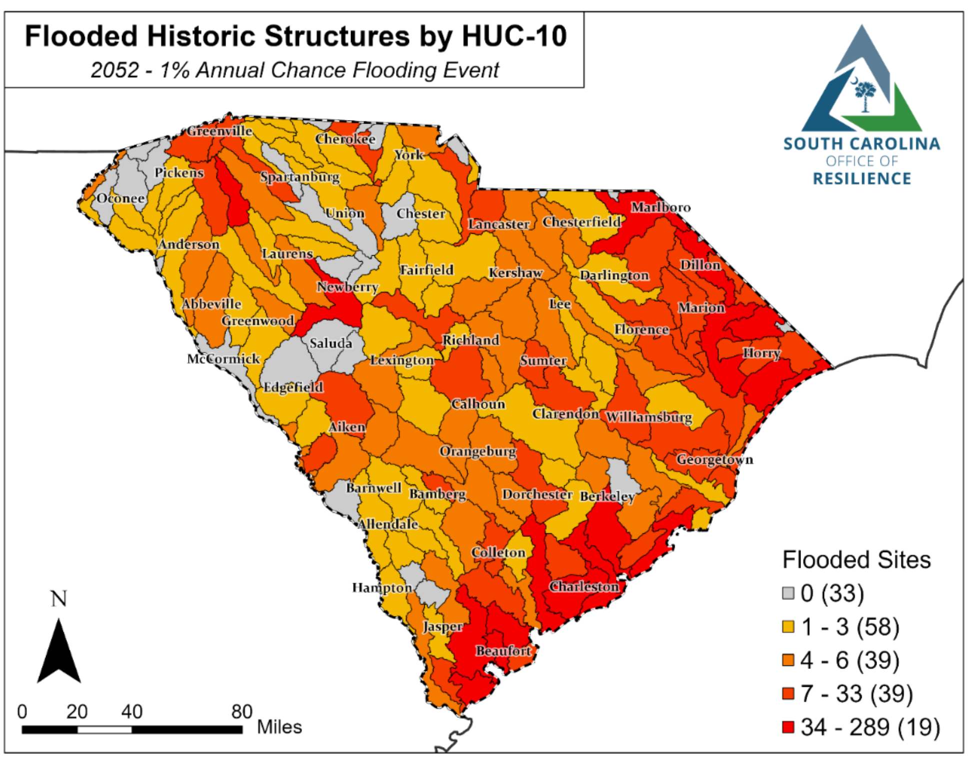


Figure 5.79: Estimated flooding of Historical Structures in the 2052 1% annual chance flooding event by local watershed (HUC-10) (ArchSite). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 and has a significant presence in our State. The State's 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 supports multiple defense missions that contribute to defense readiness, training, and homeland security (SC Department of Veterans' Affairs, n.d.). Therefore, understanding base exposure as well as access routes to the bases, is important to addressing military readiness.

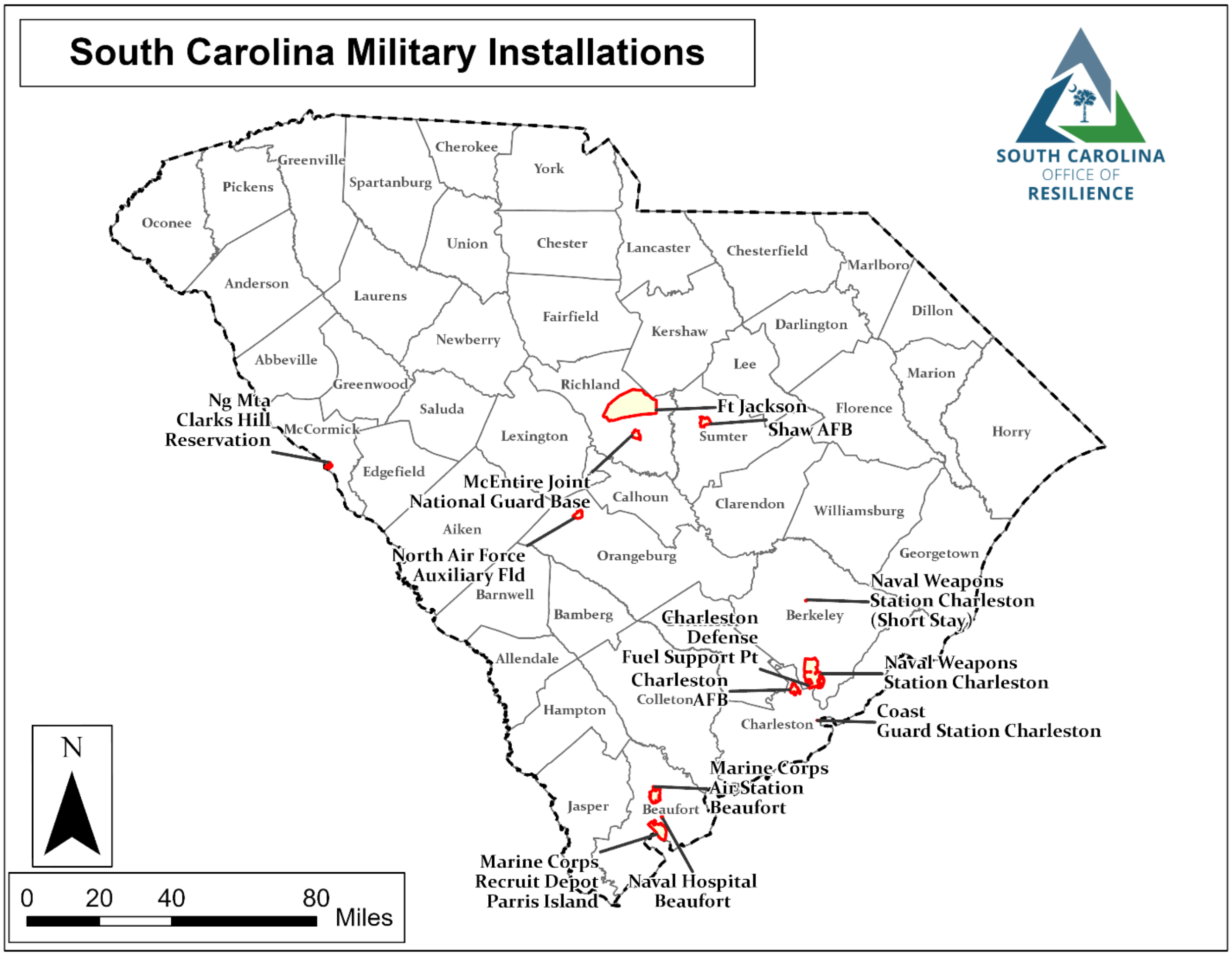


Figure 5.80: South Carolina Military Installations

Figure 5.81 and Figure 5.82 below display the current and future flood risk to military bases in the Midlands region using the First Street Foundation's hazard layers for a 1% annual chance flood event.

Figure 5.83 and Figure 5.84 below display the current and future flood risk to military bases in the Beaufort area using the First Street Foundation's hazard layers for a 1% annual chance flood event.

Figure 5.85 and Figure 5.86 below display the current and future flood risk to military bases in the Charleston area using the First Street Foundation's hazard layers for a 1% annual chance flood event.

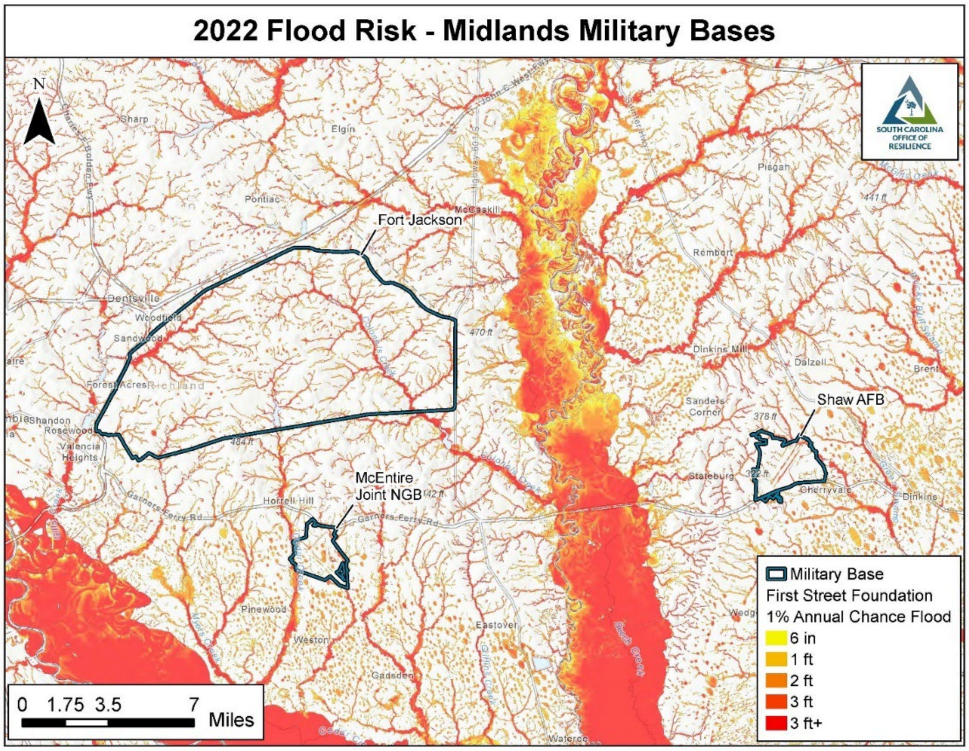


Figure 5.81: Estimated flooding of Military Installations in the Midlands, Fort Jackson, Shaw AFB, and McEntire Joint NGB, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

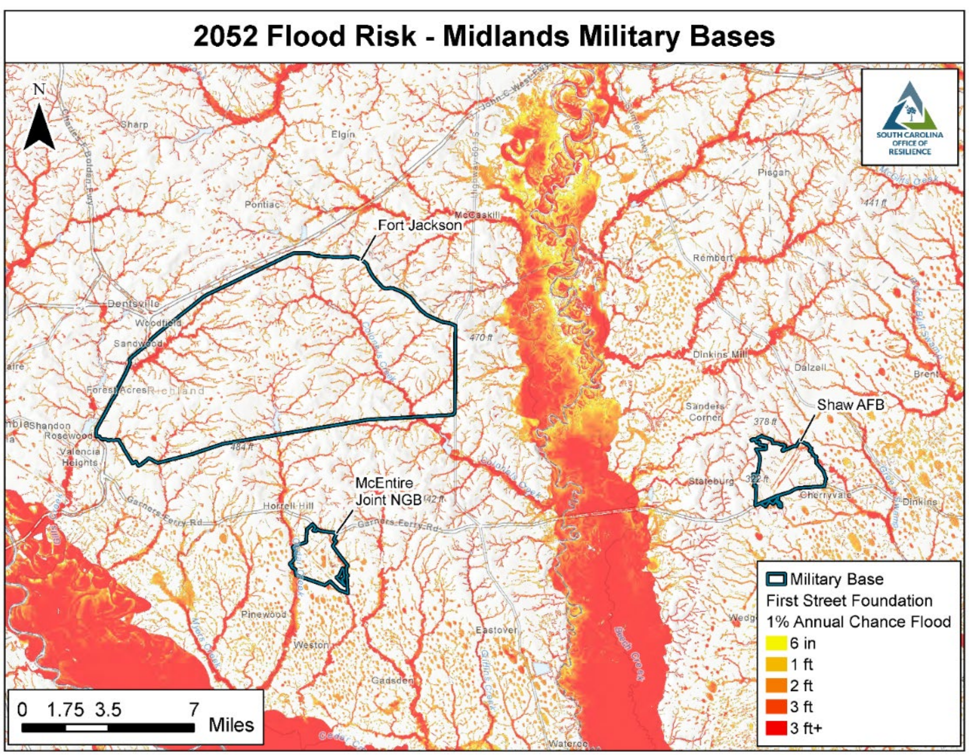


Figure 5.82: Estimated flooding of Military Installations in the Midlands, Fort Jackson, Shaw AFB, and McEntire Joint NGB, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

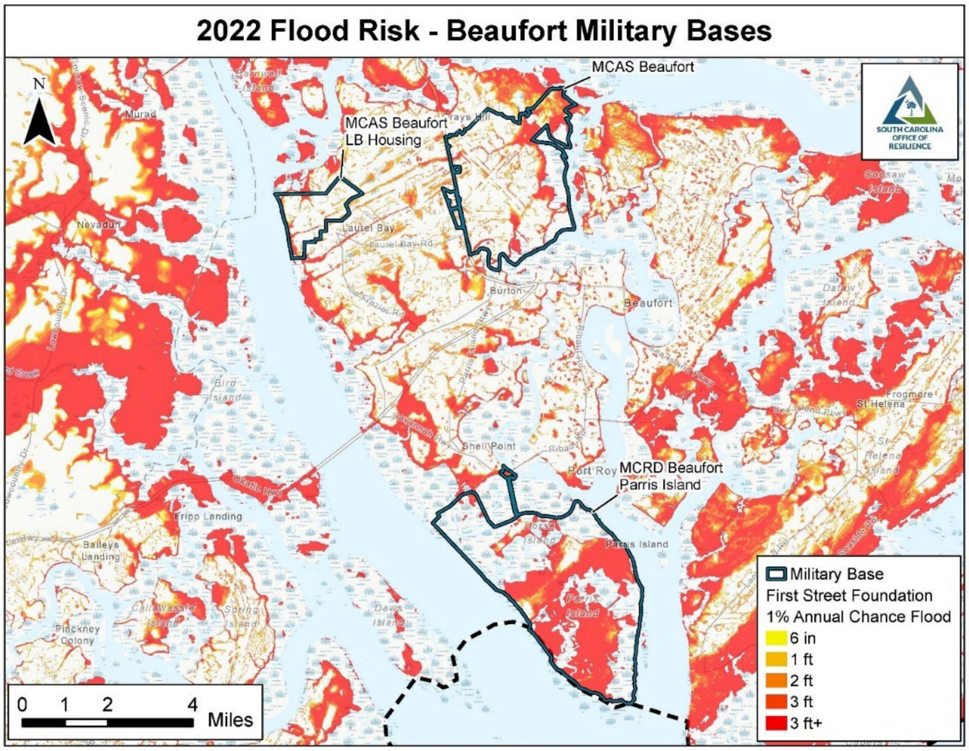


Figure 5.83: Estimated flooding of Military Installations in the Beaufort County: MCAS Beaufort, MCAS Beaufort LB Housing, and MCRD Beaufort Parris Island, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

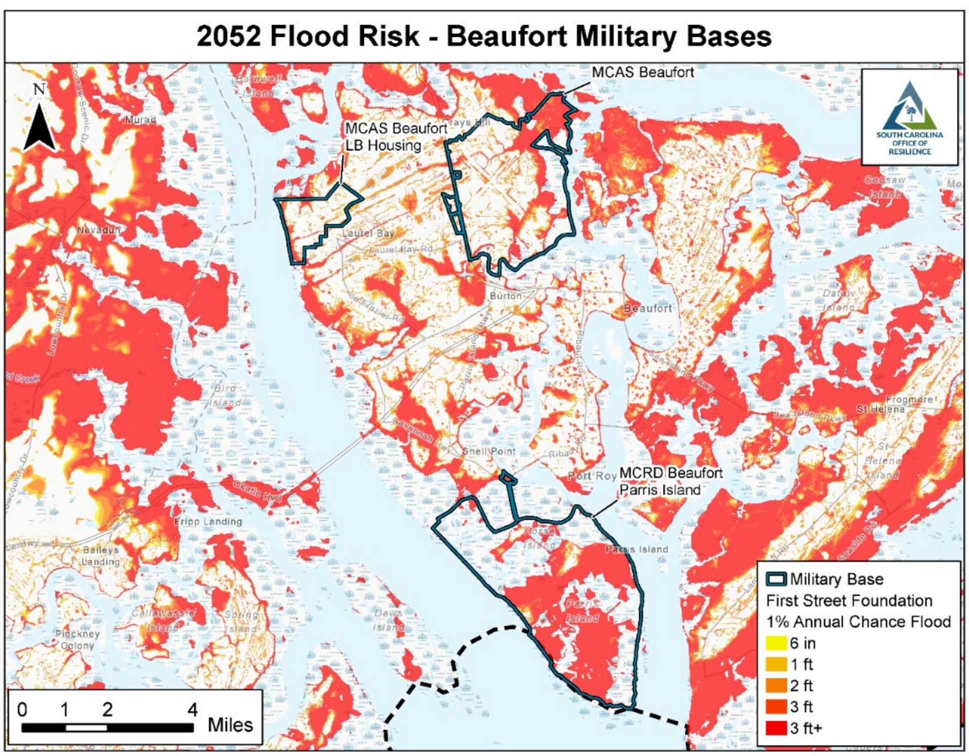


Figure 5.84: Estimated flooding of Military Installations in the Beaufort County: MCAS Beaufort, MCAS Beaufort LB Housing, and MCRD Beaufort Parris Island, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

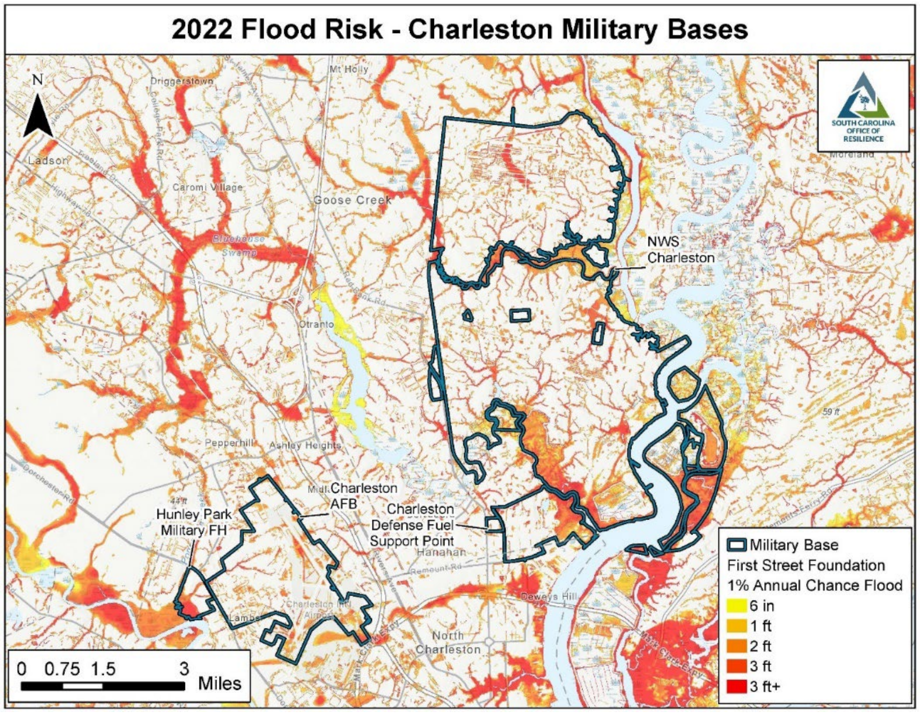


Figure 5.85: Estimated flooding of Military Installations in the Charleston County: NWS Charleston, Charleston Defense Fuel Support Point, Charleston AFB, and Hunley Park Military FH, in the 2022 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

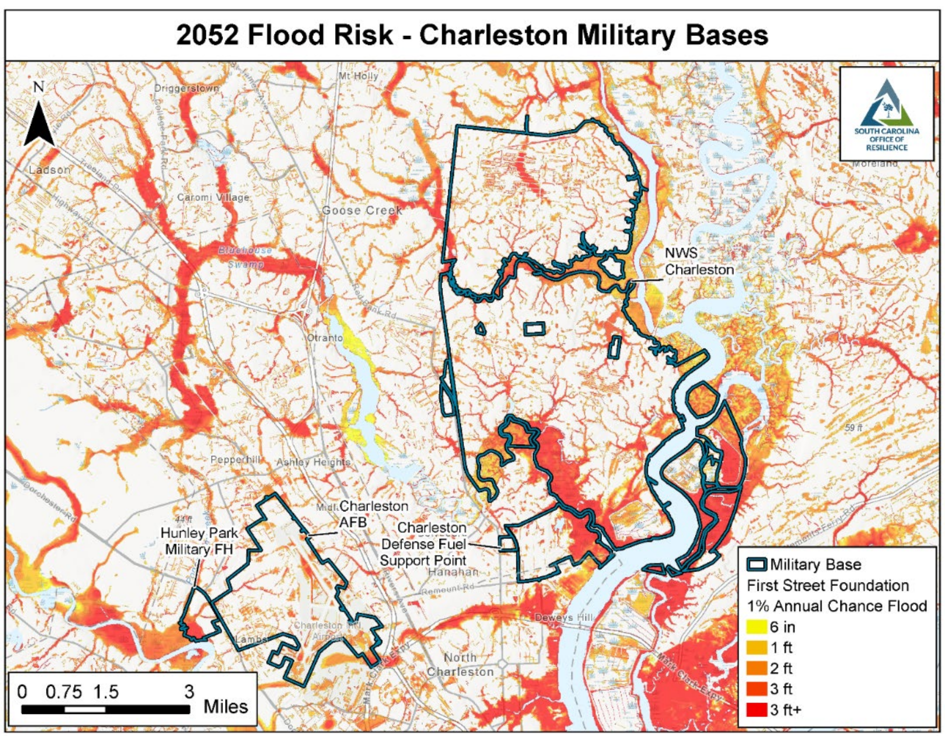


Figure 5.86: Estimated flooding of Military Installations in the Charleston County: NWS Charleston, Charleston Defense Fuel Support Point, Charleston AFB, and Hunley Park Military FH, in the 2052 1% annual chance flooding event. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PUBLIC SAFETY

STATE LEVEL LAW ENFORCEMENT

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 SC Criminal Justice Academy (SCCJA) is responsible for all mandated basic law enforcement, detention, and telecommunications training in South Carolina. The Academy provides full training continuity to every law enforcement officer in the state (includes over 300 law enforcement agencies). In addition, the SCCJA serves as a housing and operational staging point during emergencies for agencies such as FEMA, National Guard, Emergency Rescue Teams, and deployment teams.

The South Carolina Department of Probation, Parole and Pardon Services (PPP) is an accredited law enforcement agency that is charged with the community supervision of offenders placed on probation by the court and paroled by the State Board of Paroles and Pardons. The Department is committed to the use of innovative, cost effective strategies proven to reduce new crime and new victimization in South Carolina. PPP is currently divided into 5 Regions and has offices in all 46 counties. PPP provides assistance and staffing for Emergency Support Function-13 security missions, hurricane evacuations, and other natural disaster assistance when called upon.

LOCAL LAW ENFORCEMENT

While the above state agencies support local law enforcement agencies, initial response depends on county, city, and town law enforcement agencies.

The figures below illustrate the number of local law enforcement facilities vulnerable in the 2022 (Figure 5.87) and 2052 (Figure 5.88) 1% annual chance flood events.

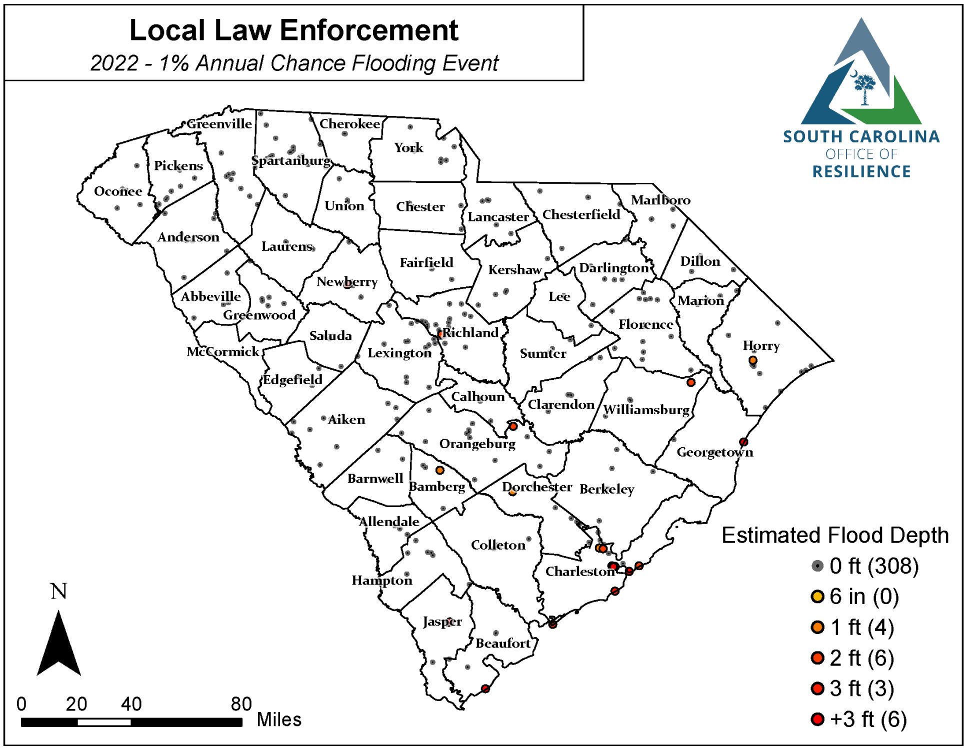


Figure 5.87: Estimated flooding of local law enforcement agencies in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

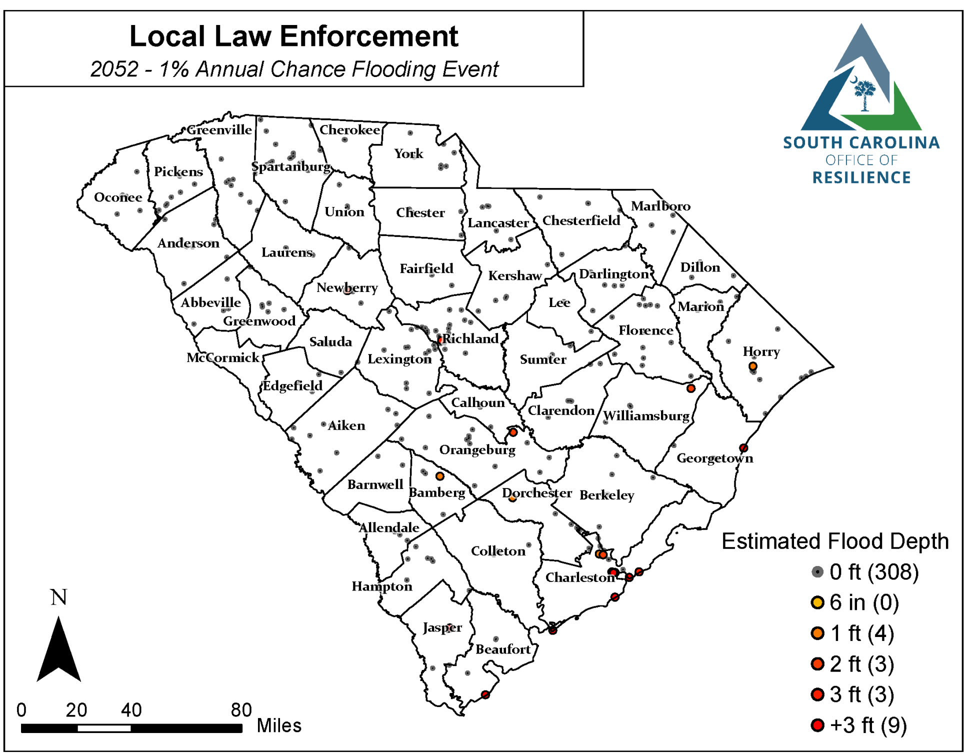


Figure 5.88: Estimated flooding of local law enforcement agencies in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

DETENTION CENTERS

SLED identifies 84 detention centers across the state, which includes county, state federal, and juvenile facilities.

One of the most studied and pressing issues that these detention centers and the SC Department of Corrections face during flooding events is the need to evacuate large numbers of people from the facilities. The figures below illustrate the vulnerability of these centers in the 2022 (Figure 5.89) and 2052 (Figure 5.90) 1% annual chance flood events.

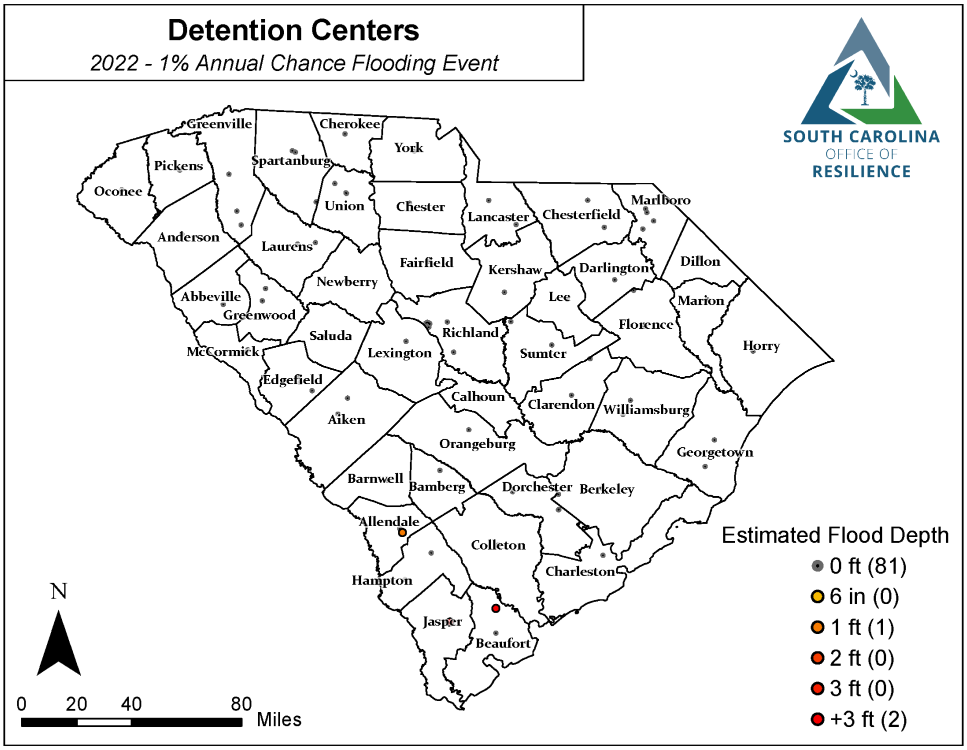


Figure 5.89: Estimated flooding of detention centers in the 2022 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

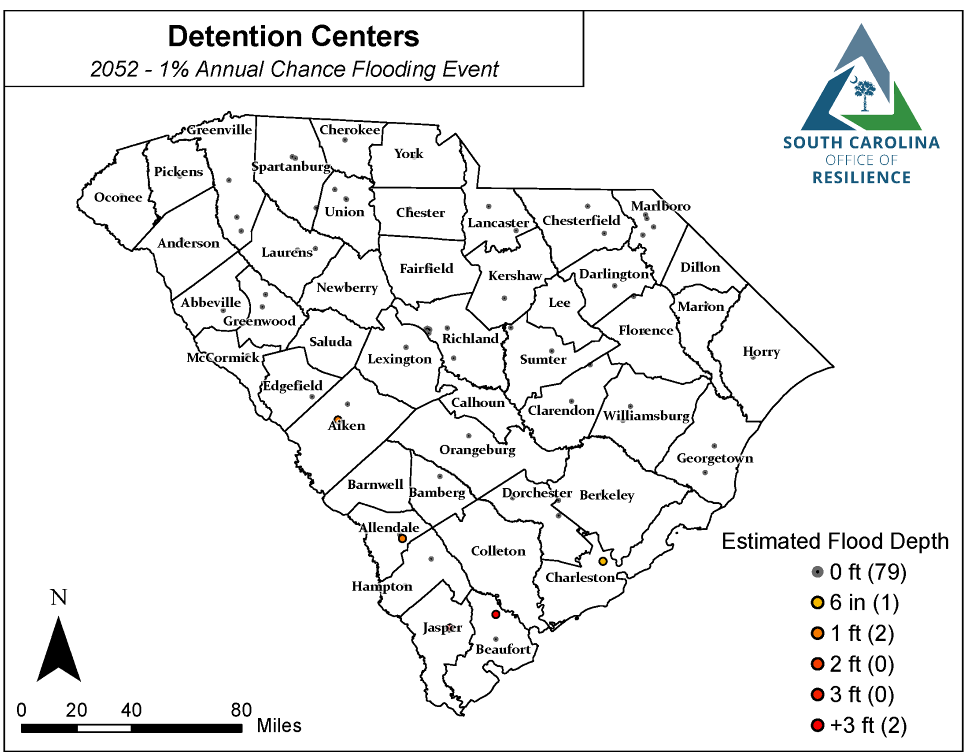


Figure 5.90: Estimated flooding of detention centers in the 2052 1% annual chance flooding event (SLED). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 an even greater need for assistance.

Flooding can create dangerous barriers for fire personnel to get to the needed locations. The figures below illustrate the vulnerability of these stations in the 2022 (Figure 5.91) and 2052 (Figure 5.92) 1% annual chance flood events. 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.

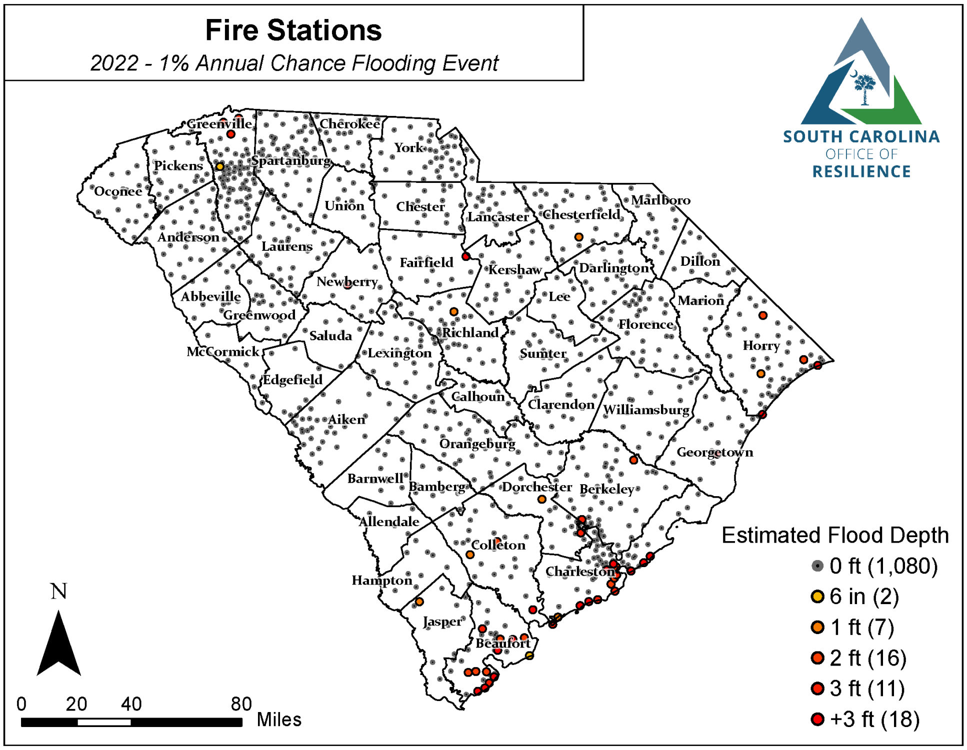


Figure 5.91: Estimated flooding of fire stations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

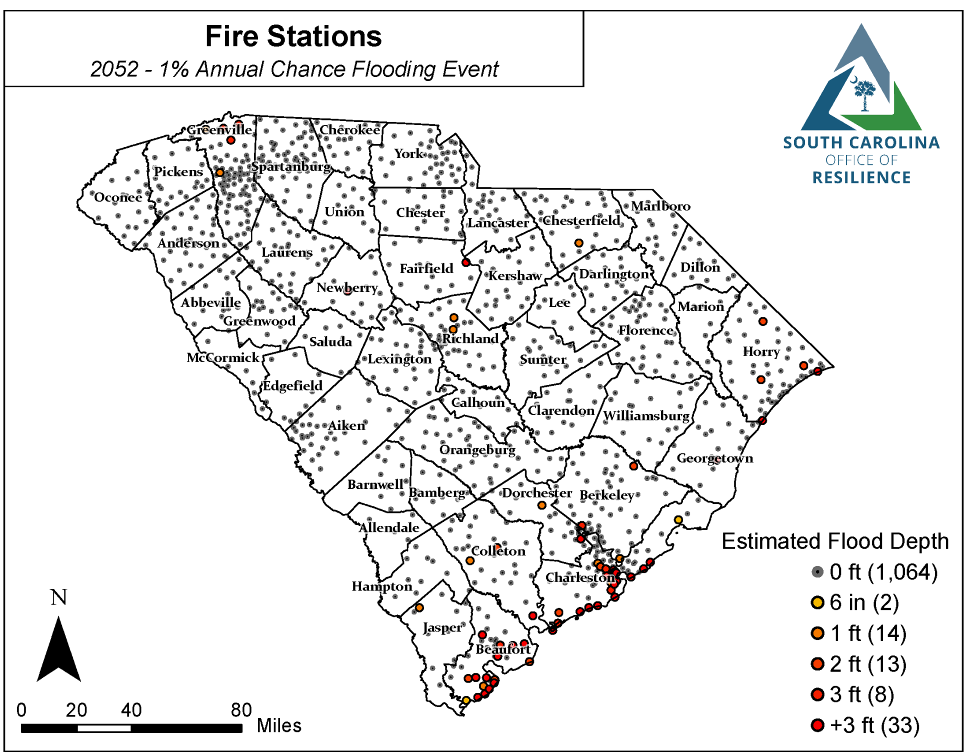


Figure 5.92: Estimated flooding of fire stations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

EMERGENCY MEDICAL SERVICES (EMS)

Like fire stations, EMS stations and personnel are needed daily, but 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.

The figures below illustrate the vulnerability of these stations in the 2022 (Figure 5.93) and 2052 (Figure 5.94) 1% annual chance flood events on these stations.

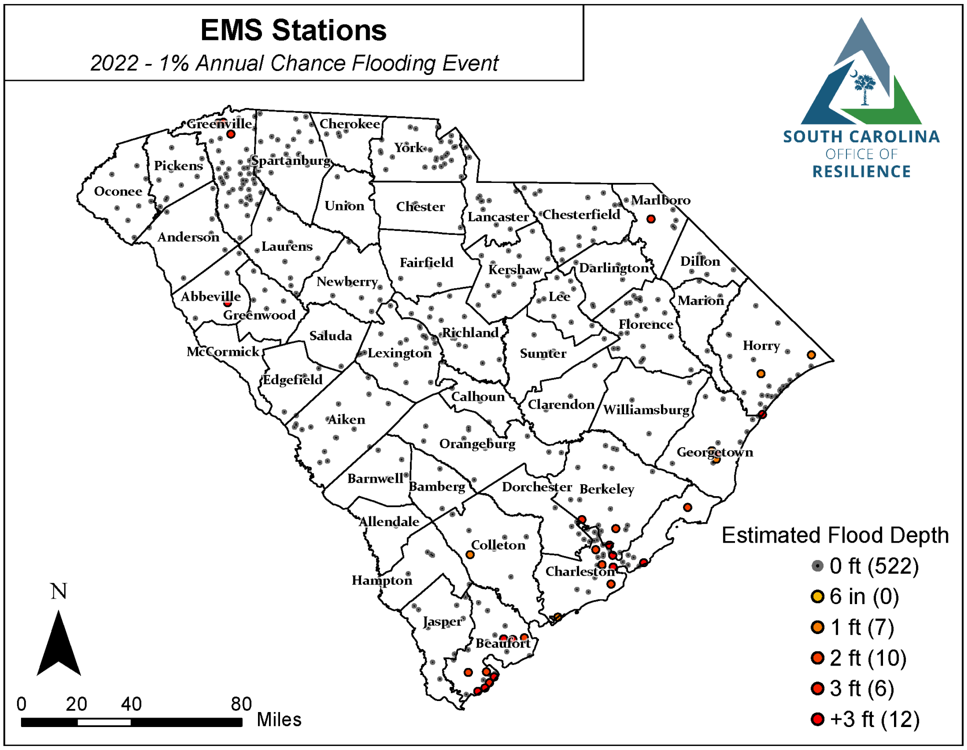


Figure 5.93: Estimated flooding of EMS stations in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

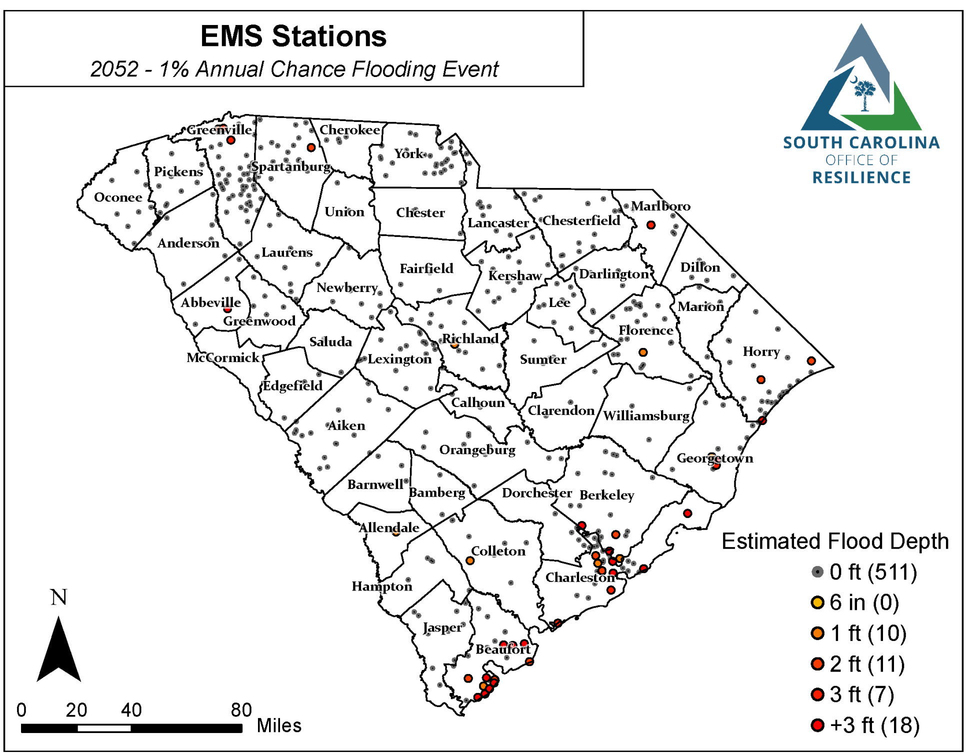


Figure 5.94: Estimated flooding of EMS stations in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

EDUCATION

In addition to the initial impact of an event on school buildings, 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). The damage public schools face due to natural hazards is compounded by their age and condition, and not being built to withstand such hazards (The Pew Charitable Trusts, 2017). While the maps below illustrate the vulnerability of public K-12 schools in the 2022 (Figure 5.95) and 2052 (Figure 5.96) 1% annual chance flood events, they do not consider these factors. Additionally, there are nearly 300 private K-12 schools across the state, shown in Figure 5.97 and Figure 5.98.

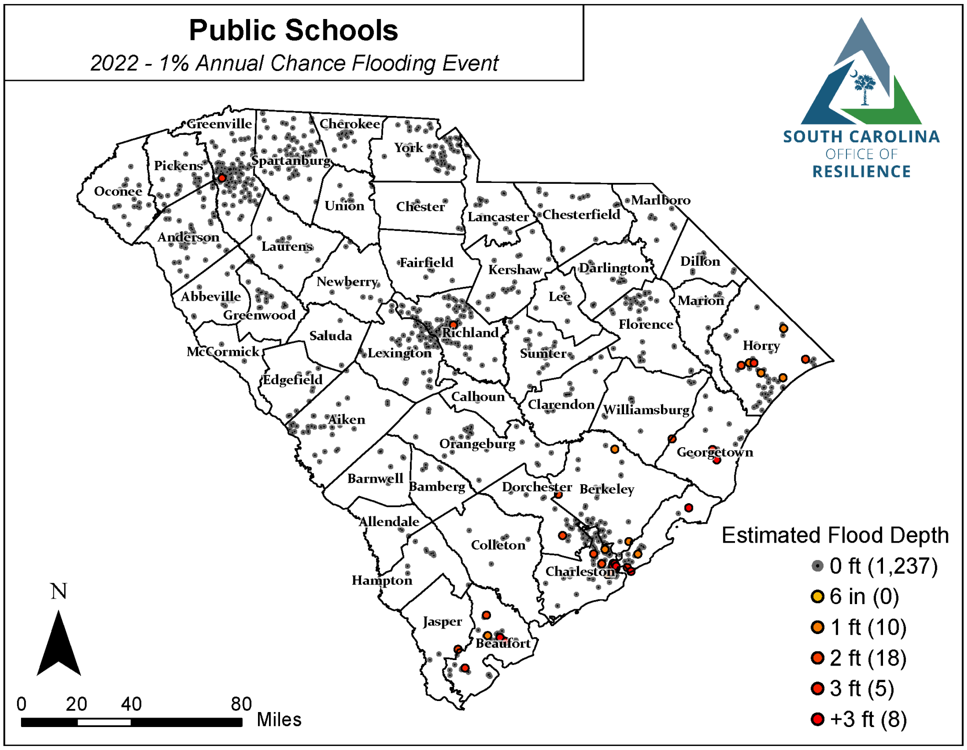


Figure 5.95: Estimated flooding of public schools in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

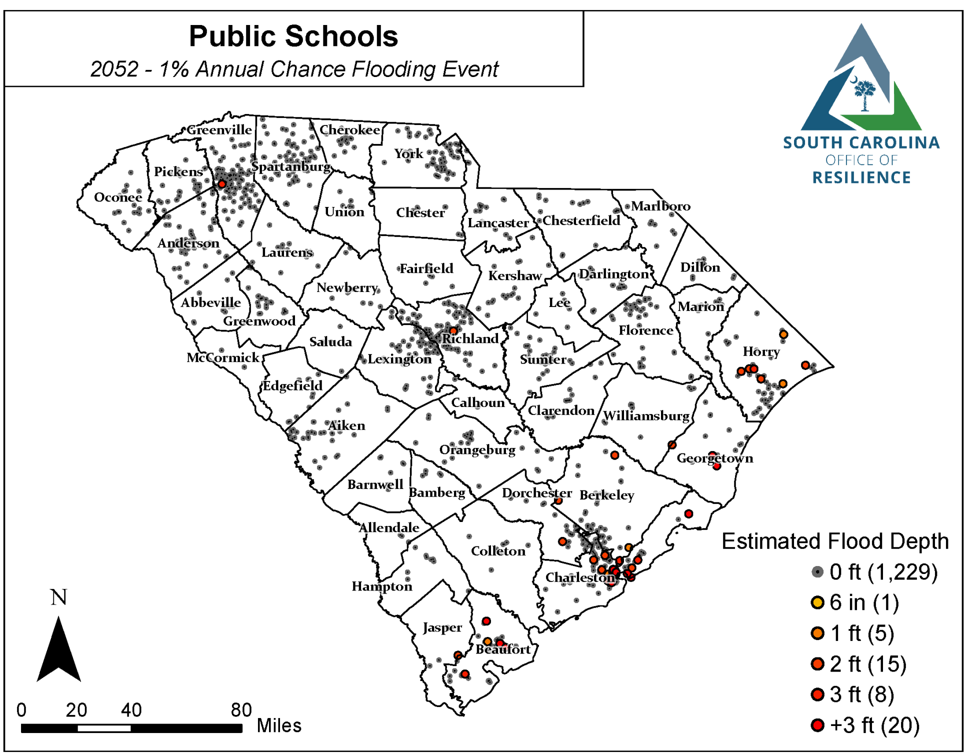


Figure 5.96: Estimated flooding of public schools in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

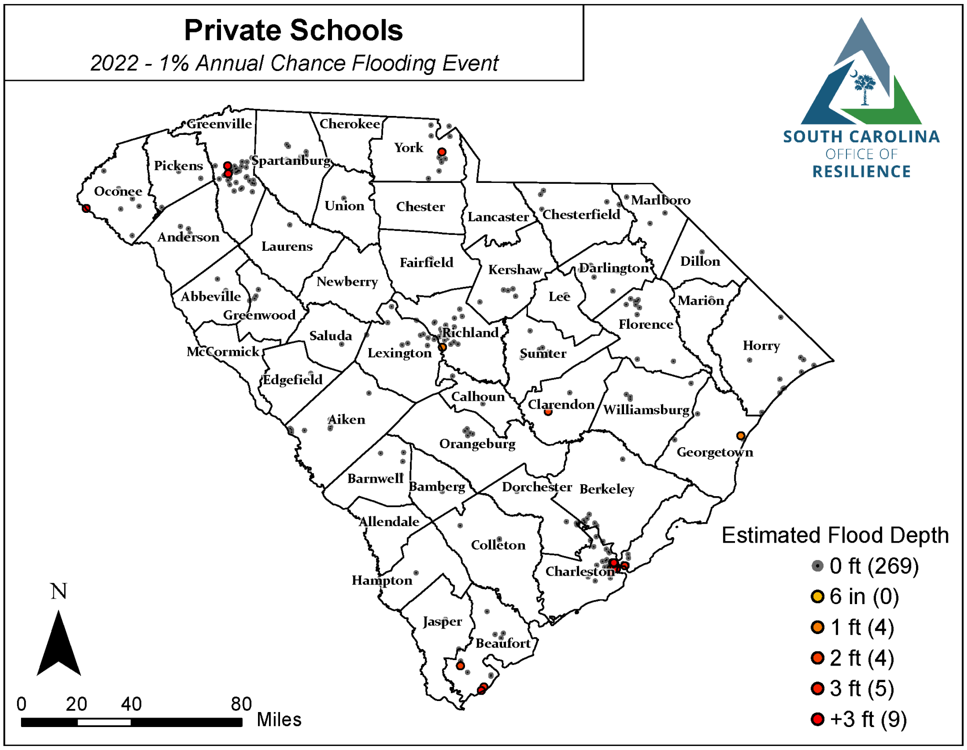


Figure 5.97: Estimated flooding of private schools in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

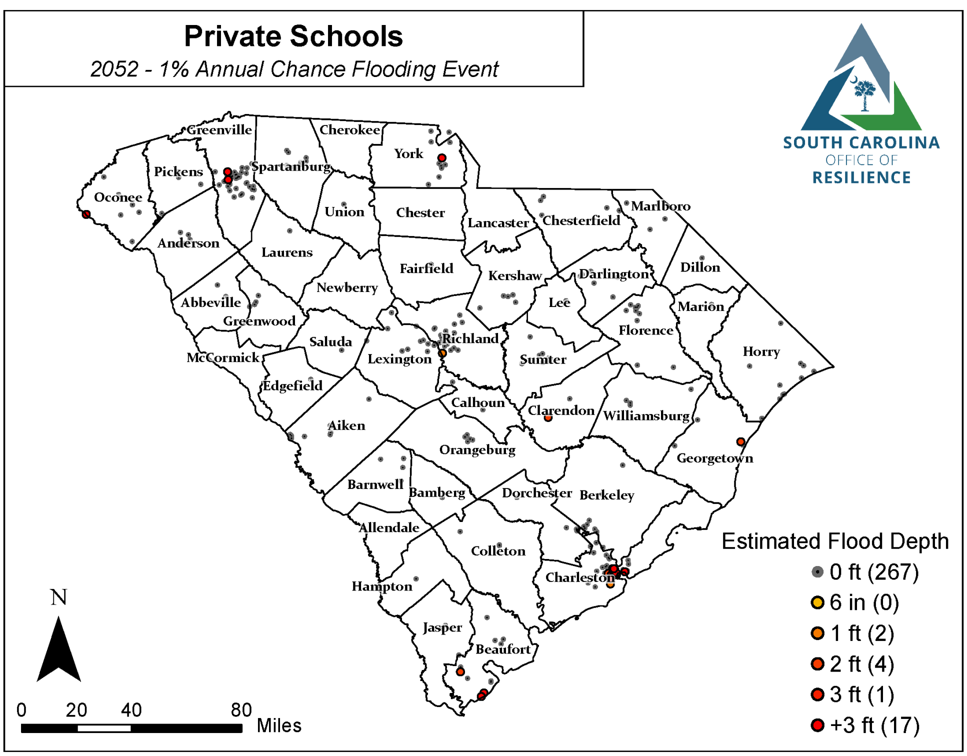


Figure 5.98: Estimated flooding of private schools in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

HIGHER EDUCATION

There are 33 public colleges and universities as well as 25 independent institutions in South Carolina. In Fall 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 total degrees awarded in the 2010-2011 school year. From an economic perspective, public and private institutions employ nearly 16,000 faculty members, 48% 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. 10% of all public campus buildings are over 99 years old, while over 40% of buildings are over 50 years old.

The figures below illustrate the vulnerability of 2-year and 4-year public and private institutions to the 2022 (Figure 5.99) and 2052 (Figure 5.100) 1% annual chance flood events. This data set does not include online colleges

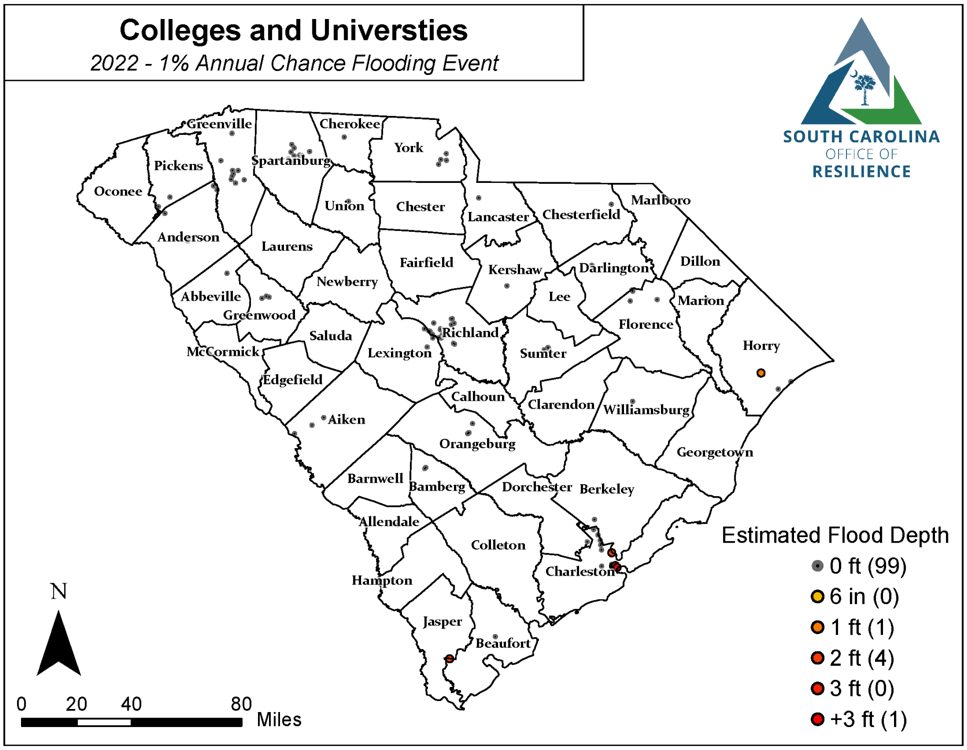


Figure 5.99: Estimated flooding of colleges and universities in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

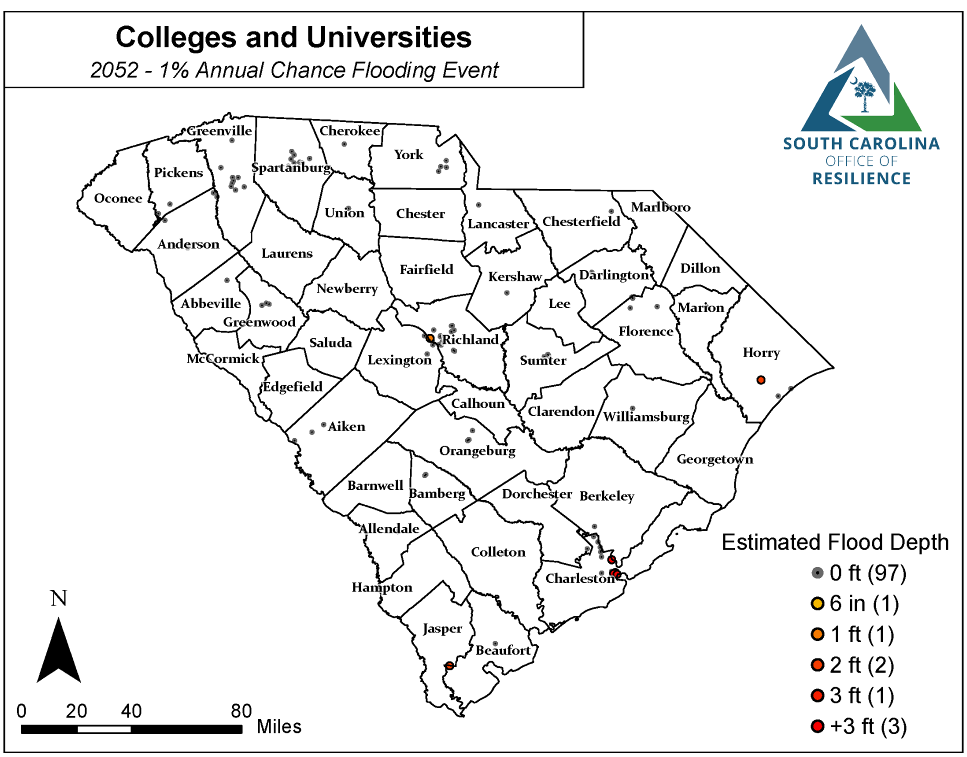


Figure 5.100: Estimated flooding of colleges and universities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PUBLIC HEALTH

Environmental change and natural hazards can impact those with existing illnesses as well as cause outbreaks of vector-borne diseases due to the presence of mosquitoes and the growth of pathogens in flood waters, for example, which can in turn affect things like food supply, water quality and other factors negatively impacting public health.

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.

Those facilities are included in Figure 5.101 and Figure 5.102 below.

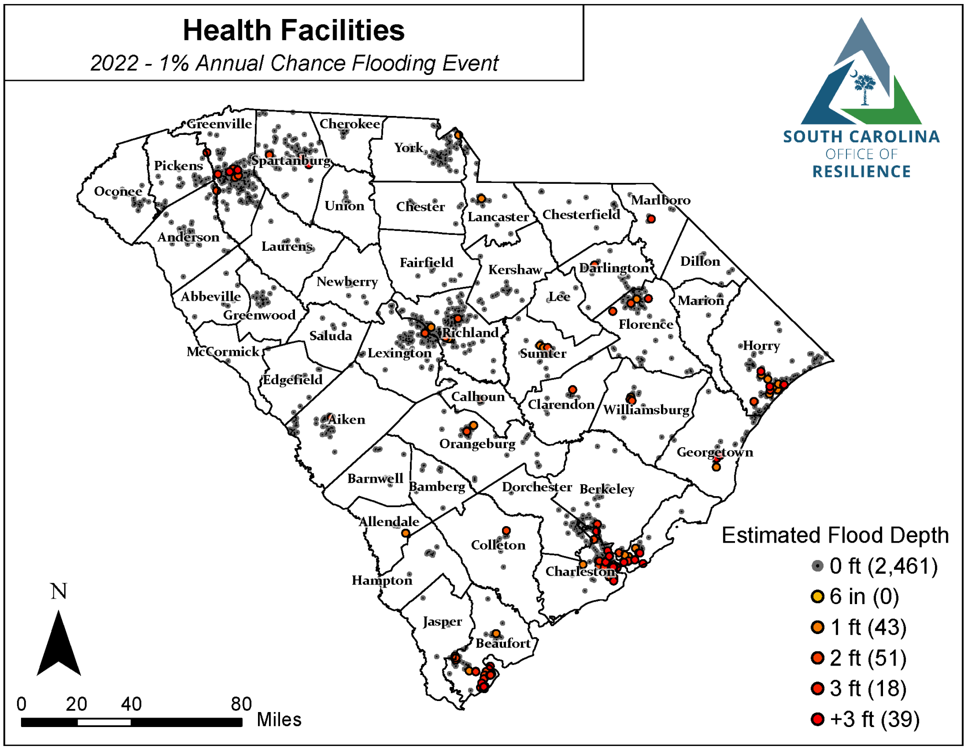


Figure 5.101: Estimated flooding of health facilities in the 2022 1% annual chance flooding event (DHEC). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

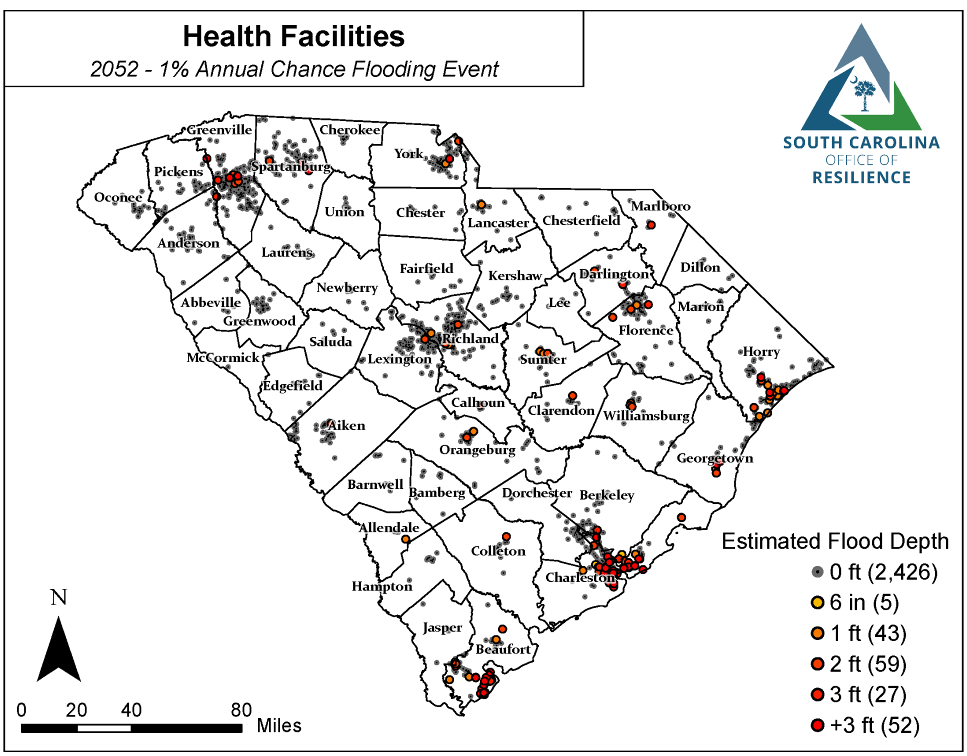


Figure 5.102: Estimated flooding of health facilities in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

HOSPITALS

Across the state, there are over 100 hospitals. In addition to the physical vulnerabilities of these facilities, environmental changes and natural hazards can increase the demand for medical care, as a result of immediate injuries from natural hazards or cascading impacts. 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 access to hospitals for both patients and staff. Demand for medical care may intensify as event effects linger. A common issue is carbon-monoxide poisoning related to the use of gas-powered generators (SC Sea Grant Consortium, 2019).

The figures below illustrate the vulnerability of hospitals in the 2022 (Figure 5.103) and 2052 (Figure 5.104) 1% annual chance flood events.

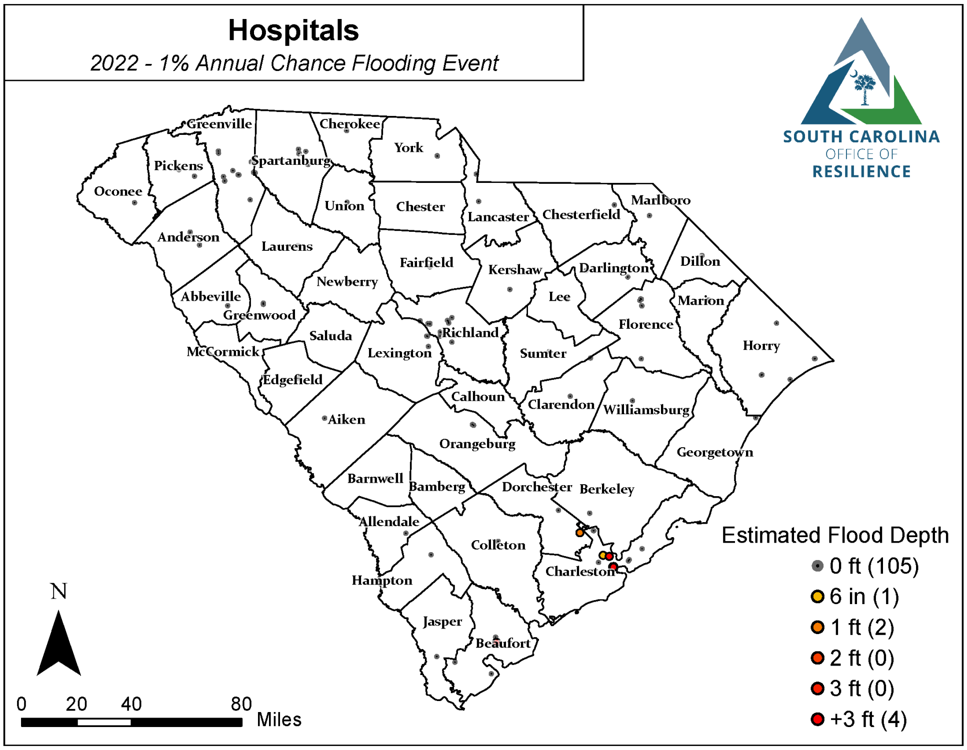


Figure 5.103: Estimated flooding of hospitals in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

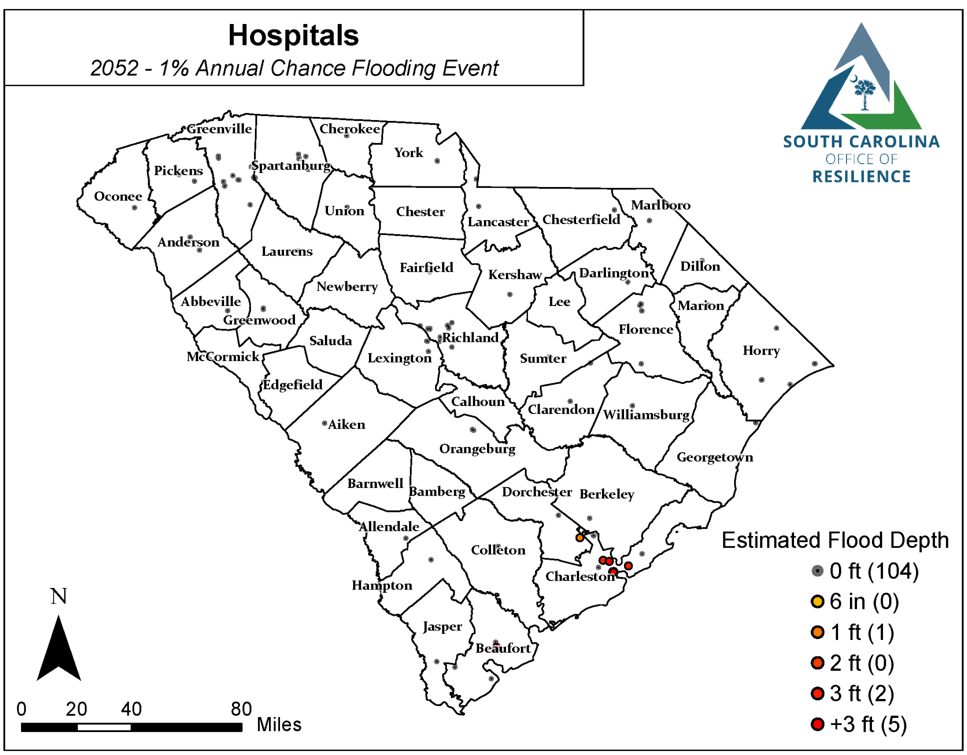


Figure 5.104: Estimated Flooding of hospitals in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

NURSING HOMES

Nursing homes have similar vulnerabilities to hospitals when it comes to providing medical care. Due to the residential nature of these facilities, there is the potential for long term impacts, if the event requires residents to find other homes to live in and results in the loss of personal belongings.

The figures below illustrate the vulnerability of these facilities to the 2022 (Figure 5.105) and 2052 (Figure 5.106) 1% annual chance flood events. This database from DHS includes facilities that house older adults and assisted care facilities.

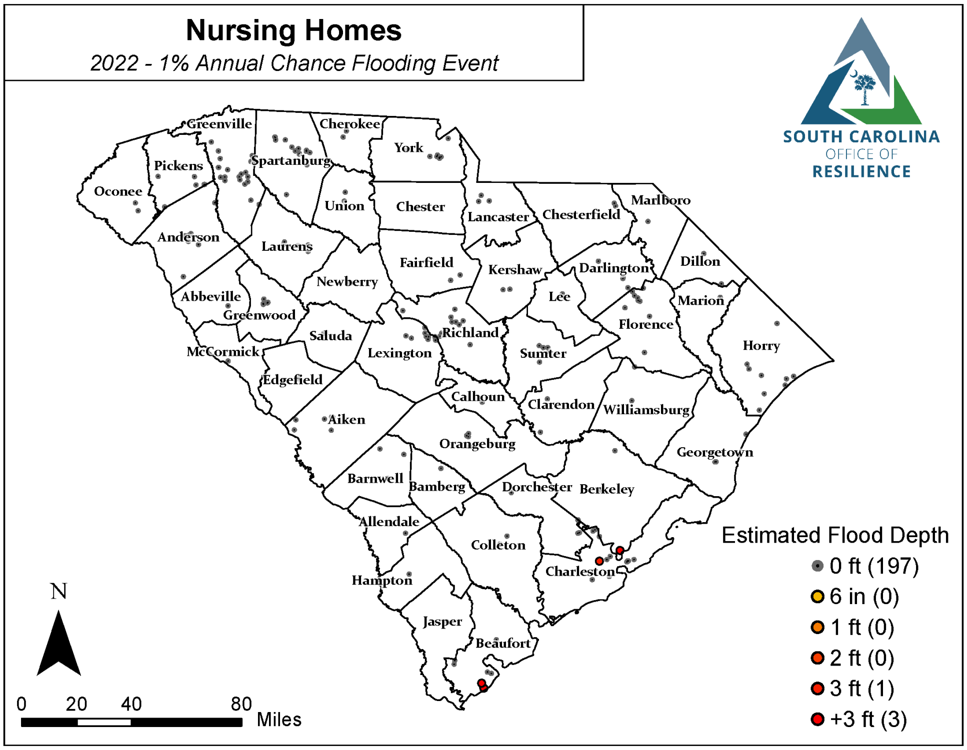


Figure 5.105: Estimated flooding of nursing homes in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

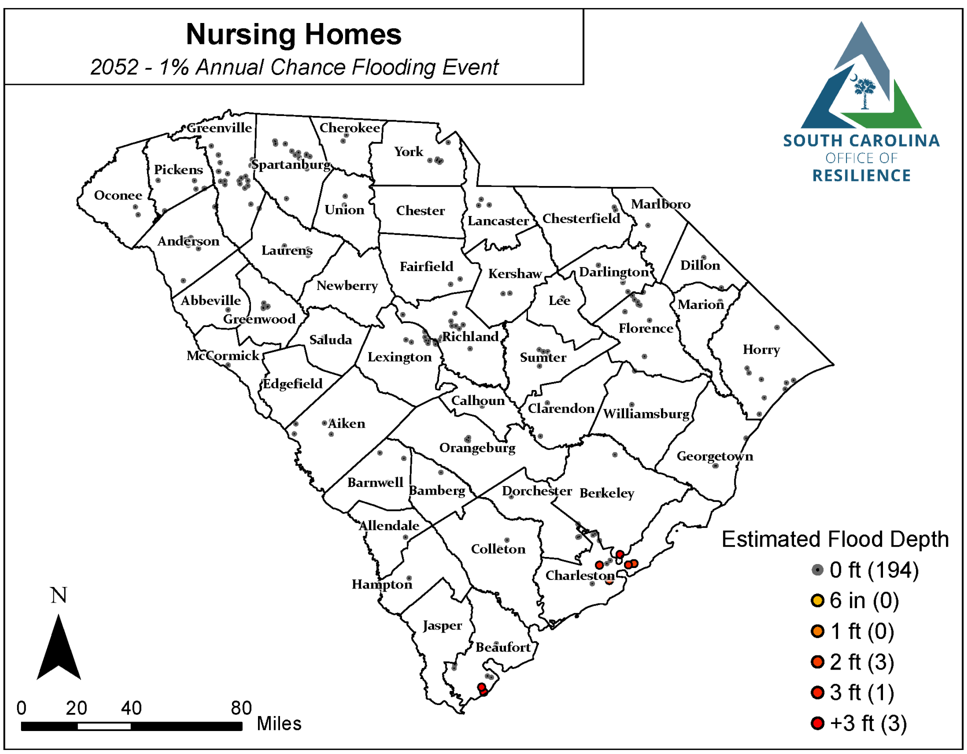


Figure 5.106: Estimated flooding of nursing homes in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 offices 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 3 hospitals, 4 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 patient’s access to these locations. Events may create accessibility issues, as well as serve as a traumatic event, spurring the need for more mental healthcare in its wake.

The figures below illustrate the vulnerability of these offices to the 2022 (Figure 5.107) and 2052 (Figure 5.108) 1% annual chance flood event.

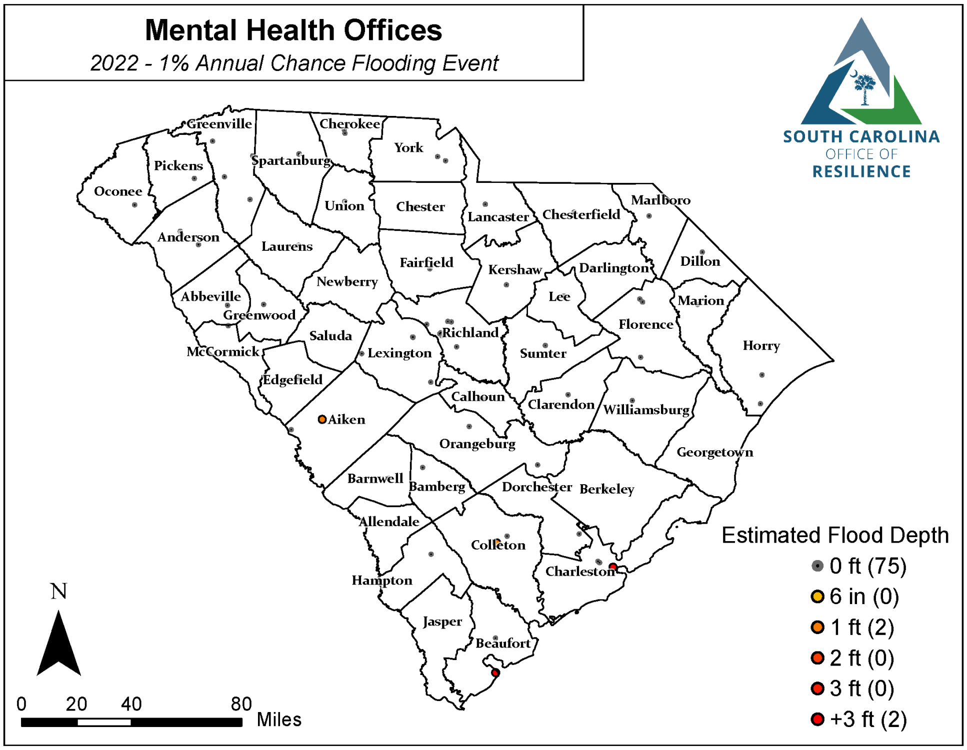


Figure 5.107: Estimated flooding of mental health offices in the 2022 1% annual chance flooding event (DMH). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

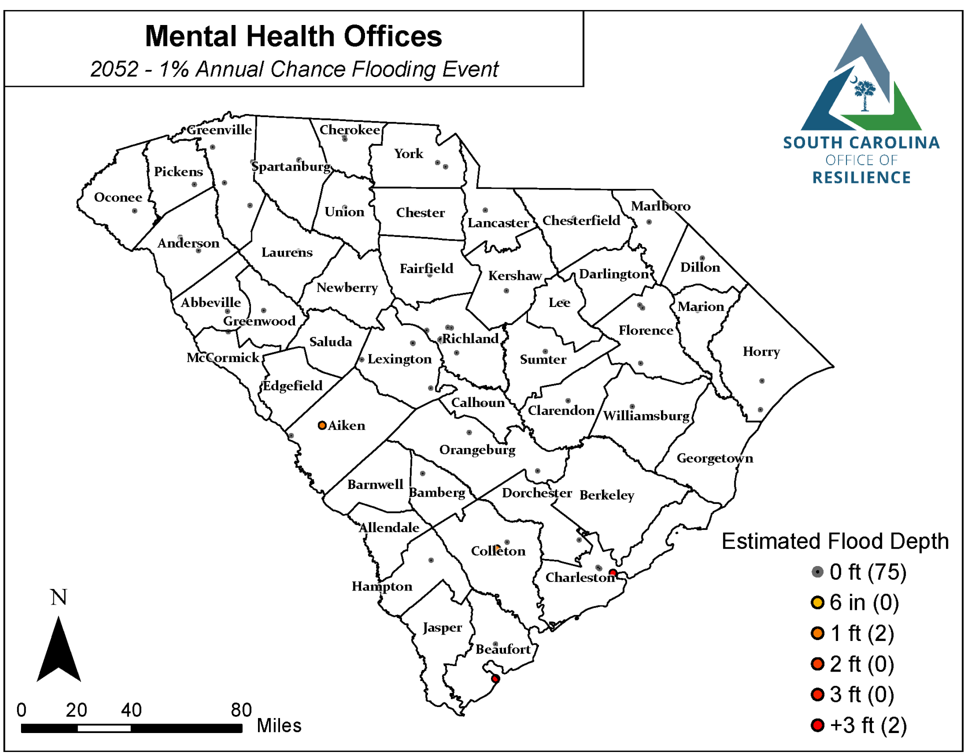


Figure 5.108: Estimated flooding of mental health offices in the 2052 1% annual chance flooding event (DMH). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

DIALYSIS CLINICS

Flooding has the potential to 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, all of which may be compromised during a hazard 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 at accessible clinics (Lempert & Kopp, 2013).

The figures below illustrate the estimated flooding of these centers by the 2022 (Figure 5.109) and 2052 (Figure 5.110) 1% annual chance flood events on these facilities.

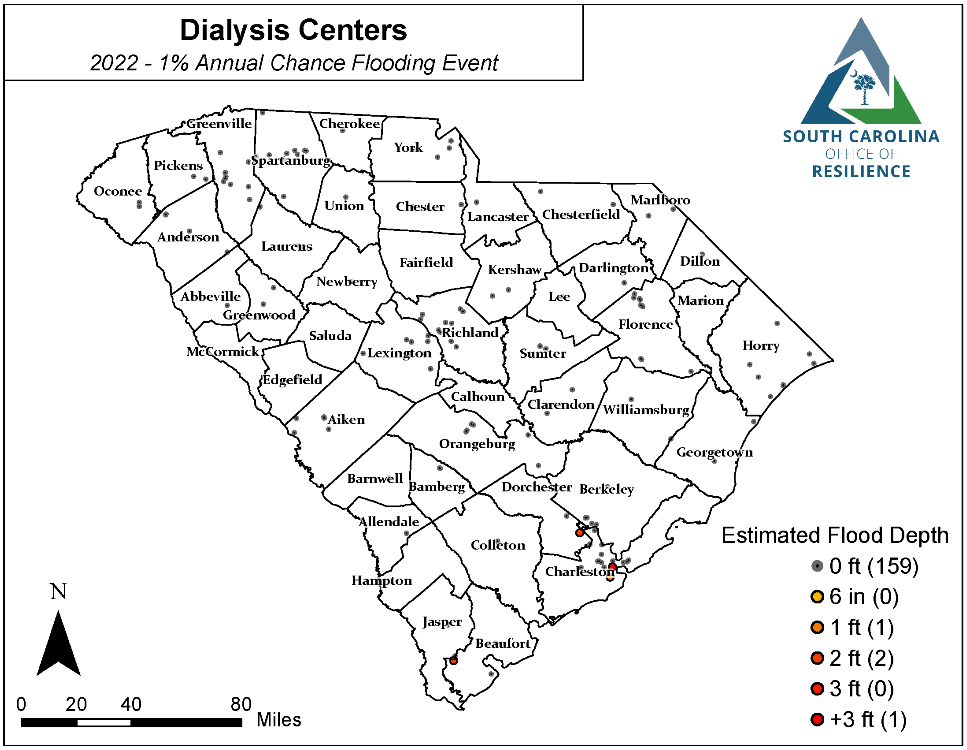


Figure 5.109: Estimated flooding of dialysis centers in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

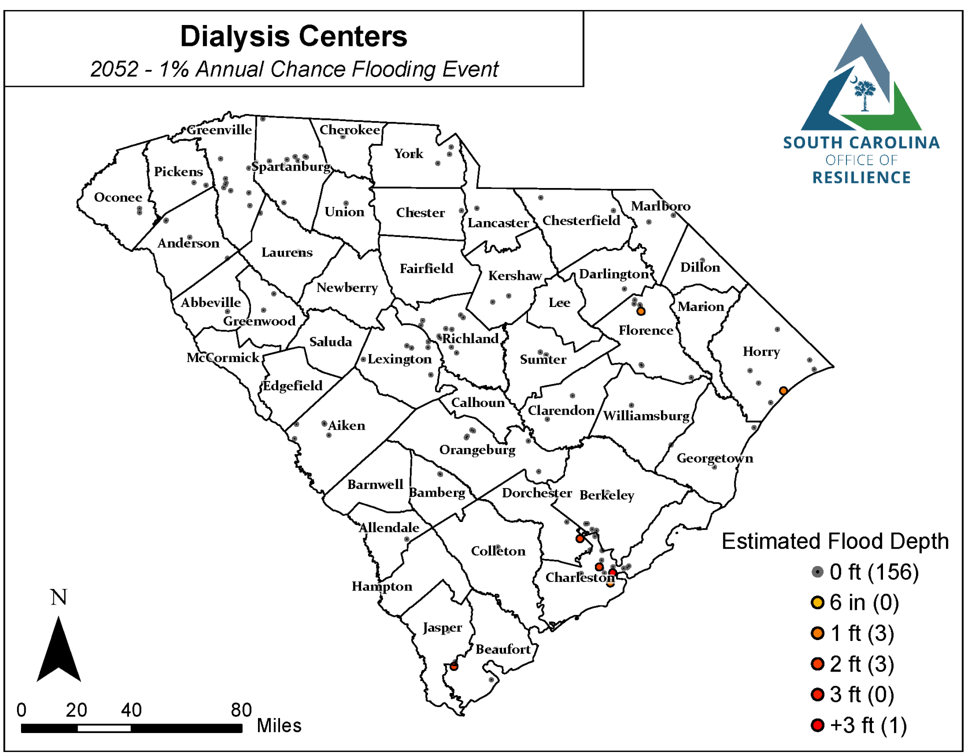


Figure 5.110: Estimated flooding of dialysis centers in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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. A study of Hurricane Florence found that pharmacy function along the North Carolina and South Carolina coast was “suboptimal” (Sharpe & Clennon, 2020).

The figures below illustrate the estimated flooding of pharmacies in 2022 (Figure 5.111) and 2052 (Figure 5.112) 1% annual chance flooding event.

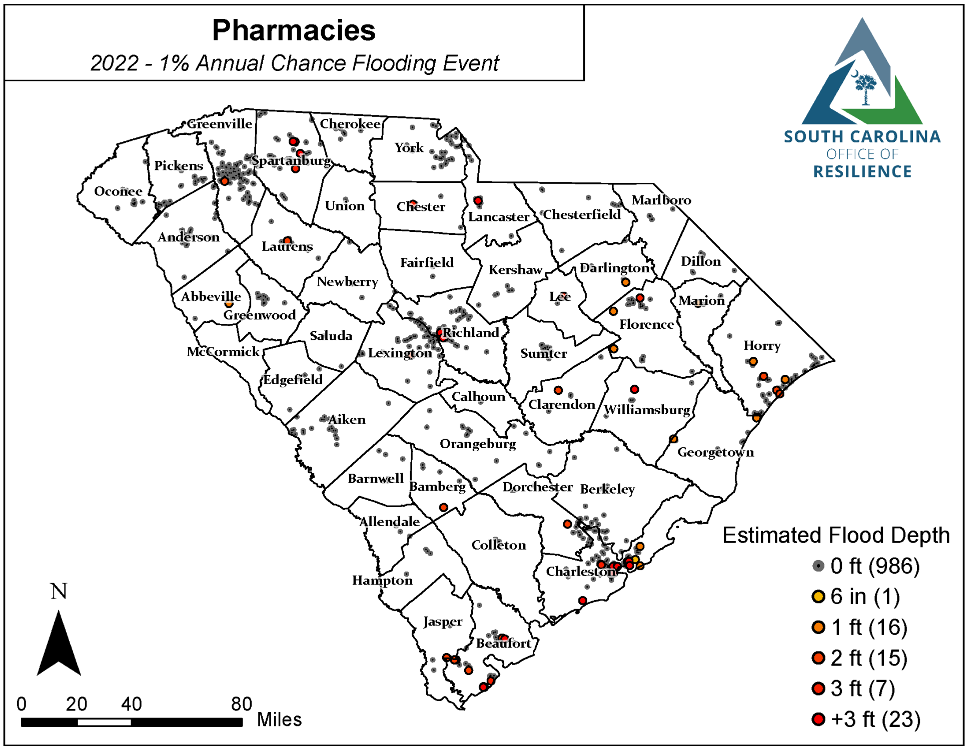


Figure 5.111: Estimated flooding of pharmacies in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

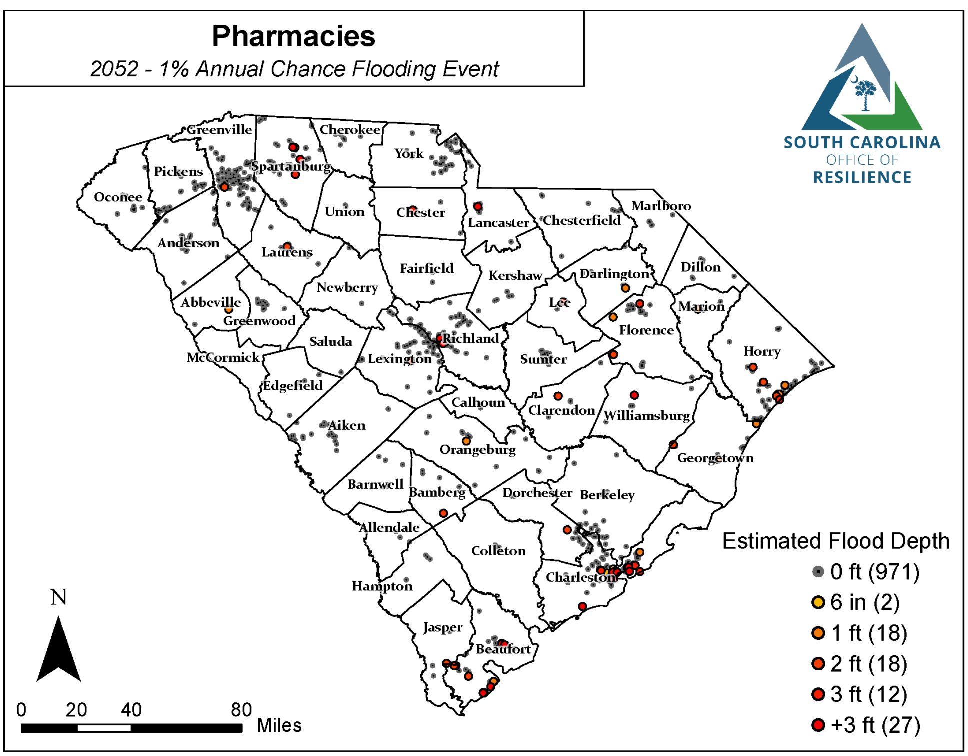


Figure 5.112: Estimated flooding of pharmacies in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

TELEHEALTH

Telehealth services gained momentum during the COVID-19 pandemic, with authorizations for the use of federal funds to expand telehealth. The SC Telehealth Alliance Strategic Plan seeks to continue this expansion; however, a potential barrier is the lack of broadband service across the State. Nearly 435,000 people across the state either have no internet service provider available or have internet service that is not capable of person-to-person telehealth visits (South Carolina Telehealth Alliance, 2022). Additionally, as noted in this chapter, flooding can have a significant impact on internet cables, especially those that are underground or located near bodies of water causing disruption of services.

HEALTH AND HUMAN SERVICES

The SC Department of Health and Human Services (DHHS) administers a variety of health related service programs. This includes Medicaid, Community Long Term Care, Telehealth, and BabyNet.

Medicaid: Medicaid supports 1 in 4 South Carolinians. The program serves to expand medical coverage to those with certain income thresholds as well as pregnant women and newborns, the elderly, the blind, the disabled, and those who may be in a nursing home or hospital for extended periods of time. DHHS maintains offices in every county that serve as enrollment centers for Medicaid.

Community Long Term Care (CLTC): CLTC provides in-home services to Medicaid-eligible people wish to remain in their home but need special services. CLTC services are available for persons aged 18 years or older who are unable to perform activities of daily living such as bathing, dressing, and toileting due to illness or disability. In order to meet the qualifications to enroll into the Community Choices waiver the individual must meet the same level of care that is needed to enter a nursing facility (SC Department of Health and Human Services, n.d.). There are 14 CLTC enrollment offices throughout the state, but the major vulnerability lies with connecting health providers with those residents who depend on them, as well as making sure that the patient’s residence is safe in times of flooding.

BabyNet: The BabyNet program connects children and youths with developmental delays or disabilities to care programs for early intervention, special education, and related programs. There are 14 offices throughout the state where children can be referred and enrolled to the program.

The maps below show the vulnerability of these offices to flooding in the 2022 (Figure 5.113) and 2052 (Figure 5.114) 1% annual chance flood event

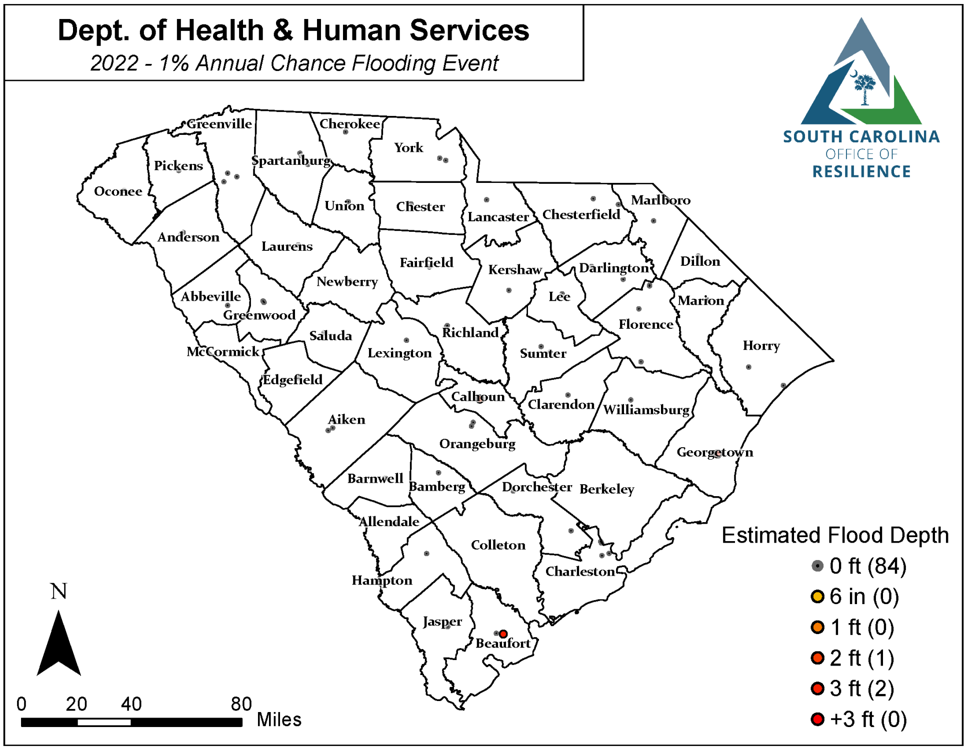


Figure 5.113: Estimated flooding of Department of Health and Human Services' offices in the 2022 1% annual chance flooding event (DHHS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

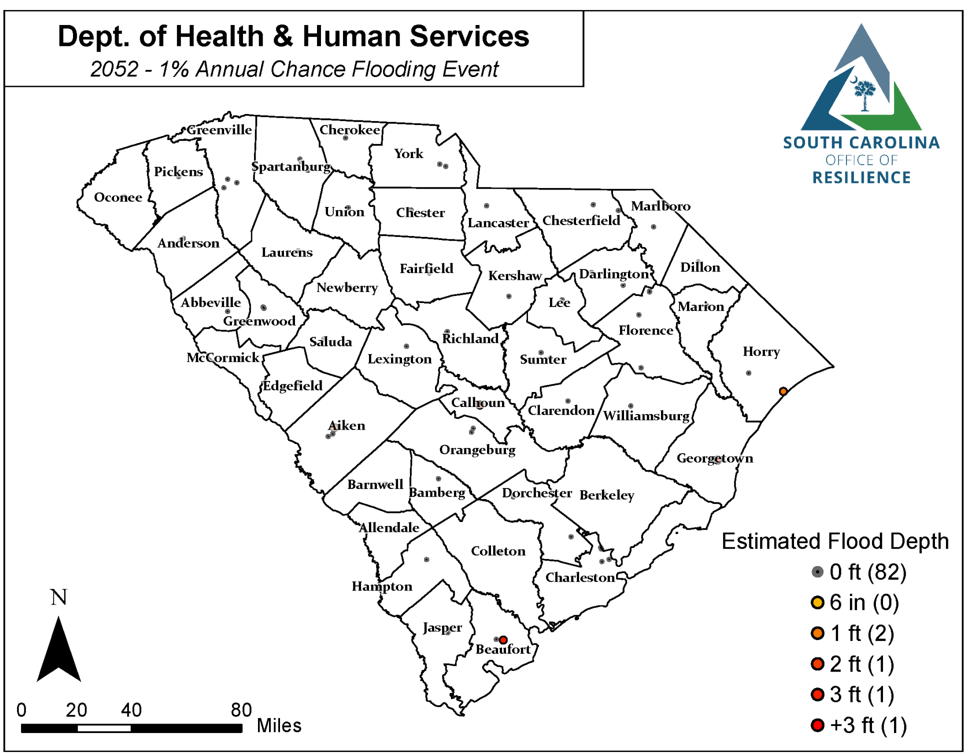


Figure 5.114: Estimated flooding of Department of Health and Human Services' offices in the 2052 1% annual chance flooding event (DHHS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

SOCIAL SERVICES

The South Carolina Department of Social Services (DSS) hosts a diverse 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. Regarding flooding, DSS operates Disaster Supplemental Nutritional Program (D-SNAP) and maintains evacuation plans for all of 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.

The maps below show the vulnerability of childcare facilities licensed by DSS to flooding in the 2022 (Figure 5.115) and 2052 (Figure 5.116) 1% annual chance flood event

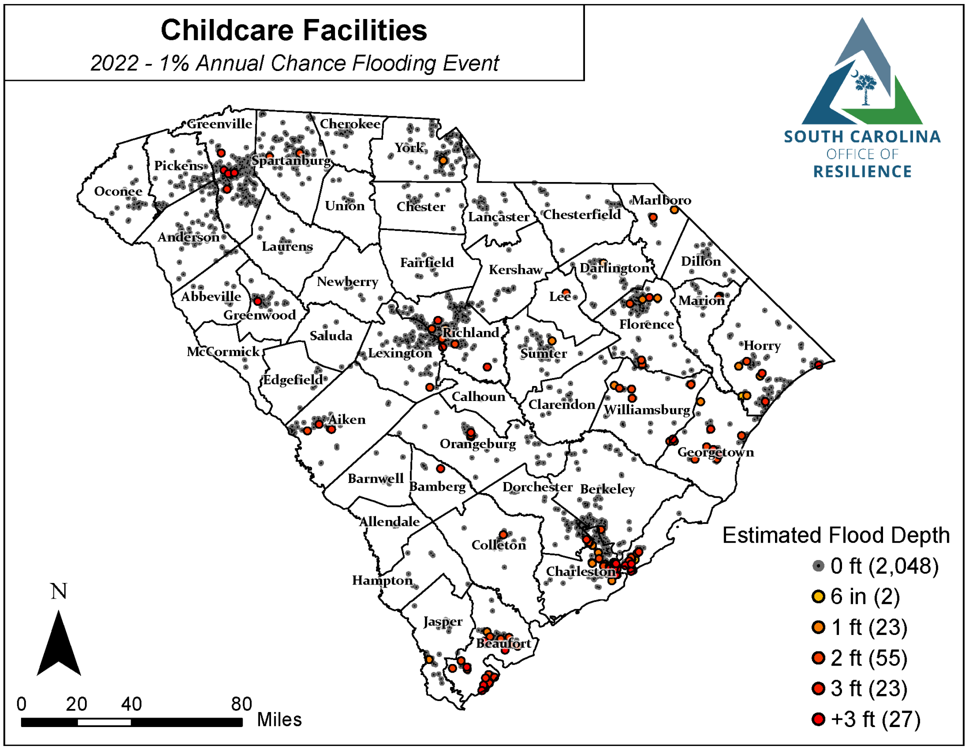


Figure 5.115: Estimated flooding Childcare Facilities in the 2022 1% annual chance flooding event (DSS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

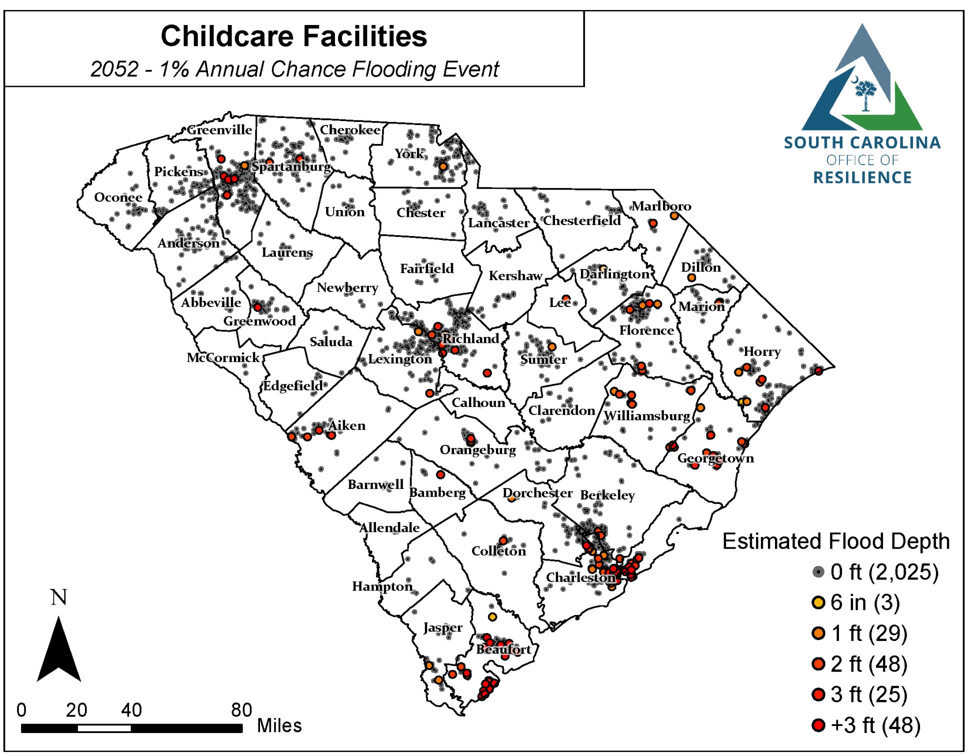


Figure 5.116: Estimated flooding Childcare Facilities in the 2052 1% annual chance flooding event (DSS). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

VETERANS' AFFAIRS

The South Carolina Department of Veterans' Affairs (DVA) coordinates county level Veterans' Affairs offices where veterans can access benefits. The DVA assists veterans with employment, healthcare, suicide prevention, and education.

The maps below show the vulnerability of DVA facilities to flooding in the 2022 (Figure 5.117) and 2052 (Figure 5.118) 1% annual chance flood event

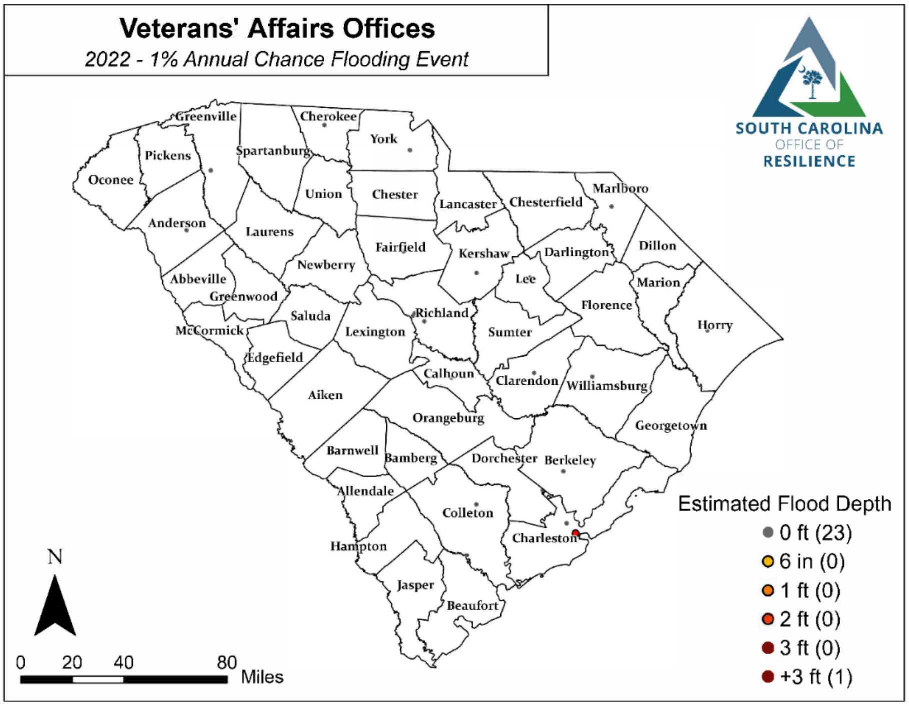


Figure 5.117: Estimated flooding of Veterans' Affairs facilities in the 2022 1% annual chance flooding event (DVA). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

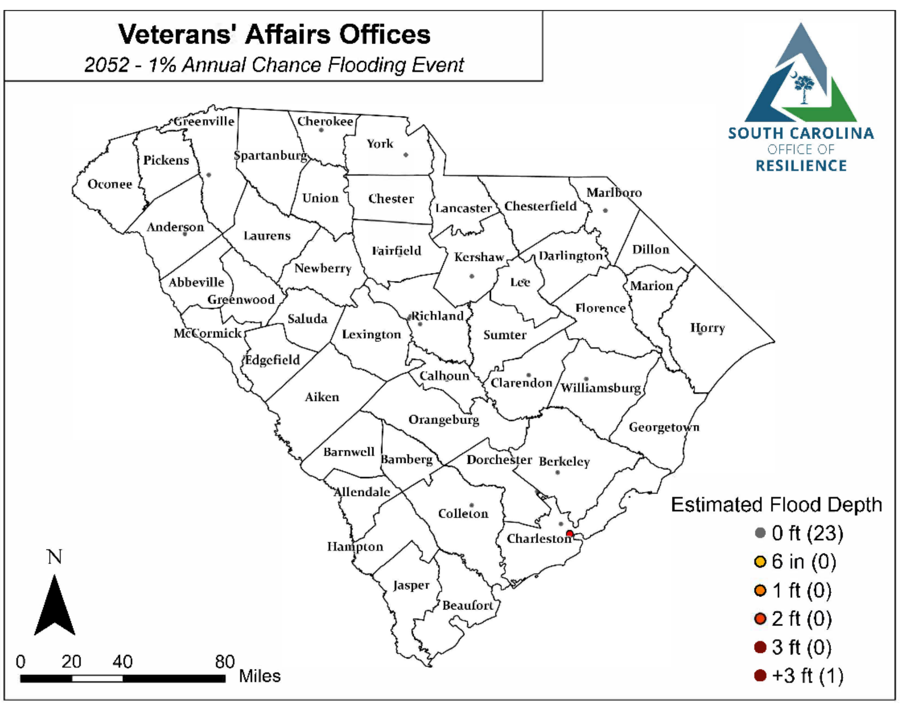


Figure 5.118: Estimated flooding of Veterans Affairs facilities in the 2052 1% annual chance flooding event (DVA). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

PLACES OF WORSHIP

There are nearly 6,000 places of worship across the State. After a disaster, these places provide essential support such as the collection, storing and distribution of supplies, shelter, and other community needs

The maps below show the vulnerability of places of worship to flooding in the 2022 (Figure 5.119) and 2052 (Figure 5.120) 1% annual chance flood event

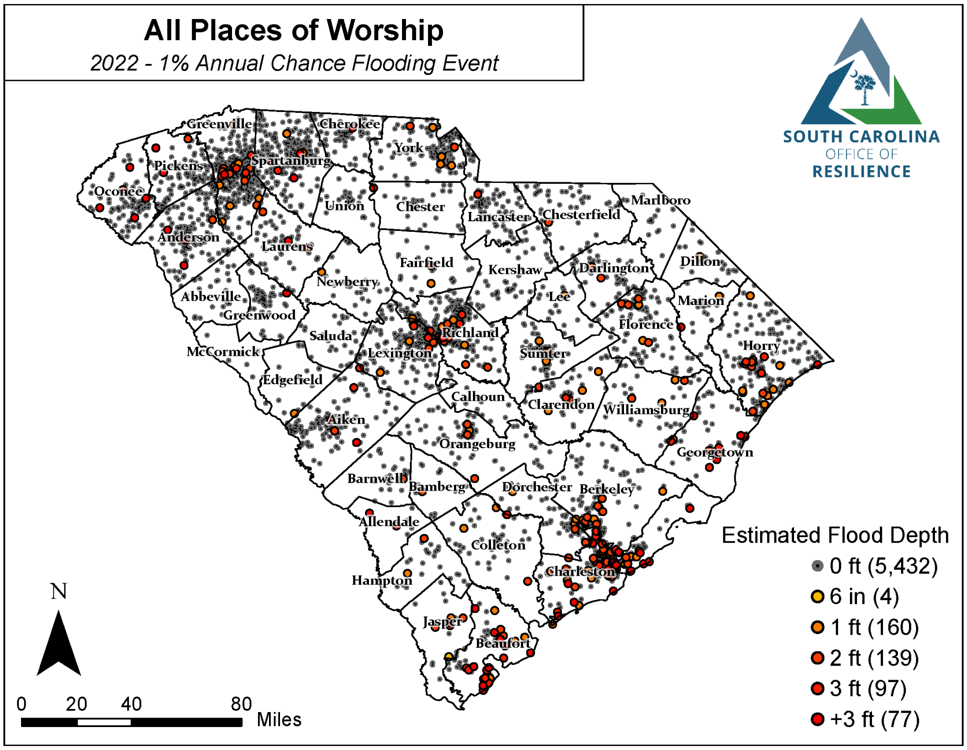


Figure 5.119: Estimated flooding of places of worship in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

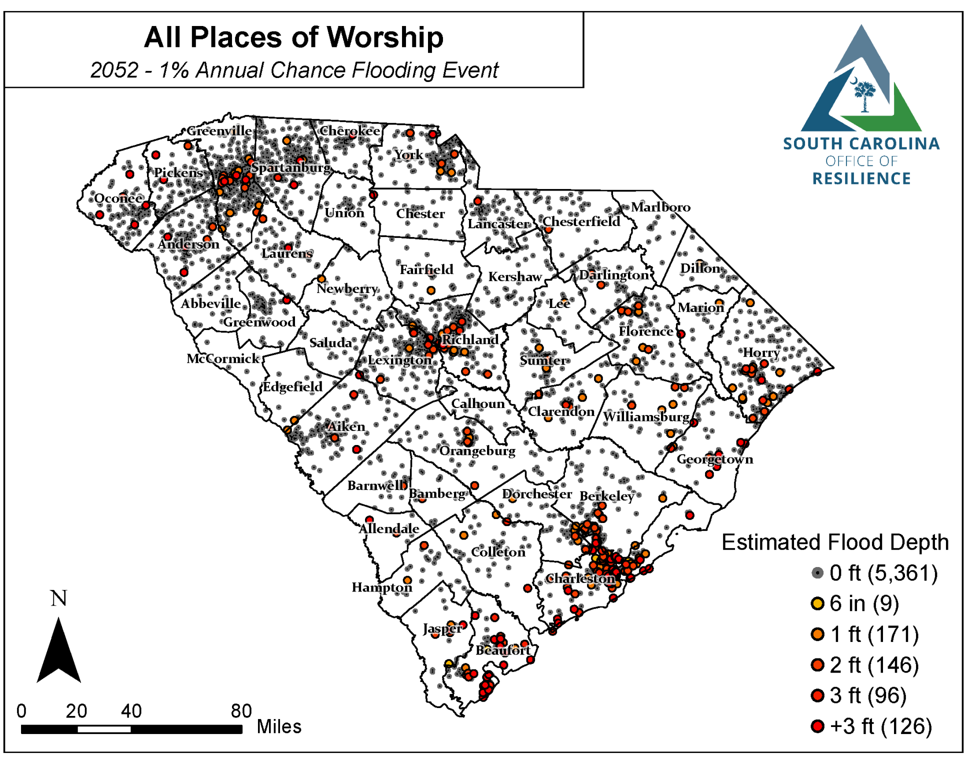


Figure 5.120: Estimated flooding of places of worship in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

ECONOMIC SYSTEMS

AGRICULTURE

According to the SC Department of Agriculture, there are nearly 25,000 farms and 4.7 million acres of farmland in South Carolina. Agribusiness (agriculture & forestry) accounts for 246,957 jobs and $46.2 billion in annual economic impact. The top 10 agricultural commodities are: broilers, turkeys, corn, cattle/calves, soybeans, cotton, chicken eggs, peanuts, floriculture, and tobacco (SC Department of Agriculture, 2017). Agriculture relies on weather, climate, and water availability, all of which are easily impacted by environmental change and natural hazards (United States Environmental Protection Agency (EPA), 2022).

Flooding has a history of destroying a variety of crops in South Carolina. A study on the 2015 flood estimated losses in the field and from prevented planting totaling over $375 million (SC Department of Agriculture, 2015). Flooding also impacts the processing, transportation, and sales of agricultural products vital to the State's economy.

Using the USDA Cropland Data Layer, croplands are identified through the use of remote sensing techniques such as satellite imagery. The Cropland Data Layer identifies crop extent and probable type in a 30m resolution across the country and is accessible through the USDA CropScape webtool (Han, et al., 2012). From the Cropland Data Layer dataset, the majority of croplands in South Carolina are located in the Coastal Plain, although there is agricultural land statewide (Figure 5.121). Figure 5.122 indicates that, according to the First Street Foundation's model, the majority of potentially inundated crops are also located in the Coastal Plain.

The Cropland Data Layer also delineates the potential crop type being grown. Table 5.15 shows the percent of cropland potentially inundated by a 1% annual chance event ("100-year" event) for 2022 and future projected 2052. Rice has the highest exposure to flooding, 72.4% for 2022 and 74.1% for 2052, due to the low-lying nature and requirement of flooding the crop. The percentage of total crop area at risk to flooding in 2022 and 2052 is shown in Table 5.16 and Table 5.17.

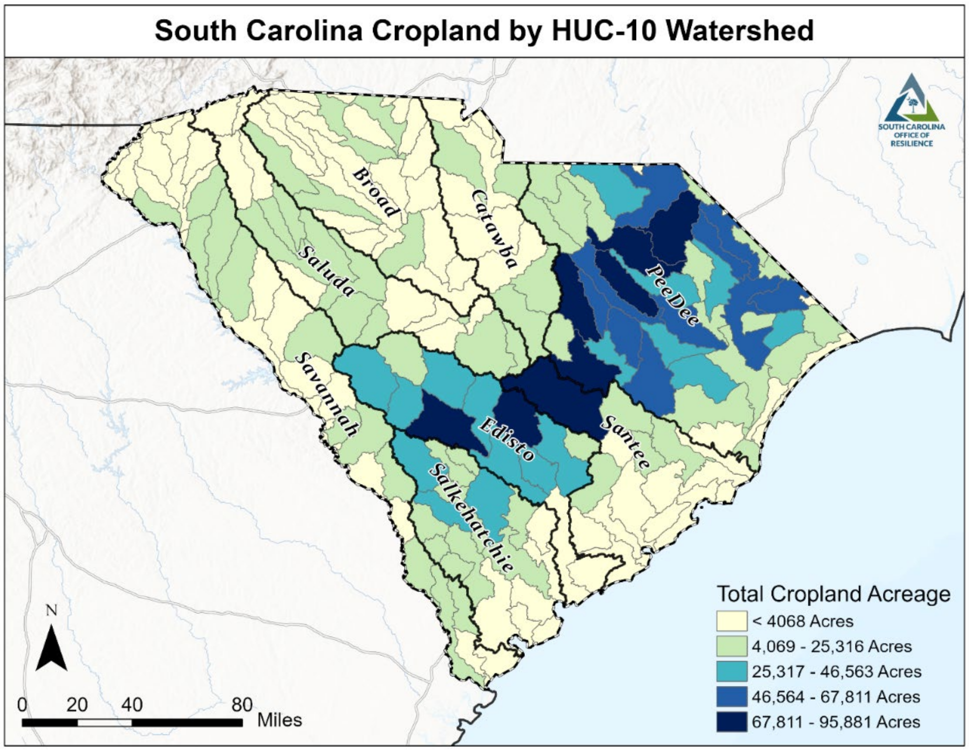


Figure 5.121: Cropland coverage by HUC10 as listed in the USDA Cropland Data Layer

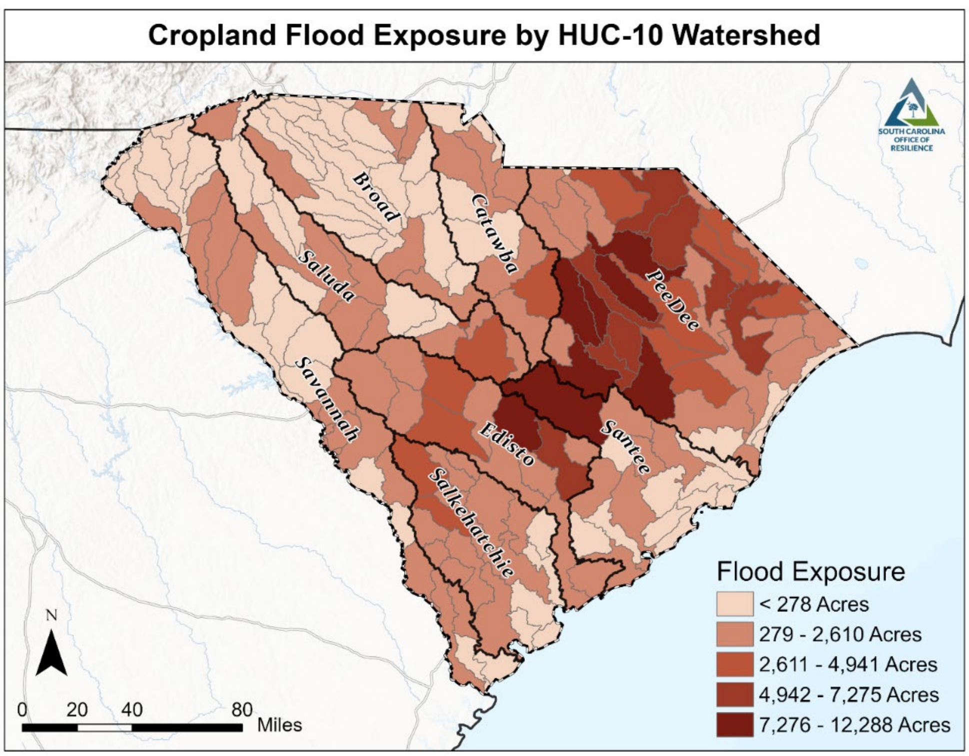


Figure 5.122: Cropland Exposure to any inundation during a 1% annual chance of flood by HUC10 as listed in the USDA Cropland Data Layer

Table 5.15: 1% annual chance of total crop area flooding over 6 inches of inundation in 2022 and 2052 Hazard Layer 2.0 model by crop type in the USDA Cropland Data Layer

Crop Type	2022	2052
Alfalfa	5.2%	5.4%
Apples	4.6%	4.6%
Barley	2.9%	2.9%
Barley/Soybeans	4.4%	4.6%
Blueberries	24.8%	26.1%
Cabbage	11.6%	12.3%
Cantaloupes	6.3%	6.6%
Clover/Wildflowers	7.3%	7.4%
Corn	12.4%	13.3%
Corn/Soybeans	6.9%	7.4%
Cotton	7.9%	8.4%
Cucumbers	10.2%	10.9%
Dry Beans	4.8%	5.4%
Fallow/Idle Cropland	7.4%	8.0%
Grapes	4.7%	5.0%
Greens	9.4%	10.1%
Millet	7.6%	8.0%
Non-Alfalfa Hay	7.4%	7.9%
Oats	6.5%	7.0%
Oats/Corn	10.6%	11.3%
Onions	0.0%	0.0%
Other Crops	6.1%	6.6%
Other Tree Crops	4.8%	5.1%
Peaches	5.5%	5.7%
Peanuts	7.2%	7.9%
Peas	10.8%	11.8%
Pecans	10.4%	10.8%
Peppers	4.4%	4.7%
Potatoes	11.6%	12.2%
Pumpkins	18.5%	18.6%
Rice	72.3%	74.1%
Rye	6.9%	7.2%
Sod/Grass Seed	9.3%	10.1%
Sorghum	6.6%	7.1%
Soybeans	10.5%	11.3%
Soybeans/Oats	6.9%	7.4%

Squash	4.6%	4.8%
Strawberries	6.5%	6.6%
Sunflower	9.7%	10.2%
Sweet Corn	12.2%	13.3%
Sweet Potatoes	8.2%	9.0%
Switchgrass	3.6%	3.6%
Tobacco	6.4%	6.8%
Tomatoes	8.8%	9.4%
Triticale	3.4%	3.5%
Triticale/Corn	11.6%	11.9%
Watermelons	5.8%	6.1%
Winter Wheat	12.2%	12.7%
Winter Wheat/Corn	6.1%	6.3%
Winter Wheat/Cotton	6.4%	6.7%
Winter Wheat/Sorghum	4.3%	4.5%
Winter Wheat/Soybeans	10.1%	10.8%

Table 5.16: 2022 – 1% Annual Chance of flooding by inundation levels, not cumulative

Crop Type	0 feet	6 Inches	1 Foot	2 Foot	3 Foot	Over 3 Ft
Alfalfa	94.78%	0.00%	1.06%	1.69%	1.22%	1.25%
Apples	95.36%	0.00%	0.49%	1.64%	0.97%	1.53%
Barley	97.07%	0.00%	0.79%	1.32%	0.42%	0.40%
Barley/Soybeans	95.57%	0.20%	1.48%	1.12%	0.58%	1.06%
Blueberries	75.16%	0.44%	8.85%	7.04%	2.21%	6.30%
Cabbage	88.38%	0.00%	7.56%	3.86%	0.20%	0.00%
Cantaloupes	93.75%	0.00%	2.36%	2.88%	0.75%	0.27%
Clover/Wildflowers	92.65%	0.00%	4.89%	2.39%	0.07%	0.00%
Corn	87.56%	0.25%	5.07%	4.58%	1.16%	1.39%
Corn/Soybeans	93.09%	0.01%	3.52%	2.99%	0.28%	0.12%
Cotton	92.11%	0.12%	3.56%	3.12%	0.62%	0.46%
Cucumbers	89.77%	0.00%	4.87%	4.71%	0.48%	0.17%
Dry Beans	95.22%	0.00%	2.40%	1.98%	0.29%	0.11%
Fallow/Idle Cropland	92.64%	0.07%	3.13%	2.81%	0.70%	0.65%
Grapes	95.28%	0.07%	1.69%	1.70%	0.89%	0.36%
Greens	90.58%	0.05%	5.42%	3.42%	0.30%	0.23%
Millet	92.43%	0.03%	2.34%	2.26%	0.90%	2.04%
Non-Alfalfa Hay	92.56%	0.11%	2.34%	2.66%	0.98%	1.35%
Oats	93.52%	0.09%	2.32%	2.26%	0.68%	1.12%
Oats/Corn	89.36%	0.01%	3.84%	4.47%	1.19%	1.13%
Onions	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Other Crops	93.86%	0.01%	2.66%	2.45%	0.53%	0.48%
Other Tree Crops	95.24%	0.00%	1.72%	3.04%	0.00%	0.00%
Peaches	94.55%	0.01%	1.87%	2.18%	0.76%	0.63%
Peanuts	92.76%	0.08%	3.04%	2.90%	0.68%	0.54%
Peas	89.21%	0.13%	5.57%	3.94%	0.60%	0.55%
Pecans	89.57%	0.06%	2.85%	3.95%	1.45%	2.12%
Peppers	95.57%	0.00%	1.53%	1.78%	0.51%	0.60%
Potatoes	88.43%	0.01%	3.89%	4.34%	1.80%	1.54%
Pumpkins	81.52%	0.00%	0.38%	18.10%	0.00%	0.00%
Rice	27.70%	3.92%	23.57%	43.17%	0.59%	1.05%
Rye	93.08%	0.04%	1.60%	2.17%	0.97%	2.14%
Sod/Grass Seed	90.70%	0.08%	4.67%	3.28%	0.72%	0.55%
Sorghum	93.37%	0.07%	2.52%	2.42%	0.70%	0.92%
Soybeans	89.48%	0.23%	4.82%	3.83%	0.80%	0.85%
Soybeans/Oats	93.12%	0.09%	3.53%	2.32%	0.55%	0.39%
Squash	95.39%	0.00%	2.78%	1.68%	0.07%	0.07%
Strawberries	93.49%	0.02%	1.51%	1.20%	2.63%	1.16%
Sunflower	90.34%	0.01%	3.58%	3.42%	1.37%	1.28%
Sweet Corn	87.83%	0.04%	6.11%	4.56%	0.60%	0.87%
Sweet Potatoes	91.76%	0.03%	3.09%	3.74%	0.84%	0.54%
Switchgrass	96.41%	0.00%	0.77%	0.85%	1.76%	0.21%
Tobacco	93.60%	0.00%	2.57%	3.57%	0.19%	0.07%
Tomatoes	91.18%	0.02%	3.26%	2.94%	1.02%	1.60%
Triticale	96.63%	0.00%	0.96%	1.13%	0.51%	0.77%
Triticale/Corn	88.38%	0.00%	4.71%	5.54%	1.36%	0.00%
Watermelons	94.23%	0.00%	2.26%	2.47%	0.82%	0.22%
Winter Wheat	87.83%	0.40%	2.59%	3.14%	1.61%	4.43%
Winter Wheat/Corn	93.94%	0.07%	1.16%	1.28%	1.16%	2.40%
Winter Wheat/Cotton	93.61%	0.00%	3.01%	2.37%	0.51%	0.50%
Winter Wheat/Sorghum	95.66%	0.08%	1.18%	1.39%	0.68%	1.00%
Winter Wheat/Soybeans	89.87%	0.19%	4.01%	3.59%	1.06%	1.27%

Table 5.17: 2052 – 1% Annual Chance of flooding by inundation levels, not cumulative

Crop Type	0 feet	6 Inches	1 Foot	2 Foot	3 Foot	Over 3 Ft
Alfalfa	94.63%	0.00%	1.13%	1.65%	1.21%	1.37%
Apples	95.38%	0.00%	0.46%	1.66%	0.85%	1.66%
Barley	97.05%	0.01%	0.79%	1.16%	0.58%	0.41%
Barley/Soybeans	95.44%	0.17%	1.40%	1.19%	0.60%	1.19%
Blueberries	73.86%	0.43%	6.51%	9.66%	2.48%	7.06%
Cabbage	87.67%	0.00%	7.44%	4.46%	0.43%	0.00%
Cantaloupes	93.41%	0.00%	2.41%	3.11%	0.80%	0.28%
Clover/Wildflowers	92.62%	0.00%	4.81%	2.49%	0.07%	0.00%
Corn	86.70%	0.25%	5.30%	4.94%	1.24%	1.58%
Corn/Soybeans	92.63%	0.00%	3.69%	3.25%	0.30%	0.13%
Cotton	91.56%	0.11%	3.74%	3.39%	0.69%	0.52%
Cucumbers	89.06%	0.00%	5.07%	5.12%	0.57%	0.18%
Dry Beans	94.65%	0.00%	2.43%	2.44%	0.31%	0.17%
Fallow/Idle Cropland	92.01%	0.06%	3.30%	3.12%	0.76%	0.75%
Grapes	95.02%	0.04%	1.84%	1.79%	0.91%	0.40%
Greens	89.85%	0.01%	5.66%	3.88%	0.34%	0.25%
Millet	92.00%	0.03%	2.44%	2.44%	0.94%	2.15%
Non Alfalfa Hay	92.13%	0.10%	2.44%	2.81%	1.04%	1.48%
Oats	93.04%	0.15%	2.42%	2.42%	0.70%	1.27%
Oats/Corn	88.72%	0.02%	3.95%	4.73%	1.22%	1.36%
Onions	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Other Crops	93.40%	0.07%	2.84%	2.61%	0.57%	0.51%
Other Tree Crops	94.93%	0.00%	1.82%	3.25%	0.00%	0.00%
Peaches	94.26%	0.01%	1.95%	2.29%	0.81%	0.68%
Peanuts	92.11%	0.09%	3.15%	3.02%	0.72%	0.91%
Peas	88.24%	0.08%	5.95%	4.41%	0.71%	0.60%
Pecans	89.19%	0.04%	2.80%	4.06%	1.63%	2.28%
Peppers	95.33%	0.00%	1.59%	1.86%	0.58%	0.63%
Potatoes	87.81%	0.01%	4.15%	4.49%	1.88%	1.66%
Pumpkins	81.44%	0.00%	0.46%	18.10%	0.00%	0.00%
Rice	25.91%	2.58%	6.86%	62.57%	0.91%	1.17%
Rye	92.82%	0.05%	1.64%	2.27%	0.98%	2.24%
Sod/Grass Seed	89.87%	0.07%	4.99%	3.58%	0.82%	0.67%
Sorghum	92.93%	0.06%	2.69%	2.56%	0.71%	1.05%
Soybeans	88.66%	0.24%	5.09%	4.18%	0.86%	0.96%
Soybeans/Oats	92.55%	0.04%	3.83%	2.53%	0.60%	0.44%
Squash	95.22%	0.00%	2.66%	1.97%	0.07%	0.08%
Strawberries	93.43%	0.01%	1.38%	1.31%	2.63%	1.25%

Sunflower	89.78%	0.04%	3.87%	3.58%	1.39%	1.34%
Sweet Corn	86.71%	0.05%	6.82%	4.87%	0.65%	0.90%
Sweet Potatoes	91.04%	0.02%	3.29%	4.10%	0.93%	0.62%
Switchgrass	96.41%	0.00%	0.63%	0.99%	1.69%	0.28%
Tobacco	93.18%	0.00%	2.66%	3.86%	0.20%	0.09%
Tomatoes	90.65%	0.05%	3.42%	3.14%	1.01%	1.73%
Triticale	96.51%	0.00%	0.98%	1.16%	0.48%	0.87%
Triticale/Corn	88.12%	0.00%	4.84%	5.46%	1.58%	0.00%
Watermelons	93.93%	0.00%	2.26%	2.64%	0.89%	0.28%
Winter Wheat	87.28%	0.35%	2.64%	3.28%	1.68%	4.77%
Winter Wheat/Corn	93.75%	0.06%	1.21%	1.31%	1.06%	2.61%
Winter Wheat/Cotton	93.31%	0.01%	3.07%	2.55%	0.55%	0.51%
Winter Wheat/Sorghum	95.47%	0.09%	1.24%	1.41%	0.71%	1.07%
Winter Wheat/Soybeans	89.20%	0.18%	4.23%	3.87%	1.13%	1.39%

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 hard to obtain immediately before, during, and after hazardous events.

Public refrigerated warehouses support this food system by storing perishable food. These temperature controlled storage facilities can also house medication, plants, and flowers. Additionally, there are cultural resources and other fragile items that may need to be kept in a climate controlled setting.

The maps below show the vulnerability of these refrigerated warehouses to flooding in the 2022 (Figure 5.123) and 2052 (Figure 5.124) 1% annual chance flood event.

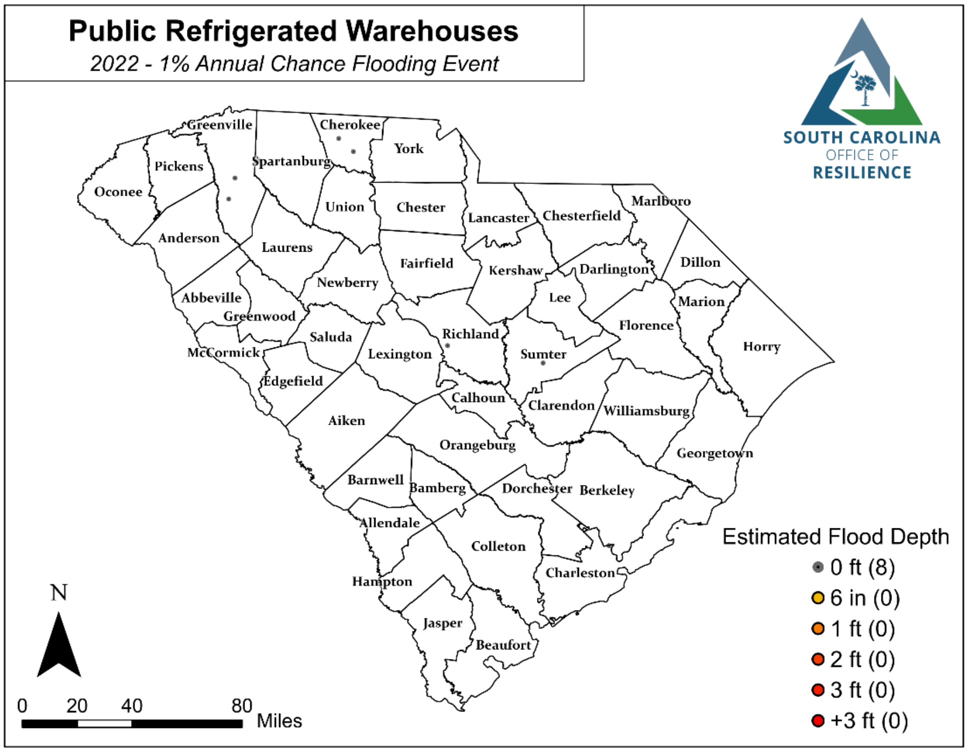


Figure 5.123: Estimated flooding of public refrigerated warehouses in the 2022 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

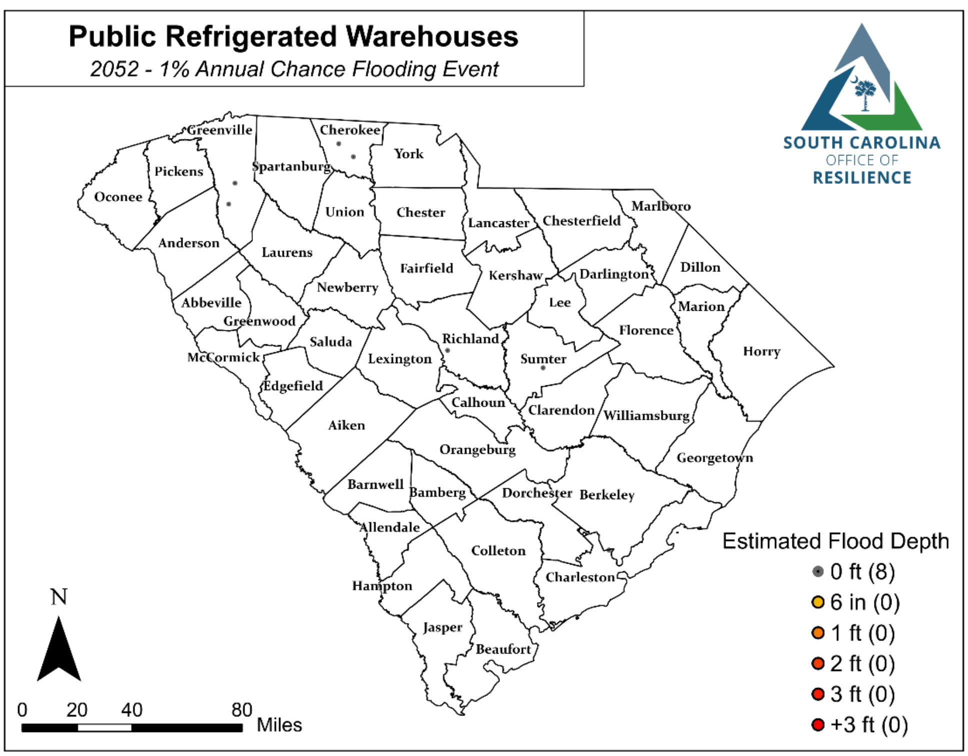


Figure 5.124: Estimated flooding of public refrigerated warehouses in the 2052 1% annual chance flooding event (Department of Homeland Security). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

MANUFACTURING

Manufacturing accounts for 12% of the employment in the state. Businesses in South Carolina manufacture a wide range of products including automobiles, appliances, boats, and aircraft (SC Department of Commerce, 2020).

The maps below show the estimated flooding of these manufacturing facilities in the 2022 (Figure 5.125) and 2052 (Figure 5.126) 1% annual chance flood event.

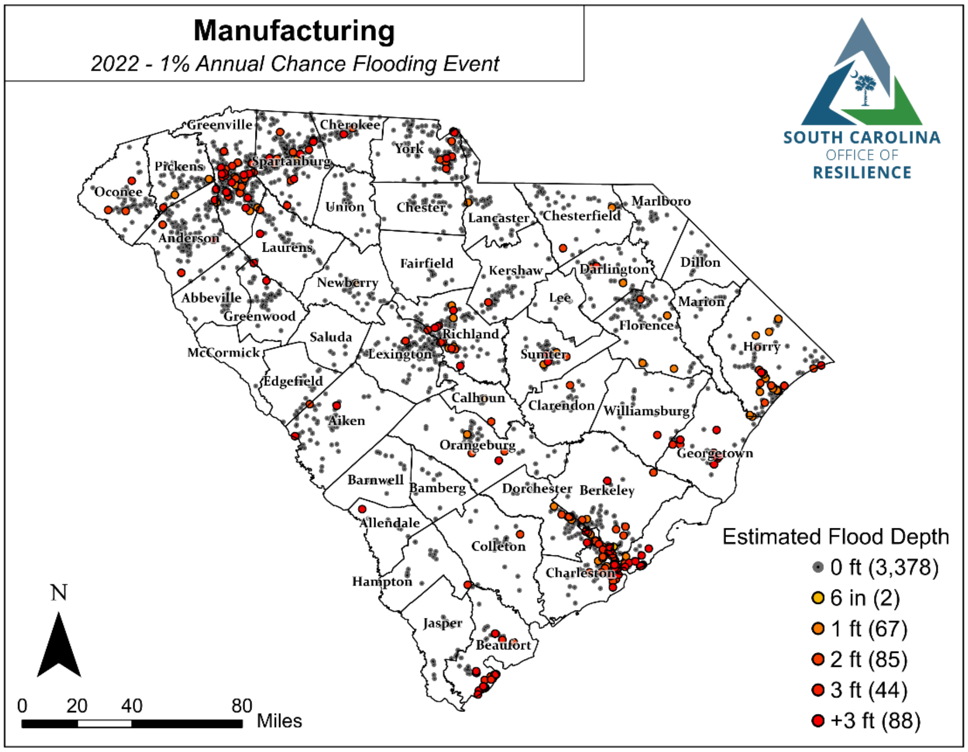


Figure 5.125: Estimated flooding of manufacturing facilities in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

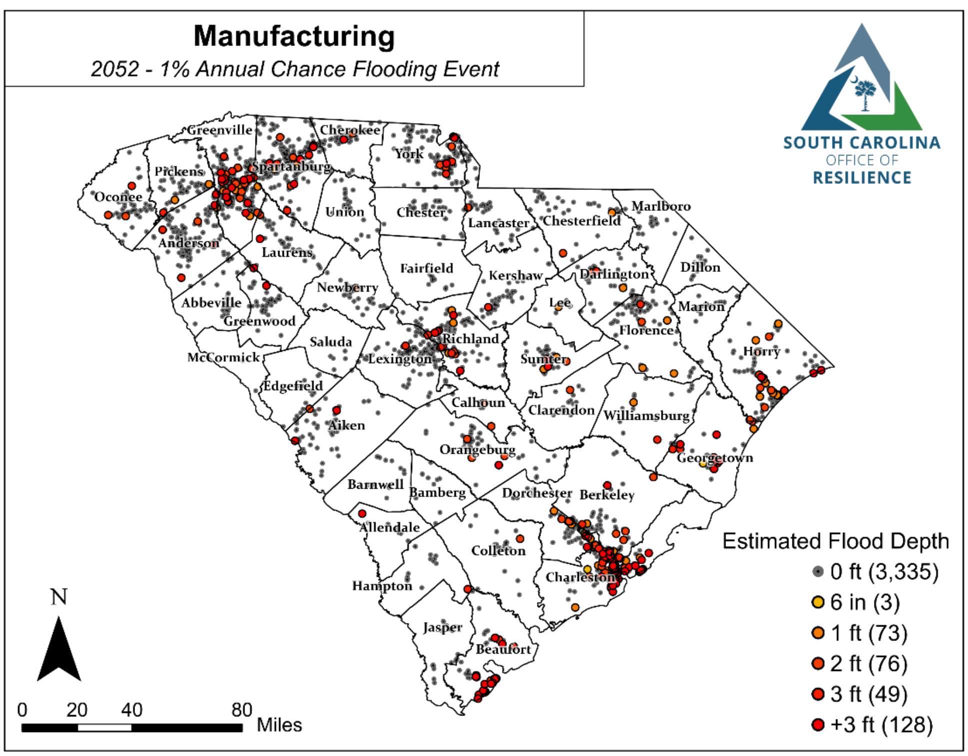


Figure 5.126: Estimated flooding of manufacturing facilities in the 2052 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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 us predict where we are likely to see industrial buildings constructed in the future.

The first maps below show the estimated flooding of these buildings in the 2022 (Figure 5.127) and 2052 (Figure 5.128) 1% annual chance flood event, while Figure 5.129 and Figure 5.130 show the industrial sites.

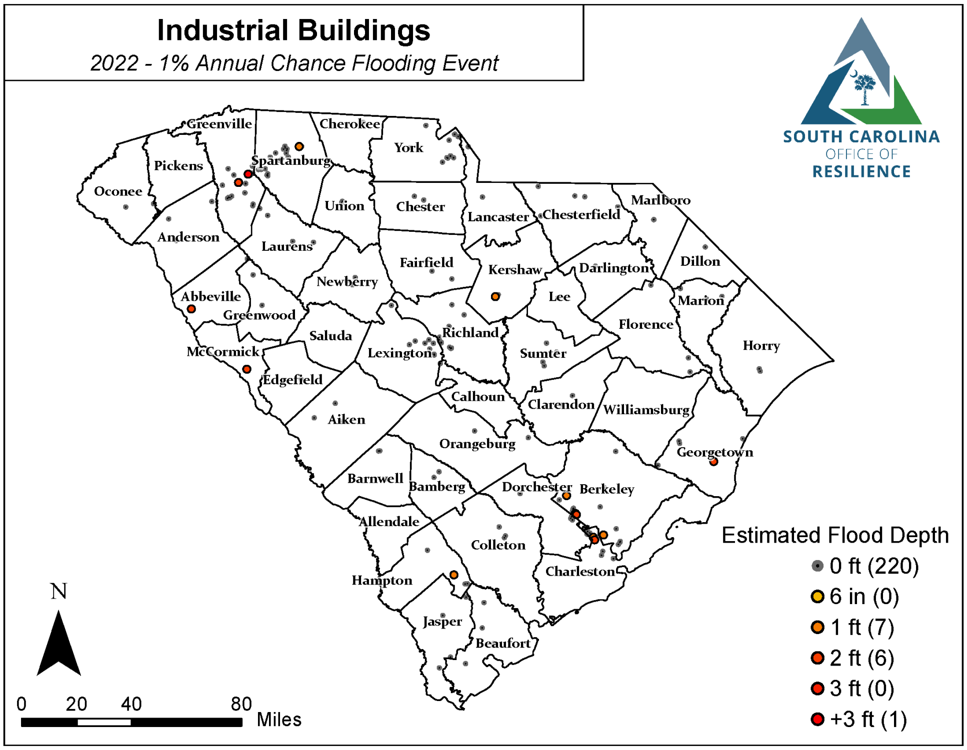


Figure 5.127: Estimated flooding of commerce industrial buildings in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

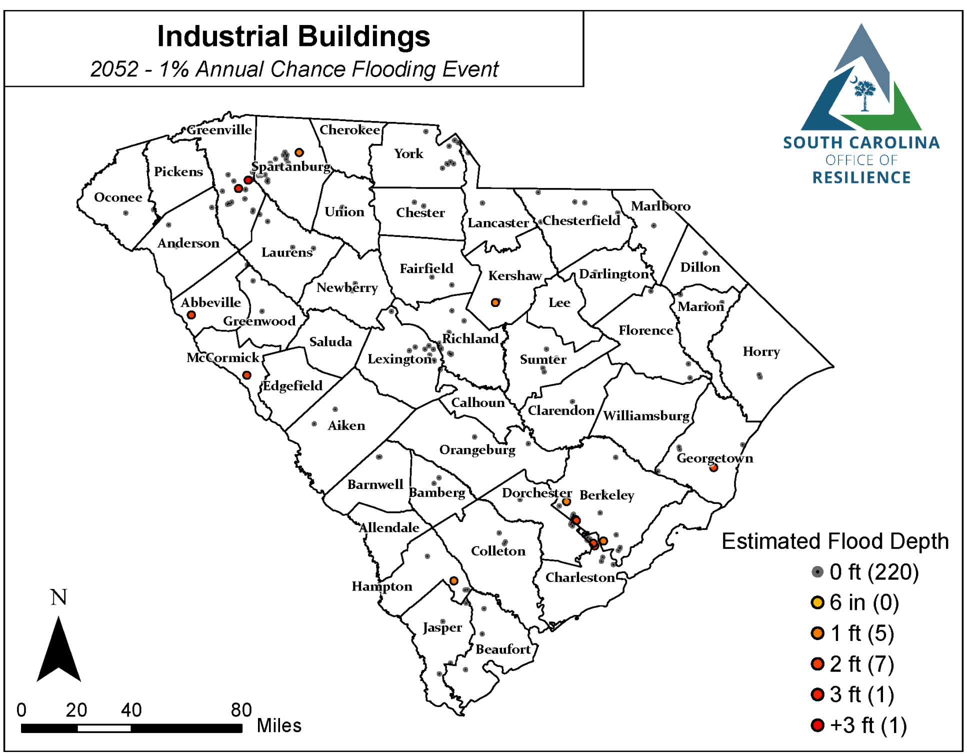


Figure 5.128: Estimated flooding of commerce industrial buildings in the 2052 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

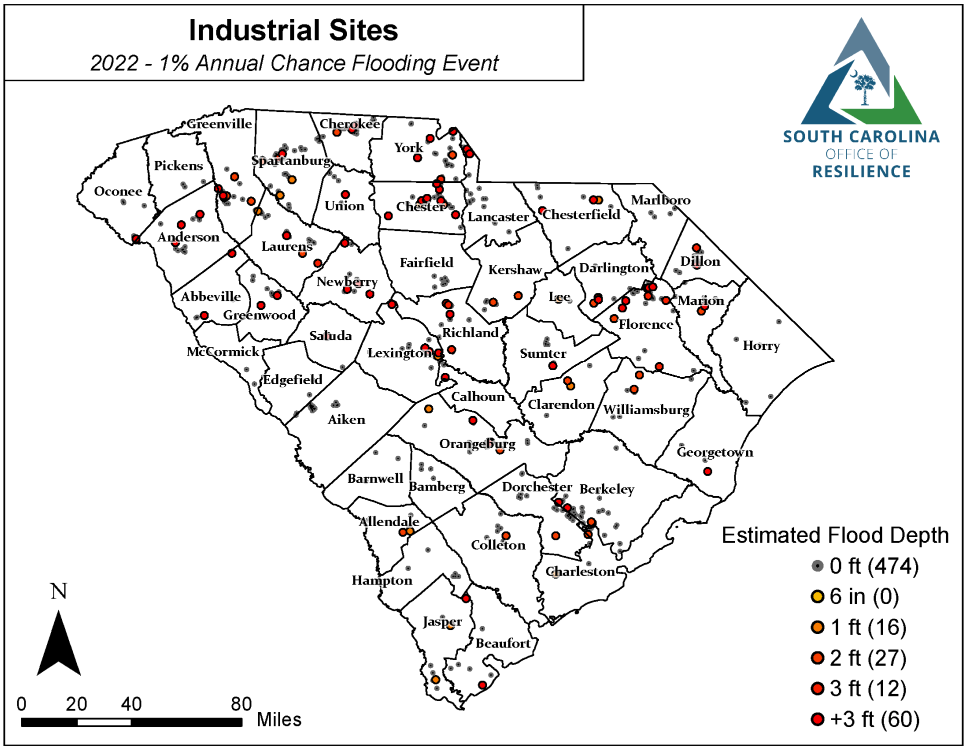


Figure 5.129: Estimated flooding of industrial sites in the 2022 1% annual chance flooding event (SC Department of Commerce). Flood data provided by the First Street Foundation Hazard Layers, V2.0.

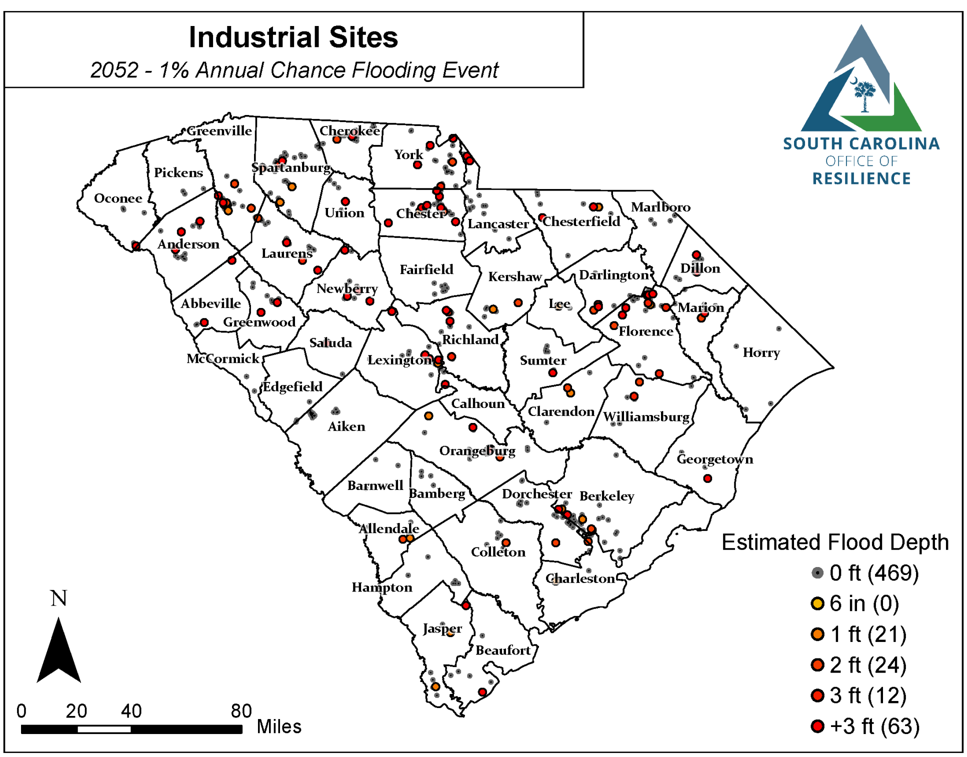


Figure 5.130: Estimated flooding of industrial sites in the 2052 1% annual chance flooding event (SC Department of Commerce. Flood data provided by the First Street Foundation Hazard Layers, V2.0.

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