Natural hazards such as hurricanes, tornadoes, earthquakes and wildfires often result in extensive damage to communities, costing hundreds of human lives and injuring many more. They can damage or destroy public and private property, disrupt the local economy, and impact residents' quality of life for many years. The National Oceanic and Atmospheric Administration (NOAA) studies these impacts in an effort to help better prepare America for the future. For the past several decades, NOAA has tracked and analyzed natural disaster trends and calculated the costs of impacts across the country, ultimately releasing an annual 'Billion-Dollar Weather and Climate Disasters' Report[1]. NOAA's release of 2020 data officially confirmed what scientists, communities and people across the country already knew or experienced: 2020 reached historic extremes in terms of the number of incidents and costs in damage and in lives.

Since NOAA's Billion-Dollar report was first released in 1980, data from each subsequent year and decade points to an apparent trajectory toward an increasing number of hazard events and costs[2]. In 2020 alone, the U.S. experienced 22 billion-dollar disasters costing $95 billion dollars. As a historical comparison, this is nearly the number of total disasters that occurred throughout the 1980s (29 total throughout the 1980s) and just over five times the total cost of annual damages ($17.8 billion in average cost per year throughout the 1980s). Table 1 below summarizes NOAA's Billion-Dollar Disasters in Historical Context from 1980 to 2020 (CPI-adjusted).

Table 1: U.S. Billion-dollar Disasters in Historical Context from 1980-2020 (CPI-adjusted)

TIME PERIOD	NO. OF BILLION-DOLLAR DISASTERS	AVERAGE NO. OF EVENTS PER YEAR	COST ($ IN BILLIONS)	AVERAGE COST PER YEAR ($ IN BILLIONS)	TOTAL DEATHS
1980s (1980-1989)	29	2.9	$178.1 B	$17.8 B	2,870
1990s (1990-1999)	53	5.3	$274.0 B	$27.4 B	3,045
2000s (2000-2009)	62	6.2	$519.0 B	$51.9 B	3,091
2010s (2010-2019)	119	11.9	$810.5 B	$81.1 B	5,217
Last Year (2020)	**22**	**22.0**	**$95.0 B**	**$95.0 B**	**262**
All Years (1980-2020)	285	7.0	$1,876.6 B	$45.8 B	14,485

Source: '2020 U.S. Billion-Dollar Weather and Climate Disasters in Historical Context,' www.climate.gov

Background

The Federal Emergency Management Agency, known as FEMA, was founded in 1979 amid an increasing need to "lead America to prepare for, prevent, respond to and recover from disasters" by providing recovery and relief funds for communities and individuals following disaster events. FEMA is funded through regular tax-funded appropriations and additional emergency funding in response to events.

1. *https://www.ncdc.noaa.gov/billions/*
2. *https://www.climate.gov/news-features/blogs/beyond-data/2020-us-billion-dollar-weather-and-climate-disasters-historical*

However, these funds[3] are somewhat limited in their scope, eligibility requirements, and often require substantial administrative effort prior to disbursement. Other disaster management organizations and non-profits such as the US Office of Emergency Management and the American Red Cross often join forces with FEMA, and yet, their combined efforts may remain inadequate to address the full breadth and cost of large-scale hazards, including a variety of adverse community impacts and human casualties.

Another federal effort toward emergency preparedness arrived in 2000 when the U.S. Congress passed the Disaster Mitigation Act (DMA) aimed at reducing the nation's mounting natural disaster losses and invoking new and revitalized approaches to mitigation planning. The DMA of 2000 emphasizes the need for state and local government entities to closely coordinate on mitigation planning activities and mandates development and maintenance of a hazard mitigation plan (HMP) as a specific eligibility requirement for any local government applying for federal mitigation grant funds. Berkeley County's latest HMP was recently updated and approved by the state in 2021, remaining valid for a 5-year period through 2026. Individual jurisdictions within Berkeley County, including Goose Creek, are addressed within this plan.

Regionally, the south and southeastern United States have experienced the highest national frequency and diversity of billion-dollar disasters with some of the highest cumulative costs due to the diversity of hazards, frequency and severity of events in the region. The cost of weather and climate disasters in South Carolina alone from 1980-2020 reached approximately $20-$50 billion dollars, according to NOAA's 2020 report[4], with the costliest damages attributed to tropical cyclones ($10-$20 billion) then drought, flooding and severe storms ($2-$5 billion each). Although we cannot control the force, frequency or intensity of future hazards, communities can work to reduce the impact felt in the aftermath of a natural disaster by implementing measures to reduce risks and minimize the loss of life and property.

Perhaps in response to mounting risks, costs and data trends, the South Carolina legislature recently passed the South Carolina Resilience Revolving Fund Act ("RRFA" or "the Act") or Disaster Relief and Resilience Act, on September 29, 2020, to expand the state's planning efforts for resilience to natural disaster and flooding events. The act establishes the new state Office of Resilience and creates two state funding programs:

1. ***The Disaster Relief and Resilience Reserve Fund****, to finance disaster recovery efforts and hazard mitigation projects, and*
2. ***The Resilience Revolving Fund****, to provide low-interest loans to local governments to perform voluntary floodplain buyouts and restoration activities*[5]*.*

Furthermore, the Act requires local comprehensive plans to include a new Resiliency element to consider and analyze local natural hazard risks, assess the potential effects of natural hazards on the safety, health, and welfare of the community, and provide actionable recommendations in response to those risks (S.C. Code Ann. § 6-29-510(D)).

It is in the interest of all communities to effectively manage local risks and reduce the need for federal disaster relief funds to minimize an increasing financial burden on tax paying citizens.

3. *https://www.fema.gov/sites/default/files/2020-07/fema_individuals-households-program_fact-sheet.pdf*
4. *https://www.ncdc.noaa.gov/billions/summary-stats*
5. *https://www.adaptationclearinghouse.org/resources/south-carolina-disaster-relief-and-resilience-act.html*

Communities must take preventative action now to identify potential hazards, minimize their risks, and measurably reduce the impacts they will inevitably face following natural disasters in years to come. As such, this Resiliency chapter has been prepared in response to the RRFA and serves as an addendum to the City of Goose Creek's Comprehensive Plan[6], which was formally adopted by ordinance on May 11, 2021. This document should not be construed as a local hazard mitigation plan, but instead, as a preliminary planning level effort requiring additional studies and steps to further refine the recommendations.

Geographic Context of Goose Creek

The City of Goose Creek is situated in the tricounty Region of South Carolina approximately 20-miles inland from the Atlantic coastline and the Charleston Harbor. According to Berkeley County's 2020 tax assessment data, the city currently encompasses 26,259 acres, or 42 square miles, of incorporated land area. Goose Creek is vulnerable to a wide range of natural hazards, primarily due to its proximity to the Atlantic Ocean, surface waters and rivers, many of which are tidally influenced, loss of protective natural environment features, and human development patterns over the past several decades. Much of the city's land area, properties, and/or population today is vulnerable to impacts from one or more natural hazards.

When undisturbed by human forces, natural habitats and ecosystems are generally able to repair and regenerate over time following natural hazard events. When left intact, they also serve as natural protective barriers for human environments, such as sand dunes protecting against storm surge and wetlands helping to slow, store, and distribute flood waters. Natural disasters occur when the human environment, such as buildings, infrastructure, agriculture and other land uses, are located in the path of the destructive forces of nature. The built environment, however, is typically much less resilient than natural ecosystems, as most infrastructure was not originally designed to withstand any variety of hazards. Since the built environment is more susceptible to natural hazards and cannot recuperate like the natural environment, particularly when much of the protective aspects of the natural environment have been damaged or removed, the recovery period for impacted communities is often long, and comes at great social and economic cost.

Image source:
South Carolina Lowcountry, Wikipedia

Wetlands and Surface Waters

Wetlands function as transitional areas where land meets water near streams, rivers, lakes, and estuaries, or in low-lying flat areas or natural depressions in the landscape. Wetlands can be comprised of freshwater or saltwater, or both, known as brackish water. Most of the wetlands in Goose Creek are freshwater forested/shrub wetlands located at the headwaters of and alongside stream reaches. Freshwater emergent wetlands exist along the riparian areas of the Cooper and Back Rivers and Foster Creek. Estuarine and marine wetlands occur upstream of and along the confluence of the Cooper River and Goose Creek. Map 1 below depicts the location and type of wetlands in and surrounding the city today.

6. *https://www.cityofgoosecreek.com/sites/default/files/PIO/GooseCreekCP_FINAL_05.11.2021_low-res.pdf*

Map 1: Goose Creek Wetlands and Buildings Within or Near (≤ 50 feet) Wetlands

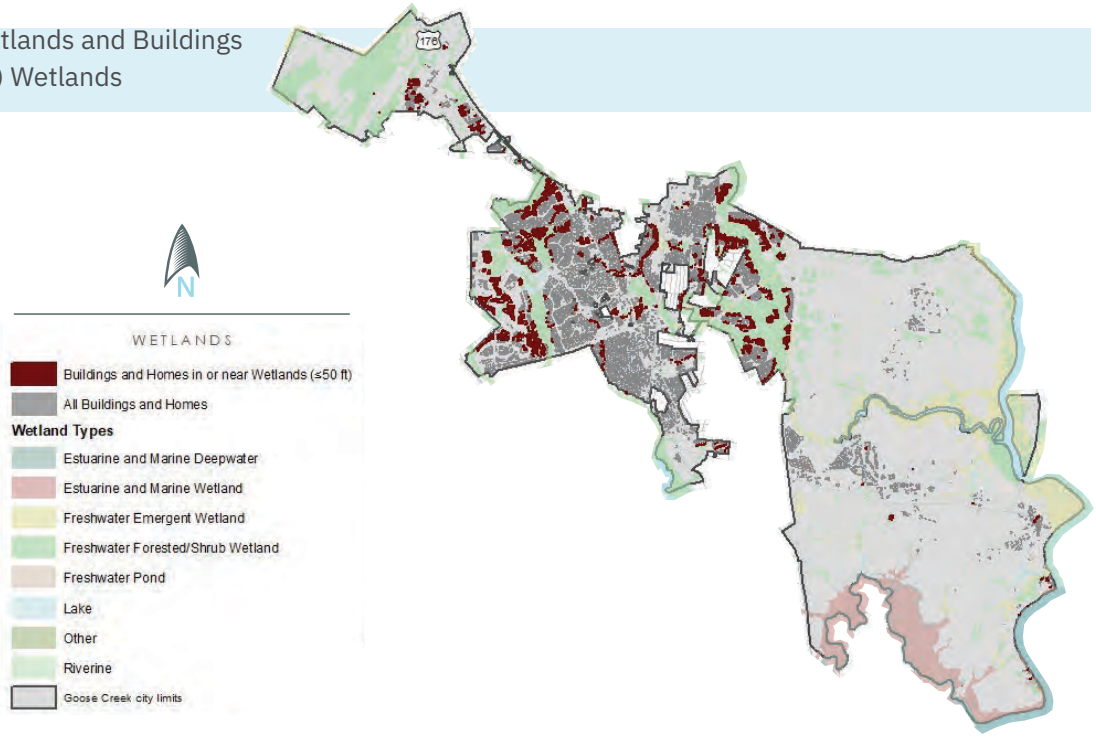
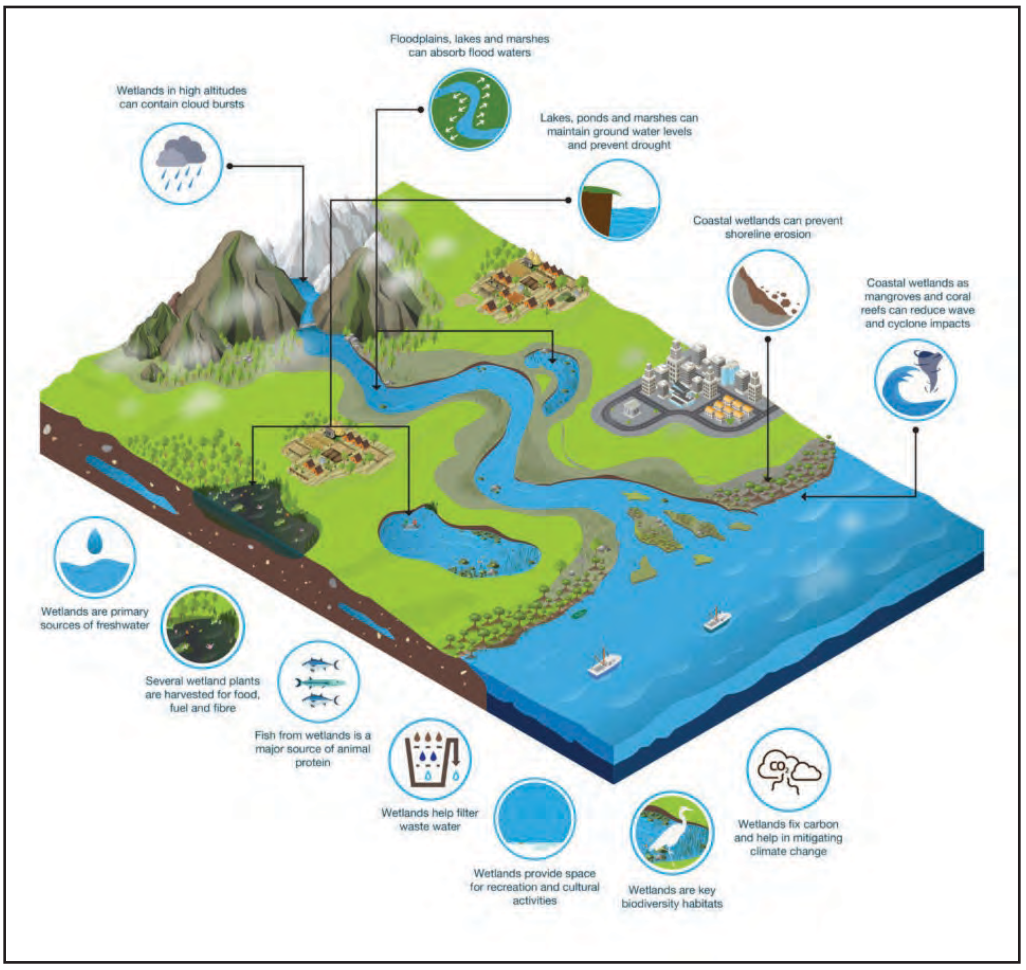


Figure 1: Benefits of Wetlands



Because wetlands serve a critical role as receiving bodies during storm events, they are prone to water inundation. Inundation of flood waters do not harm the wetlands themselves as they are well-equipped for this purpose, but can negatively impact human development in or surrounding the wetland if the infrastructure was not designed to withstand flood events.

Today, approximately 3,345-built structures totaling 8,264,250-SF are located within or in close proximity (≤50 feet) to these mapped wetland areas.

Floodplains

Floodplains encompass the low-lying areas adjacent to a river or stream stretching from the river banks to the outer edges of a valley. A floodplain consists of two components: a floodway, which is the main channel of moving water, which can be constantly flowing or sometimes seasonal, and the flood fringe, which extends from the boundary of the floodway out to the edges of a valley[7]. FEMA maps define areas according to varying levels of associated flood risk. Federal law requires the purchase of insurance through the National Flood Insurance Program (NFIP) by property owners building structures in the FEMA-defined 100-year floodplain. Additional state and local laws may also apply to proposed development in the 100- and 500-year floodplains as a means to reduce community-wide flood risks.

Much like wetlands, floodplains serve important functions in the natural environment, such as storing and dissipating floodwaters, groundwater recharge, filtrating nutrients from stormwater through vegetated buffers, and creating habitat for diverse populations of plant and animal species. For these reasons, FEMA recommends keeping development out of these areas, not only for the protection of life and property from flooding, but also to preserve the vital ecosystem functioning of floodplains.

Floodplain management is an administrative effort undertaken by jurisdictions, such as a city or town, to prevent or reduce the risk of flood-related damage to property and the environment by regulating and managing the siting of development. Proactive communities with a clearly defined floodplain management program can identify flood hazards based on official maps and act to reduce associated risks through planning and the development review process.

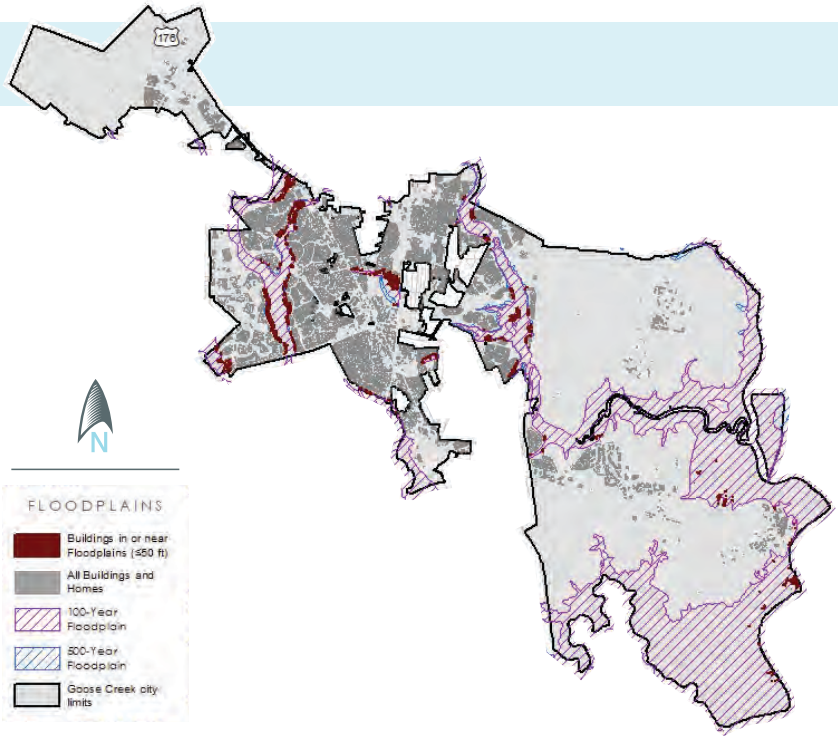
Several areas along the major creek and river systems of Goose are within the mapped FEMA-designated 100-year and 500-year flood hazard zones, illustrated in Map 2 (on next page). The 100-year floodplain represents the maximum flood level expected to occur once every 100 years (i.e., there is a 1% chance of a 100-year flood event happening in a given year). Similarly, the 500-year floodplain indicates the area where a flood event has a 1 in 500 (or 0.2%) chance of occurring in a given year.

A total of 6,712 acres, or 25% of Goose Creek, is within FEMA's Zone A, Zone AE or VE, all of which are Special Flood Hazard Areas with high-risk of flood impacts. Together, they comprise the 100-year floodplain. A total of 1,517-acres (or 6% of the city's land) is within FEMA Zone X (shaded), known as the 500-year floodplain, which has a moderate risk of flooding. The remaining 18,307 acres, or 69% of land is classified as Zone X (unshaded), which is minimal associated flood risk.

Today, approximately 1,326 built structures, with a total building footprint of 2,476,576-SF, lie within or near (≤50 feet) the regulated floodplains.

7. *https://www.nationalgeographic.org/encyclopedia/flood-plain/*

Map 2: Buildings in Floodplains



While FEMA's mapped flood zones provide guidance about the locations and relative levels of flood risk, it is important to recognize that they are not foolproof, and floods can occur anywhere.

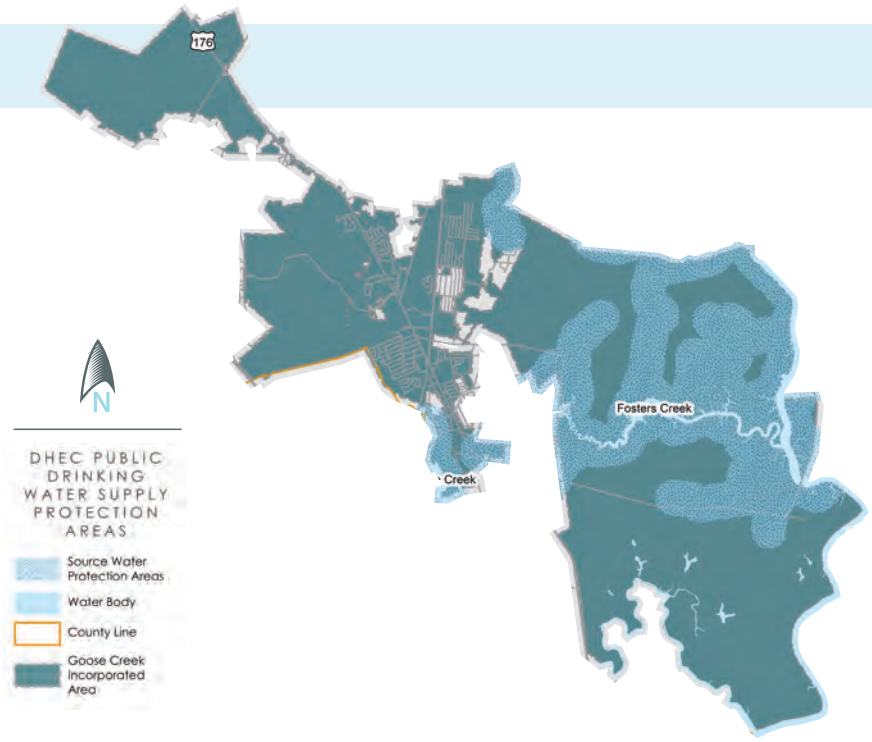
According to the National Flood Insurance Program Fact Sheet, people outside of FEMA's designated high-risk areas still file over 20% of flood insurance claims and receive one-third of FEMA's disaster assistance for flooding. Recent, local examples of flood events such as Hurricanes Joaquin (2015), Matthew (2016) and Irma (2017) resulted in widespread, historic levels of flooding in South Carolina, reaching the 100-year and 500-year floodplain in some places, and even reached levels qualifying as a 1,000-year flood event in parts of the tri-county area[8]. This may be an indicator that rapid changes in climate are impacting the frequency and intensity of flood events locally. The potential for devastating flood impacts should be carefully considered during land use decision making as areas in the mapped floodplains, and possibly beyond, are at higher risk to incur property damage.

Watersheds and Water Quality Protection

The City of Goose Creek is located within the Cooper River Watershed of the Santee River Basin which lies within the Lower Coastal Plain of South Carolina. Major hydrologic features within or adjacent to Goose Creek include the Back River and Cooper River, the headwaters of Goose Creek and the Goose Creek Reservoir, Bushy Park Reservoir, and Foster Creek. Together, these various water features and other water features beyond the city's municipal boundaries comprise the Cooper River Watershed. Most local watersheds, such as the Cooper River Watershed, eventually merge with larger, regional watersheds and ultimately, flow to the ocean or other large water bodies, or infiltrate into groundwater aquifers. The connectivity of watersheds and aquifers means that water quality protection must occur at a regional scale in order to be effective.

8. *Berkeley County Hazard Mitigation Plan, 2020 update*

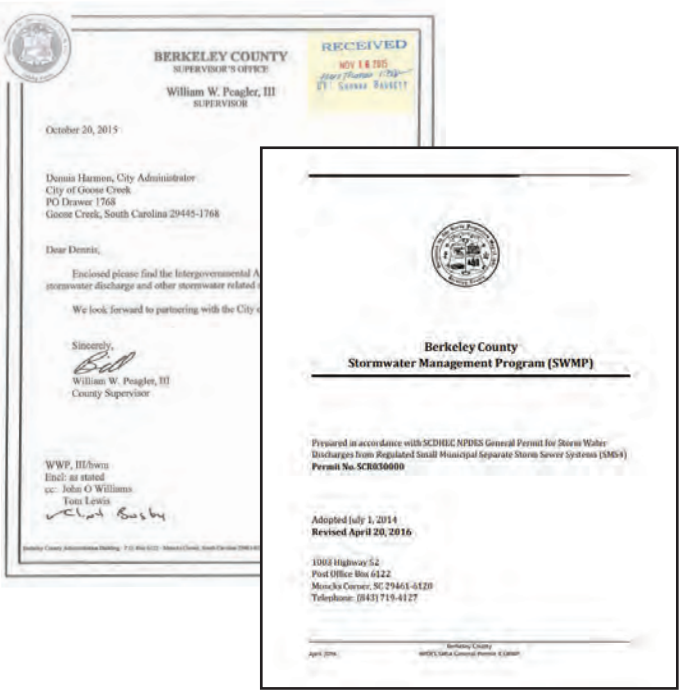
Map 3: Water Quality Protection Areas



Water quality is a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics. To protect aquatic life in these waters and human health and safety, states establish Water Quality Standards. Water Quality Standards help to protect and restore the quality of water in accordance with the Clean Water Act (CWA), and define goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions to protect water quality from pollutants. To do this, DHEC continually monitors waterbodies and reviews, revises, or creates new standards based on changing water quality conditions. DHEC routinely monitors surface waters to characterize current water quality, determine if waters are meeting current standards, analyze long-term water quality trends, and help formulate limits for permitted wastewater discharges. There are multiple monitoring stations located in the Goose Creek Reservoir and just below the confluence of Foster Creek and the Back River, as well as in the Cooper River along the eastern edge of the City's boundary.

Stormwater runoff is one of the most common ways in which water bodies receive pollutants from the ground. The National Oceanic and Atmospheric Administration (NOAA) states that: "Stormwater runoff is one of the most significant threats to aquatic ecosystems in the United States. As water runs over and through the watershed, it picks up and carries contaminants and soil. If untreated, these pollutants wash directly into waterways carried by runoff from rain and snowmelt. These contaminants can infiltrate groundwater and concentrate in streams and rivers, ultimately being carried down the watershed and into the ocean."

Image source:
Environment Texas 2017 News Brief


BERKELEY COUNTY
SUPERVISOR'S OFFICE
William W. Peagler, III
SUPERVISOR
RECEIVED
October 20, 2015
Dennis Harmon, City Administrator
City of Goose Creek
PO Drawer 1768
Goose Creek, South Carolina 29445-1768
Dear Dennis,
Sincerely,
William W. Peagler, III
County Supervisor
WWP, III/bwn
Encl: as stated
cc: John O Williams
Tom Lewis
Berkeley County
Stormwater Management Program (SWMP)
Permit No. SCR030000
Adopted July 1, 2014
Revised April 20, 2016
1002 Highway 52
Post Office Box 6122
Moncks Corner, SC 29461-6120
Telephone: (843) 719-4127

Development and urbanization can lead to increased pollution in waterways due to reduced natural, permeable surfaces, like forests, fields and grassland, that assist with infiltration and water purification. Impervious surfaces such as asphalt, concrete, and buildings do not allow rainwater to slowly percolate and absorb into the ground. Instead, water runs across the hardened, solid surfaces, collecting pollutants like fertilizers, motor oil, and pet waste, before reaching and depositing the pollutants into the nearest storm drain or surface water feature.

Local and regional Stormwater Management Programs (SWMP) are adopted as a regulatory means to review, permit and monitor construction sites to prevent contaminants from entering the stormwater drainage system, to continue monitoring businesses and residential areas to ensure no pollutants are being discharged directly into larger waterbodies, and to educate the public about personal practices to reduce the risk of polluting rainwater. Finally, Stormwater Best Management Practices (BMPs) are implemented during development activities to control the movement of pollutants, prevent degradation of soil and water resources, and help manage and lessen the adverse impacts that are typically associated with stormwater runoff. These can include the retention and maintenance of natural features like wetlands and riparian buffers, which slow the flow of stormwater and help to filter and improve the quality of surface water runoff entering the watershed, or engineered features such as green roofs, rain gardens, bioswales and permeable pavements, which are also effective means of reducing the velocity and quantity of stormwater runoff and improving water quality.

In 2015, Goose Creek entered into an Intergovernmental Agreement with Berkeley County pursuant to the county's National Pollutant Discharge Elimination System Permit (NPDES) Stormwater Discharge Permit, which rendered the county responsible for administering the city's stormwater management, including: SWMP, Enforcement Response Plan, monitoring discharges to sensitive waters, public education and outreach on stormwater impacts, Illicit Discharge Detection and Elimination, Construction Site Stormwater Runoff Control, Pollution Prevention for Municipal Operations, and Stormwater Capital Improvements.

Development Patterns

From 1990 to 2020, the City's incorporated land area increased substantially, primarily attributable to the annexation of the Carnes Crossroads development area in 2005. The land area increase was further attributable to the incorporation of land along the Cooper River, western Daniel Island, and residential developments around Red Bank Road, Liberty Hall Road, and several smaller neighborhoods and parcels throughout the upper and central areas of the city.

Existing Local Regulations

Goose Creek's Code of Ordinances[9] includes regulatory measures to address the sensitive nature of many of these natural environments and the related hazards, including:

- ***Stormwater Management*** (Title V., Chapter 50), which was passed in November 2007 and last amended in 2018. This city ordinance aims to manage stormwater runoff and its associated negative impacts using a Stormwater Management Plan (SWMP). In 2018, the city entered a partnership with Berkeley County for stormwater management activities whereby the county began overseeing the city's SWMP.
- ***Buildings; Construction and Related Activities*** (Title XV., Ch. 150), which was first passed in 1985 (Standard Building Code and CABO Model Energy Code) and most recently updated in March 2020 (International Building and Residential Codes). This city ordinance includes provisions regulating the Adoption of Building Codes (§150.20), and Inspections for Code Compliance (§150.26).
- ***Zoning*** (Title XV., Ch. 151), which was passed in 1985 and last amended in 1999. This city ordinance aims to "guide development in accordance with existing and future needs and in order to protect, promote and improve the public health, safety, morals, convenience, order, appearance, prosperity and general welfare" by means of regulating many facets of development in the city, including:
    - ***General Development Provision - Use of Land or Buildings*** (§151.080), which was passed in 1985 and last amended in 2019, aims to: (A) Preserve the natural environment and vegetative cover, (B) Minimize tree felling, particularly in undeveloped areas, (C) Prohibit clear-cutting, and generally, (D) Promote tree conservation efforts. This provision may require consideration for a procedural amendment detailing the specific ways in which Planning Commission should assess prospective development to ensure project compliance with the intent of this section.
    - ***Flood Hazard Controls*** (§151.081, pg 158), which was passed in 1985 and last amended in 2018. This city ordinance states that *"The special flood hazard areas of the city are subject to periodic inundation resulting in loss of life, property, health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures of flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety, and general welfare." Additionally, it states that "these flood losses are caused by the cumulative effect of obstructions in floodplains causing increases in flood heights and velocities, and by the occupancy in flood hazard areas by uses vulnerable to floods or hazardous to other lands that are inadequately elevated, floodproofed, or otherwise unprotected from flood damages."* This analysis indicates that, as of 2020, approximately 1,326 built structures in Goose Creek with a total building footprint of 2,476,576-SF lie within or near (≤50 feet) of these regulated floodplains. Thus, the City's flood hazard controls and management may require additional consideration with respect to project review procedures to ensure project compliance with the intent of this section.

9. *https://codelibrary.amlegal.com/codes/goosecreek/latest/overview*

Currently, the city does not have a local regulatory means of protection for wetlands or requirements for wetland buffers. Because wetlands are also intrinsically connected to floodwater management, the city should consider a new ordinance to regulate development in and near wetland areas, as well as the addition of a wetland buffer requirement to ensure these important natural features remain undisturbed to the greatest extent practicable.

Natural Hazards

The occurrence of extreme weather events such as hurricanes, tropical storms, earthquakes, tornadoes, and wildfires, is not a new phenomenon. These weather patterns have existed on earth since the dawn of time; what is new, however, is the way in which our ever-growing human population and the built environment is increasingly coming into conflict with these hazards, resulting in natural disasters. This section details the potential natural hazards present in Goose Creek today, provides a risk assessment of each hazard, and considers the potential impacts on the community should disaster strike.

Residential Flooding in Goose Creek
Source: KUTV News

300 Block of Boulder Bluff
Source: Berkeley Observer

Flooding

Flooding is defined by the rising and overflowing of water onto otherwise dry or already saturated land. As defined by FEMA, a flood is a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties. Flooding can result from an overflow of inland waters or an unusual accumulation and runoff of surface waters from any source.

According to the 2021 Berkeley County Hazard Mitigation Plan (BCHMP), changing climate and weather patterns, environmental conditions, and urban and rural development may affect the frequency and intensity of flooding. The increased likelihood of extreme precipitation due to climate change will result in greater risks of flash flooding and impacts from stormwater runoff. The rainfall that does occur will likely be more intense, and flooding impacts may intensify as a result.

Flooding in Goose Creek occurs due to excessive rainfall over land areas, seasonal or tidal riverine overflow, or coastal flooding due to storm surge, rising sea levels, or high tides. All of the following flood types are interconnected and often co-occur.

Rain Flooding

High intensity rainfall causes flooding when an area's stormwater drainage system, sewer system, and groundwater lack the necessary capacity to drain or absorb the high rate of rainfall. Urban areas are particularly susceptible to this type of flooding due to the large surface areas having been developed and converted from natural cover types, such as fields or

Image Source: National Weather Service

Image Source: Post and Courier

woodlands, to impervious surfaces, such as buildings, parking lots, or roads which block the natural infiltration of rainfall into the ground. An urbanized development pattern with large areas of impervious surface can be detrimental during extremely heavy rainfall where stormwater is channeled over low-lying areas, resulting in dangerous, rapidly moving waters capable of significant damage.

Riverine Flooding

Flooding along rivers may occur seasonally when rain or snowmelt quickly fills river basins beyond capacity and breaches over stream or river banks. Torrential rains from weakening hurricanes or tropical systems can also produce river flooding, even if the storm has moved inland. Ongoing riverine floods can intensify and become flash floods when heavy rainfall results in a rapid surge of rising flood waters. People, buildings and property on or nearby –Foster Creek, Back River, or the Cooper River and its tributaries would be most vulnerable to the impacts of riverine flooding in Goose Creek.

Coastal Flooding

All lands bordering the coast along the Atlantic Ocean and in low-lying coastal plains are susceptible to tidal effects and related flooding. Coastal floods usually occur due to abnormally high tides or tidal waves, storm surge and heavy rains in combination with high tides, or tropical storms and hurricanes. In many coastal communities, flooding occurs when tides reach anywhere from 1.75 to 2 feet above the daily average high tide and start spilling onto streets. Storm surge effects can be exacerbated if the storm occurs during an astronomical high tide, in which water levels are significantly higher than average due to high tide coinciding with a full or new moon. While Goose Creek is not an ocean front community, certain areas of the city can still be affected by tidally-influenced waters. Areas such as the Naval Weapons Station, Bushy Park, and other flooding-sensitive land uses in the far eastern extent of the city in proximity to the coastline and/or tidally influenced rivers are vulnerable to coastal flooding as floodwaters are pushed inward from the coastline.

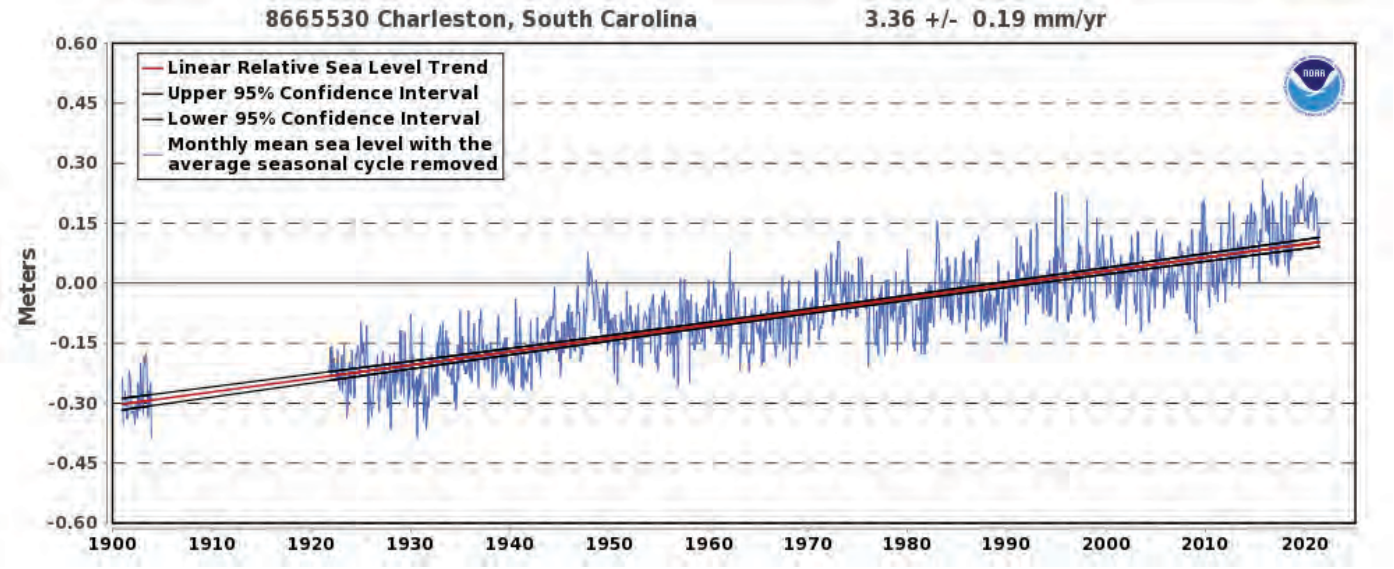
Sea Level Rise

Sea level is measured and recorded as an average level of the surface of a water body, such as the Atlantic Ocean in the Charleston Harbor, in reference to a specific point of elevation, and is known as mean sea level ("MSL"). The National Oceanic and Atmospheric Administration ("NOAA") has been measuring and recording MSL in the Charleston Harbor since 1899 using a tidal gauge located near the U.S. Customs House near East Bay Street[10]. About 122-years' worth of tidal data from this gauge indicates a tidal range of 5.76 feet[11].

10. *https://www.sac.usace.army.mil/Portals/43/docs/civilworks/peninsulastudy/Appendix%20B3_HandH.pdf*
11. *https://tidesandcurrents.noaa.gov/datums.html?id=8665530*

In a 100-year timespan from the placement of the gauge, MSL rose 1.07-feet, equating to an average rise of 1.284-inches per decade and an increase of 10% per decade. In the 20-year period from 2000 to 2020, MSL rose a total of 5.64-inches, equating to an average rise of 2.82-inches per decade, or a 60% increase per decade. These data indicate a rapid increase in MSL in recent decades. See Figure 2 below.

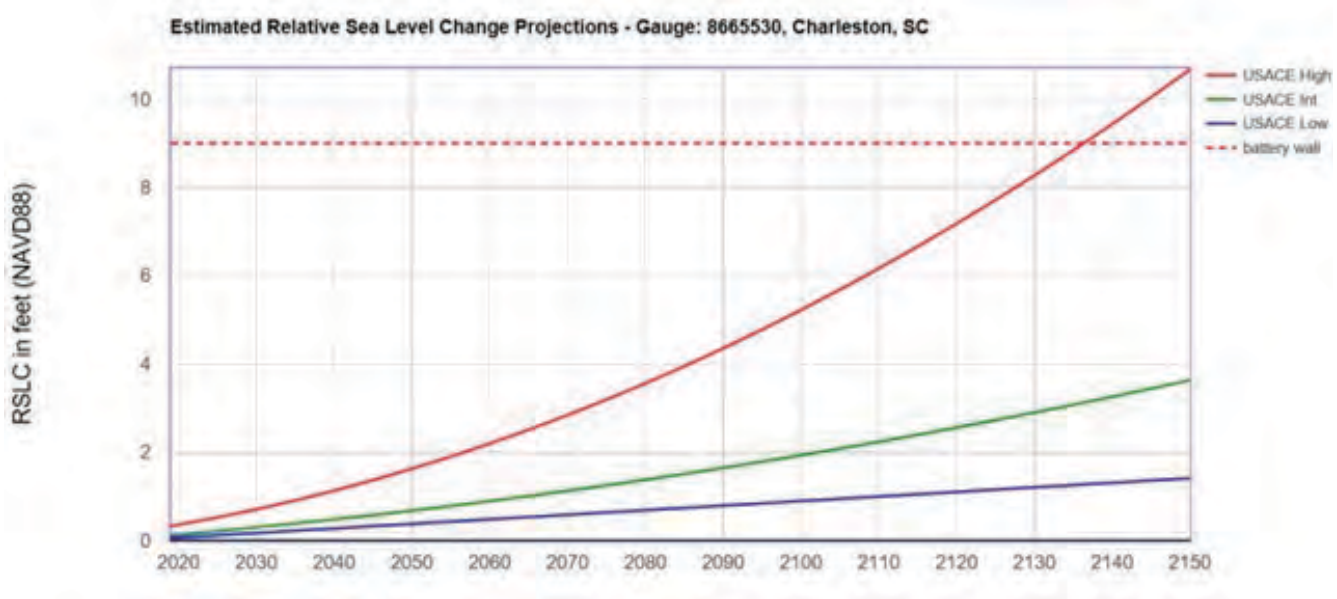
Figure 2: NOAA Sea Level Trend at Charleston Harbor Gage (1900 - 2020)



As sea levels continue rising, tidally influenced streams are more frequently inundated, resulting in waters overflowing the banks and damaging floods. Decades ago, these flood events happened only during an intense storm, but now happen more regularly during astronomical high tides or with a change in prevailing winds or currents.

The US Army Corps of Engineers recently completed an SLR analysis with projections through 2150 for the Charleston Harbor area and similarly concluded that sea levels would continue rising in the foreseeable future, as shown in Figure 3.

Figure 3: USACE Sea Level Change Projections for Charleston, SC (2020 - 2150)

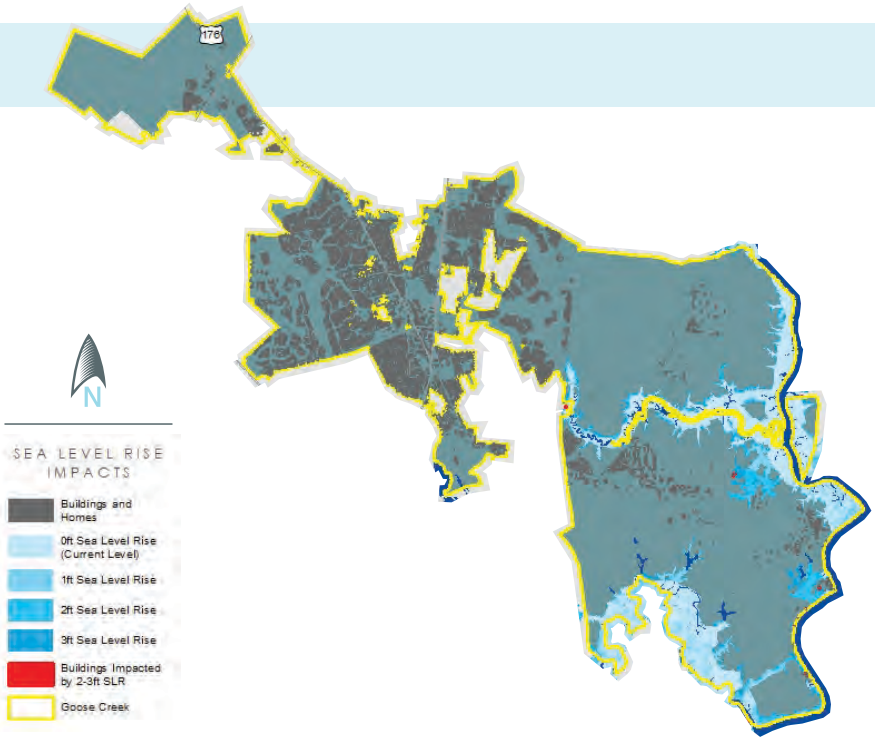


For the Charleston area, NOAA's latest projections show that approximately 6 inches of sea level rise ("SLR") will likely occur by 2030, 1-foot of SLR by 2040, and 6-feet of SLR by the end of this century. Goose Greek is considered vulnerable to the impact of sea level rise due to low-lying, water adjacent land areas with large amounts of impervious surface coverage. According to NOAA's data and projections, approximately 2,827-acres or 11% of Goose Creek's current land area will be impacted as sea levels rise 1 foot, a total of 3,242-acres (12%) at 2 feet of SLR, and a total of 3,569-acres (13%) at 3 feet of SLR.

As global air temperatures slowly rise, sea levels also rise; unlike temporary flooding caused by storm surges, these waters do not recede. Map 4 below depicts the affected land area and built structures in Goose Creek at 1-, 2- and 3-feet of sea level rise, according to data from NOAA. Structures directly impacted by 2- and 3-feet of SLR are depicted in red. Unlike flooding caused by heavy precipitation and storm surges, which are temporary, sea level rise is a more permanent outcome.

Image Source: SeaLevelRise.org

Map 4: Sea Level Rise Impacts



Flooding - Risk Assessment

Flood risk is assessed by measuring the amount of land in the floodplain and the potential magnitude of flooding as gauged by flood height and velocity, a measure known as flood extent or flood inundation, and is portrayed and calculated using scenario mapping tools.

FEMA's Flood Insurance Rate Maps (FIRMs) illustrate delineated and regulated floodplains, including the Special Flood Hazard Areas (SFHAs) and the specific risk zones applicable to the community.

FIRMs are the official maps for communities to use to determine whether a given property is on or near a FEMA-designated floodplain, and if participation in the national flood insurance program is required. SFHAs are specially regulated areas due to their high risk of inundation by a 100-year flood event. Structures located within the SFHA have a 26-percent chance of flooding during the life of a standard 30-year mortgage. Table 2 summarizes the flood insurance zones located in Goose Creek as identified by the Digital FIRM (DFIRM).

Table 2: FEMA Flood Zones in Goose Creek City Limits, 2021

ZONE	DESCRIPTION
A	Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas, no depths or base flood elevations are shown within these zones.
AE	AE Zones, also within the 100-year flood limits, are defined with BFEs that reflect the combined influence of still water flood elevations and wave effects less than 3 feet. The AE Zone generally extends from the landward VE zone limit to the limits of the 100-year flood from coastal sources, or until it reaches the confluence with riverine flood sources. The AE Zones also depict the SFHA due to riverine flood sources, but instead of being subdivided into separate zones of differing BFEs with possible wave effects added, they represent the flood profile determined by hydrologic and hydraulic investigations and have no wave effects. The Coastal AE Zone is differentiated from the AE Zone by the Limit of Moderate Wave Action (LiMWA) and includes areas susceptible to wave action between 1.5 to 3 feet.
VE	Zone VE is the flood insurance rate zone that corresponds to the 1% annual chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot Base Flood Elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.
Zone X - Shaded	Moderate risk areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by a levee. No BFEs or base flood depths are shown within these zones. (Zone X (shaded) is used on new and revised maps in place of Zone B.)
Zone X - Unshaded	Minimal risk areas outside the 1-percent and .2-percent-annual-chance floodplains. No BFEs or base flood depths are shown within these zones. Zone X (unshaded) is used on new and revised maps in place of Zone C.

Because a considerable amount of detail is shown in FEMA's official FIRM maps, the incorporated area of one city may encompass multiple different FIRM maps, known as panels. The incorporated boundary of Goose Creek currently spreads over thirteen (13) different FIRM panels. These panels are simplified into a single FEMA Flood Zone map for the city in Map 5, which is not an official map, but is used here for general visualization purposes.

While exposure to flood hazard areas varies across the city, there is some degree of flood risk citywide. A combined total of approximately 6,377-acres, or 25%, of Goose Creek falls within the high-risk special flood hazard areas (Zones A, AE and VE). The remaining 75% (19,823 acres) of land area within the city is outside the SFHA (Zones X, shaded and unshaded), though it still faces moderate or low risk of flooding.

Map 5: FEMA Flood Zones and Goose Creek Built Environment

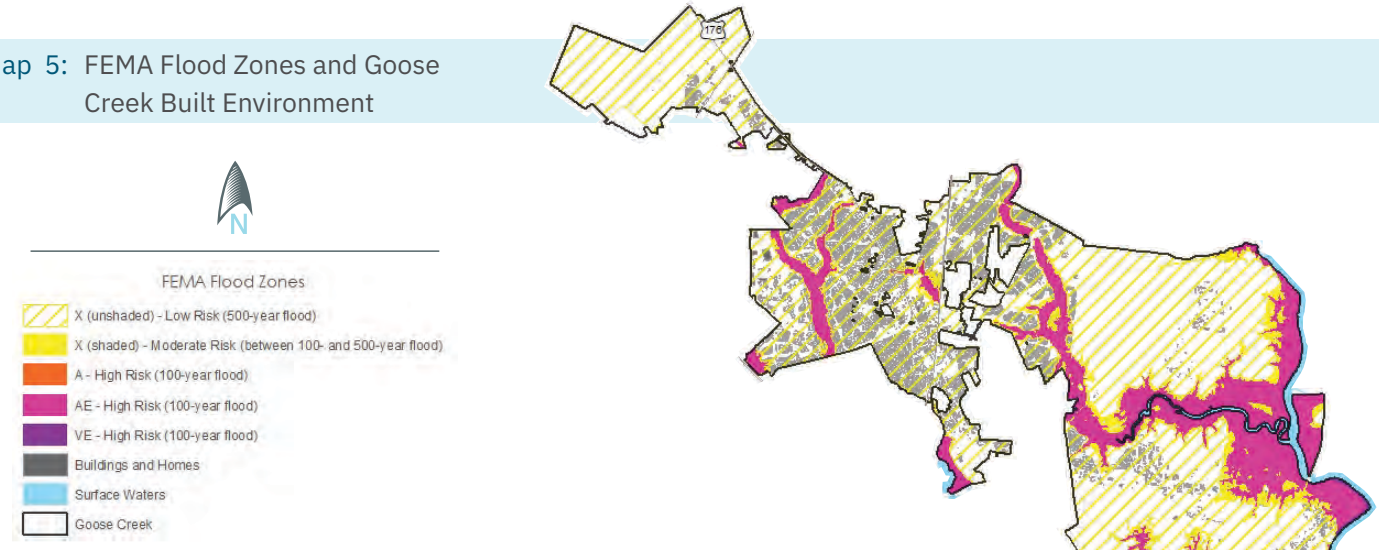
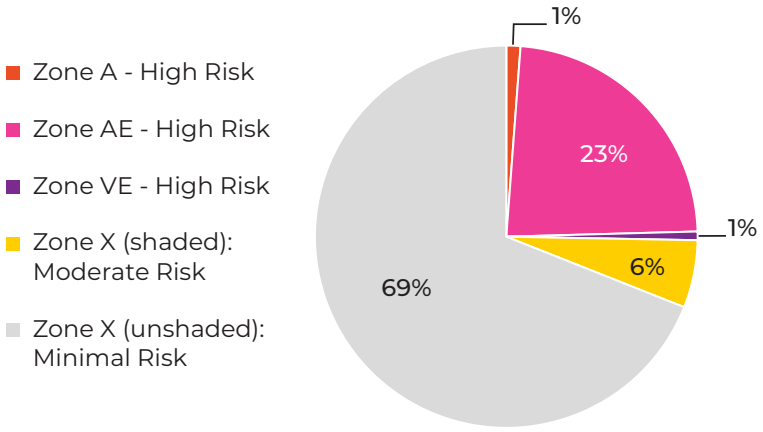


Figure 4: Percent of Land per FEMA Flood Zone (Goose Creek)



A collaboration of scientists, technologists and analysts recently created a flood risk model that "incorporates high-precision elevation data and local adaptation measures like seawalls and levees into [their] flood projections, validates against modeled historic floods, and then analyzes and maps the combined flood risk," for tidal, riverine, and rain events, known as Flood Factor[12]. Flood Factors Flood Risk Explorer tool concludes that approximately 5% of properties are currently at risk in the city and that flood risk is increasing for Goose Creek. The model predicts that as of this year (2021), approximately 609 Goose Creek properties are at risk of flood impacts; within 30 years about 694 properties will be at risk, representing a 14% increase. See Table 3 below.

Table 3: Flood Factor, Projected Flood Risk (2021 - 2041) for Goose Creek, SC

YEAR	THIS YEAR (2021)				IN 15 YEARS (2036)				IN 20 YEARS (2041)			
Flooding Likelihood	0.2%	1%	5%	20%	0.2%	1%	5%	20%	0.2%	1%	5%	20%
Properties Impacted	609	426	152	12	652	445	184	14	694	464	215	16

Source: Flood Factor, Flood Risk Explorer, Goose Creek, SC

12. *https://floodfactor.com/about*

Furthermore, the model classifies properties into Flood Factor Risk Levels on a scale of 1-10, as follows: Minimal (1), Minor (2), Moderate (3-4), Major (5-6), Severe (7-8), and Extreme (9-10). Flood Factor's analysis determined that about 85 properties or 12% of properties in Goose Creek are currently at Minor risk (risk level 2); about 165 properties or 24% of properties in Goose Creek are at Moderate risk (risk levels 3-4); about 275 properties or 40% of properties in Goose Creek are at Major risk (risk levels 5-6); about 139 properties or 20% of properties in Goose Creek are at severe risk (risk levels 7-8); and about 30 properties or 4% of properties in Goose Creek are at Extreme risk (risk levels 9-10)[13] - see Figure 5. Together, a total of about 444 properties (or 65% of land) are currently at major to extreme risk for flood impacts.

Figure 5: Flood Factor, Properties at Risk, Minor to Extreme

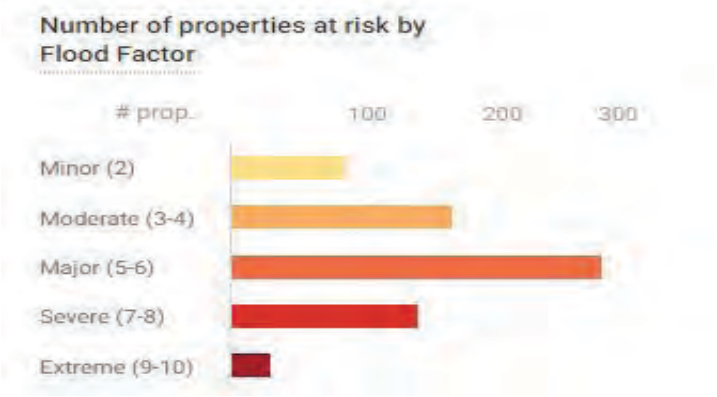


Image Source: Flood Factor, Score Map

Past flooding occurrences combined with predictions and projections from NOAA, NWS, Flood Factor and other agencies indicate that flood risks will likely increase in the future.

Flooding - Potential Impacts

The initial hazards associated with flooding are primarily related to the fast moving and potentially deep water. These risks include drowning or being swept away by the current (humans, pets, vehicles and entire homes), degradation of the transportation system which can cause failure of roadways, culverts and bridges, and the risk of electrocution if live power lines or equipment are submerged in water.

Additional health hazards frequently accompany floods in the days and weeks following the initial event, including surface water stagnation and pollution, ground water pollution, and other environmental impacts.

Hurricane Joaquin, 2015

Image Source: The Atlantic

Hurricane Matthew, 2016

Image Source: Travel Pulse

Hurricane Irma, 2017

Image Source: The Daniel Island News

13. *https://floodfactor.com/city/goose-creek-southcarolina/4529815_fsid#summary*

Surface Water

Floodwaters can transport any and all ground materials downstream, including dirt, oil, animal waste, and lawn, farm and industrial chemicals. Pastures and farming areas that contain fertilizers and animal waste pollute the receiving water bodies of floodwaters, such as lakes, bays and oceans. Stagnant pools of flood water can become breeding grounds for mosquitoes that can spread harmful diseases among the human and animal populations. Impacted buildings that have not been properly cleaned and adequately ventilated grow mold and mildew, both of which are respiratory health hazards for humans.

Another health hazard occurs when heating ducts in a forced air system are not properly cleaned after water inundation. When the furnace or air conditioner is turned on, the sediment left in the ducts are circulated throughout the building and respirated by the occupants.

Image Source: TPOmag.com

Image Source: The Atlantic

Image Source: FOX Carolina

Groundwater / water quality

The polluted surface waters also saturate the ground and infiltrate into sanitary sewer lines and aquifers. When wastewater treatment plants are inundated by flood water, the water table rises and there is nowhere for the sewage backup to flow. This can lead to the release of raw sewage overflow into the low-lying areas surrounding the treatment plant, and potentially into homes. Even when it is diluted by flood waters, raw sewage can be a breeding ground for harmful bacteria such as Escherichia coli (E-coli) and other disease-causing agents. Additionally, if the public water supply system loses pressure, a 'boil water order' may be issued to protect people and animals from drinking contaminated water following a flood.

Debris

Debris also poses a risk both during and after a flood. During a flood, large or dangerous debris (i.e., sharp objects) carried by floodwaters can cause physical injury from impact. During the recovery process, people may often need to clear debris out of their properties but may encounter dangers such as sharp materials or rusty nails that pose a risk of tetanus. People must be aware of these dangers prior to a flood so that they understand the risks and take necessary precautions before, during, and after a flood.

Environment

Flooding kills and displaces both domesticated and wild animals, and in general, disrupts the ecosystem and habitats in which they live. Potentially poisonous or dangerous insects and animals, such as spiders, snakes and alligators may also make their way to the flooded areas of an otherwise populated and developed neighborhood in hopes of finding food or safe refuge, posing a risk to humans and themselves.

Erosion

Floods can also cause significant erosion, which can alter streambanks and deposit sediment, changing the flow of streams and rivers and potentially reducing the drainage capacity of those waterbodies thereafter.

Property Damage and Loss

The cost and labor needed to repair flood-damaged homes severely strains communities, especially the unprepared and uninsured. For those living in flood-prone areas, the realization that severe weather events may again impact their home and family creates long-term fear and uncertainty about the future.

Property damage risks in Goose Creek include residential, commercial, and public buildings, as well as critical infrastructure such as transportation, water, energy, and communication systems, which may be damaged or destroyed by flood waters. Today, a total of 399 structures, including residential homes, businesses and other buildings, are located in SFHA zones (Zones A, AE and VE). See Figure 4 above.

Drought

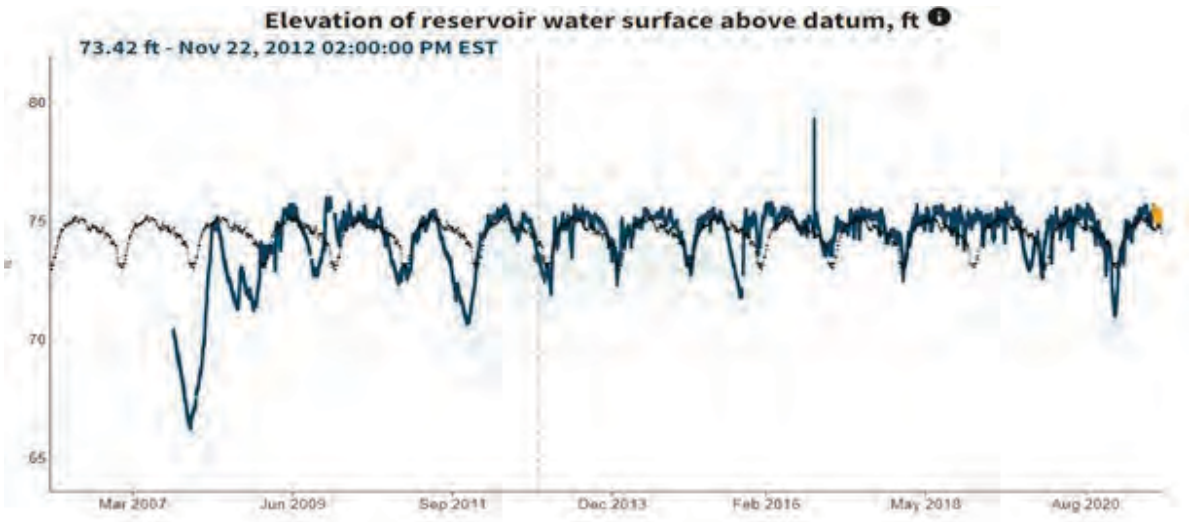
Drought is a deficiency in precipitation over an extended period. It is a normal, recurrent feature that occurs in virtually all climate zones, though the duration and extent of drought varies widely. Drought conditions can develop relatively quickly and last a short period of time, exacerbated by extreme heat and/or wind. Alternatively, droughts can span multiple years, or even decades. Drought classifications are detailed below in Table 4 below.

Table 4: Drought Classifications

LEVEL OF DROUGHT	DEFINITION
Normal	No threat of drought
Incipient	A threat of a drought as demonstrated by drought indices
Moderate	An increasing threat of a drought as demonstrated by drought indices
Severe	Drought has increased to severe levels as demonstrated by drought indices
Extreme	Drought has increased to extreme levels as demonstrated by drought indices

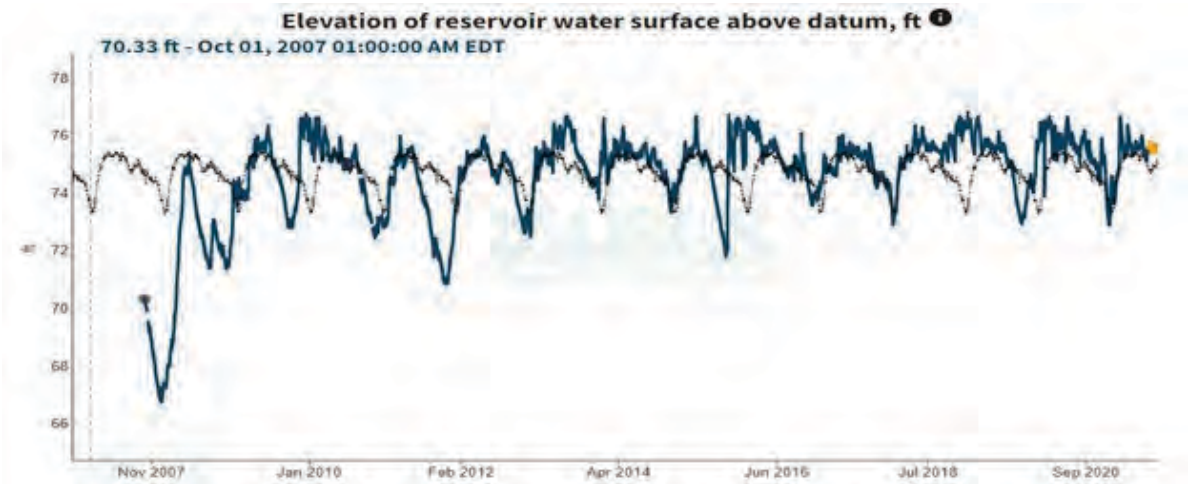
Drought events affect freshwater resources and can become a great threat to urban water supply systems, such as that in Goose Creek. Most water for the city is initially sourced from Lake Moultrie and Lake Marion. According to available USGS surface water monitoring data of Lake Moultrie (Figure 6X), water levels have remained fairly steady and generally within the median range of 73-75 feet, shown in black on the graph from 2007 to 2021.

Figure 6: Lake Moultrie Gauge Mean Height, 2007-2021



Lake Marion's gauge mean height (Figure 7) has shown more variability and periods of low water compared to its median range of 73-75 feet, particularly in December 2007 (66.75-feet), August 2008 (71.4-feet), November 2011 (70.9-feet), and September 2015 (71.9-feet).

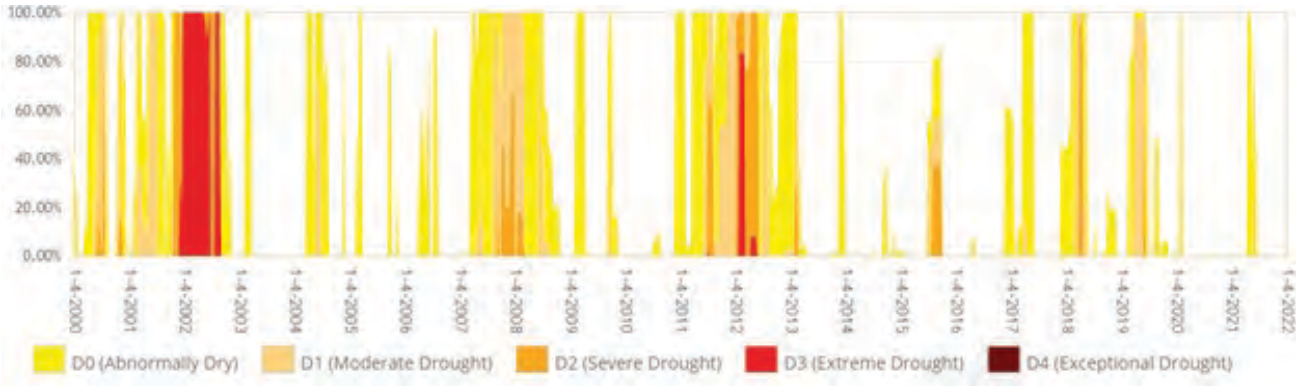
Figure 7: Lake Marion Gauge Mean Height, 2007-2021



Drought - Risk Assessment

According to the U.S. Drought Monitor[14] (USDM), over the past two decades (January 1, 2000 to July 1, 2021), Berkeley County has experienced three significant continuous dry periods, the first occurring from late 2000 to early 2003, next in early 2007 to early 2009, and most recently from early 2011 to early 2013. The drought level reached "extreme" through most of 2002, and again in early- to mid-2012. Since 2015, there have been many "abnormally dry" periods followed by periods of "moderate drought," and brief "severe drought" periods in mid- to late- 2015, early 2018, and early 2019. Figure 8 below from the USDM illustrates these drought periods in Berkeley County.

Figure 8: US Drought Monitor Chart for Berkeley County (2000 - 2022)



14. *https://www.drought.gov/data-maps-tools/us-drought-monitor (a collaboration of NOAA, U.S. Department of Agriculture and the National Drought Mitigation Center)*

According to the most recent National Climate Assessment in 2018[15], average and extreme temperatures are increasing across the country, and in the Southeast average annual precipitation is decreasing, meaning the average number of consecutively dry days is likely to increase. Additionally, if temperatures continue rising as projected, evaporation rates will simultaneously increase, resulting in decreased surface soil moisture levels. Overall, these indicators suggest that the number of days in dry and drought conditions will likely increase in frequency, intensity and duration in Goose Creek.

Drought - Potential Impacts

According to the National Drought Mitigation Center[16], drought conditions create negative economic, environmental and social impacts, as summarized in Table 5 below.

Table 5: Negative Impacts of Drought, NDMC

ECONOMIC IMPACTS	ENVIRONMENTAL IMPACTS	SOCIAL IMPACTS
Loss of crops	Loss or destruction of fish and wildlife habitat	Anxiety or depression about economic losses caused by drought
Loss of arable land	Lack of food and drinking water for wild animals	Health problems related to low water flows and poor water quality
Increased need to irrigate or drill new or deeper wells	Migration of wildlife	Health problems related to dust
Loss of hydroelectric power efficiency	Wind and water erosion of soils and poor soil quality	Loss of human life
Maritime difficulties navigating increasingly shallow waterbodies	Increased stress on endangered species or even extinction	Threat to public safety from an increased number of forest and range fires
Increased cost of food	Lower water levels in reservoirs, lakes, and ponds	Reduced incomes
Industry-specific economic hardship (tourism, maritime, etc.)	Loss of wetlands	Displacement and relocation of homes and families
	More wildfires	Fewer recreational activities

Hurricanes and Tropical Storms

Hurricanes and tropical storms are classified as cyclones and defined as any closed circulation developing around a low-pressure center in which the winds rotate counter-clockwise (in the northern hemisphere) and diameter averages 10 to 30 miles across. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation, and tornados. Wind impacts can affect the region uniformly, while storm surge impacts are more limited to the coast line and tidally influenced rivers and creeks.

Hurricane categories are classified on an intensity scale of 1 to 5, with 5 being the most intense. Table 6, on the following page, summarizes the hurricane categories, the type of damage expected per category, and the potential storm surge impacts to Goose Creek under each hurricane category.

15. *https://nca2018.globalchange.gov/*
16. *https://drought.unl.edu/Education/DroughtforKids/DroughtEffects.aspx*

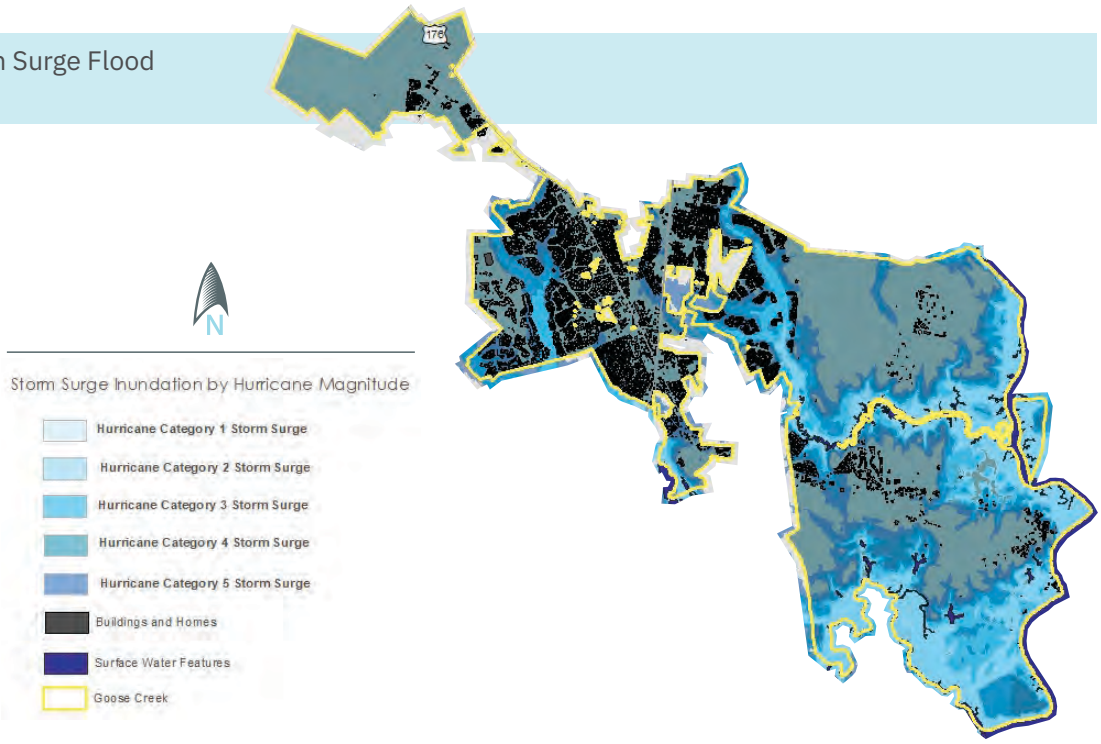
Table 6: Hurricanes - Expected Damage and Potential Impacts in Goose Creek

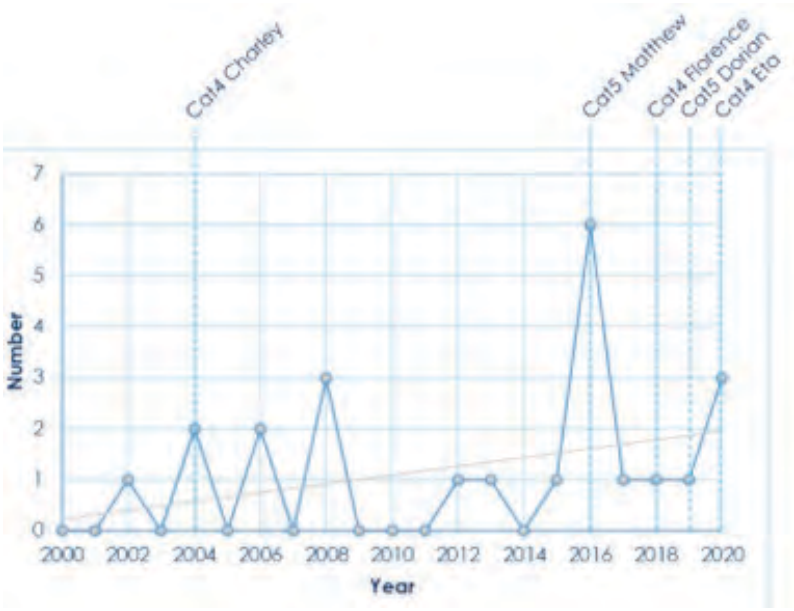
HURRICANE CATEGORY	EXPECTED DAMAGE	ACRES IN GOOSE CREEK POTENTIALLY IMPACTED BY STORM SURGE	% TOTAL LAND AREA POTENTIALLY IMPACTED BY STORM SURGE	TOTAL BUILDINGS SF POTENTIALLY IMPACTED BY STORM SURGE
1	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also, some coastal flooding and minor pier damage.	3,686-acres	14%	87,045-SF
2	Some roofing material, door, and window damage. Considerable damage to vegetation, mobile homes, etc. Flooding damages piers and small craft in unprotected moorings may break their moorings.	5,886-acres	22%	341,115-SF
3	Some structural damage to small residences and utility buildings, with a minor amount of curtainwall failures. Mobile homes are destroyed. Flooding near the coast destroys smaller structures, with larger structures damaged by floating debris. Terrain may be flooded well inland.	7,959-acres	30%	1,510,906-SF
4	More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Terrain may be flooded well inland.	9,885-acres	37%	3,672,432-SF
5	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Flooding causes major damage to lower floors of all structures near the shoreline. Massive evacuation of residential areas may be required.	12,250-acres	46%	8,292,604-SF

Map 6, on the following page, shows the estimated extent of storm surge waters that would reach Goose Creek city limits under each category of hurricane intensity (Category 1-5).

According to the Office of Coastal Resource Management's Tropical Cyclone Storm Segments data, which is a subset of the International Best Track Archive for Climate Stewardship (IBTrACS) dataset, 20 hurricanes or tropical storm have passed through or within 50 miles of the City of Goose Creek since 2000. In each year since 2015, the city has been impacted by one or more hurricanes or tropical storms. High intensity hurricanes, category 4 or 5, have also become more common in recent years, such as Hurricanes Matthew (Cat 5, 2016), Florence (Cat 4, 2018) and Dorian (Cat 5, 2019).

Map 6: Hurricane & Storm Surge Flood Impacts





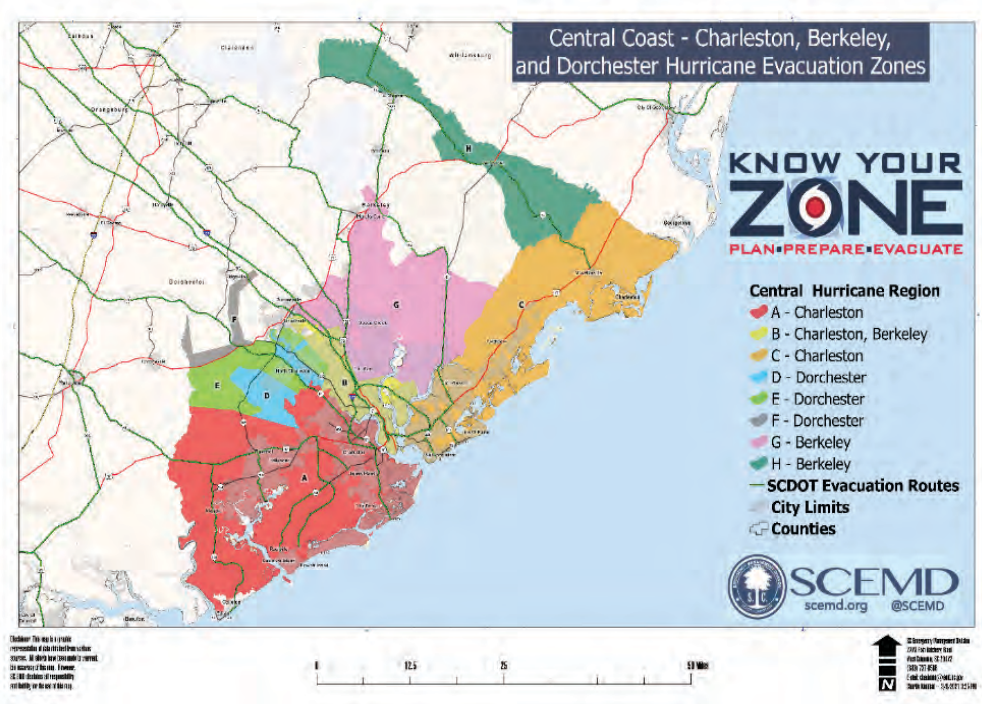
Hurricane and Tropical Storms - Risk Assessment

The extremely active 2020 Atlantic hurricane season closed last year with a record-breaking 31 total depressions, 30 total storms, 14 hurricanes and 7 major hurricanes (Category 3+). While the 2021 season is still on-going, thus far there have been 17 total depressions, 17 total storms, 6 hurricanes and 3 major hurricanes.

As illustrated in the South Carolina Emergency Management Division's (SCEMD) map, coastal South Carolina has eight designated hurricane evacuation zones and multiple SCDOT evacuation routes to enable the safe and timely movement of people during hurricane events. According to SCEMD, Goose Creek is located in Evacuation Zone G along with most of Berkeley County, and is part of the Central Coast Evacuation Region. Residents in Evacuation Zone G can use US 17A and US 176 as evacuation routes.

According to NOAA, weather extremes will likely cause more frequent, stronger storms in the future due to rising surface temperatures. NOAA models predict that while there may be less frequent, low-category storm events (Tropical Storms, Category 1 Hurricanes), there will also be more, high-category storm events (Category 4 and 5 Hurricanes) in the future. This means that there may be fewer hurricanes overall in any given year, but when hurricanes do form, it is more likely that they will become large storms that can cause massive damage.

Figure 9: SCEMD's 'Know Your Zone' Hurricane Evacuation Map



Hurricane and Tropical Storms - Potential Impacts

Hurricane and tropical storm damages are, by far, the costliest natural disasters in the US, costing $1,034.0 billion nationally and $10-$20 billion in South Carolina alone from 1980 to 2021. These storms are also the deadliest, resulting in the deaths of approximately 157 individuals per year[17].

The very young, elderly, economically disadvantaged and mobility-impaired individuals are particularly vulnerable to dangers posed by hurricanes, specifically, the challenges associated with evacuation prior to or during a storm. Stress from such disasters can result in immediate and long-term physical and emotional health problems.

General damages to property are both direct, meaning the physical damage caused by winds and rain, and indirect, meaning the additional costs, damages, and losses attributed to secondary hazards spurred by the hurricane or related hazards. Depending on the size and strength of the hurricane, associated winds are capable of damaging and eventually destroying almost anything. Construction practices and building codes can help maximize structures' resistance to damage.

Secondary impacts of damage due to hurricane winds often result from damage to infrastructure. Downed power and communications transmission lines coupled with disruptions to transportation create difficulties in reporting and responding to emergencies. These impacts of a hurricane put tremendous strain on a community.

17. *https://www.ncdc.noaa.gov/billions/summary-stats/US/1980-2021*

Earthquake

According to the U.S. Geological Survey, earthquakes[18] are "caused by a sudden slip on a fault. The tectonic plates are always slowly moving, but they get stuck at their edges due to friction. When the stress on the edge overcomes the friction, there is an earthquake that releases energy in waves that travel through the earth's crust," creating the shaking and movement felt in the ground.

Most earthquakes are caused by the release of stress or pressure accumulated as a result of the rupture of rocks along opposing fault planes in the Earth's outer crust. These fault planes are typically found along borders of the Earth's 10 tectonic plates. The areas of greatest tectonic instability occur at the perimeters of the slowly moving plates, as these locations are subjected to the greatest strains from plates traveling in opposite directions and at different speeds. Deformation along plate boundaries causes strain in the rock and the consequent buildup of stored energy. When the built-up stress exceeds the rocks' strength, a rupture occurs. The rock on both sides of the fracture is snapped, releasing the stored energy and producing seismic waves, generating an earthquake.

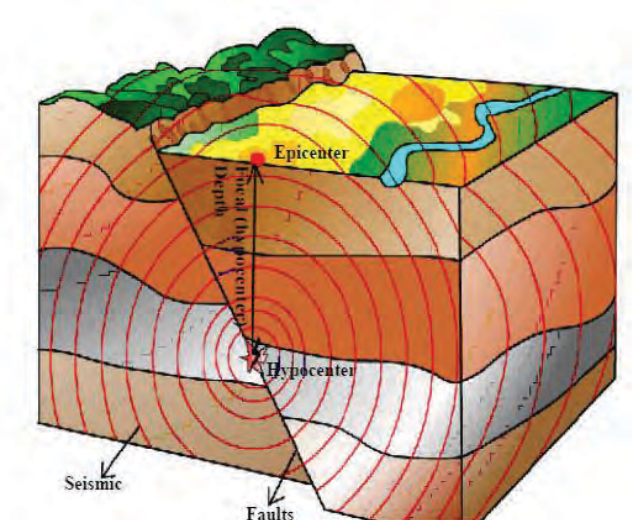


Image Source: Boston University

Earthquake - Risk Assessment

The type of seismic hazard in the tricounty region is classified as liquefaction, which is the process whereby the strength of the ground is removed by earthquake shaking. This shaking can cause the upper levels of soil to lose the ability to support structures. Strong and sustained ground motion can cause soil to act as a liquid and inflict added force on surface structures. The effect can be devastating, making liquefaction a major contributor to urban seismic risk.

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake through a measure of shock wave amplitude. A detailed description of the Richter Scale is given in Table 7.

Table 7: Richter Scale Classification System for Earthquakes

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

18. *https://www.usgs.gov/faqs/what-earthquake-and-what-causes-them-happen?qt-news_science_products=0#qt-news_science_products*

According to USGS' earthquake records, 44 earthquakes with a magnitude of 2.5 and greater have occurred in the general Tri-County Region since 1900. About 70% of all seismic activity occurs in the Middleton Place-Summerville seismic zone located on Goose Creek's western boundary. Specifically, three earthquakes with magnitudes of 2.5 and greater have been recorded within city limits: the 1959 earthquake with a 4.4 magnitude, the 1992 earthquake with a 4.1 magnitude on northern boundary of the city, and the 2004 earthquake with a 2.7 magnitude at the Naval Weapons Station.

As shown in the USGS' South Carolina Seismic Hazard Map, Figure 10, Goose Creek is located within the red zone, representing highest peak ground acceleration of greater than 80%. The South Carolina Geological Survey (SCGS) classifies Berkeley County as X (extreme) in terms of earthquake intensity, which is one of highest intensity levels in South Carolina.

Figure 10: USGS Seismic Hazard Map, South Carolina

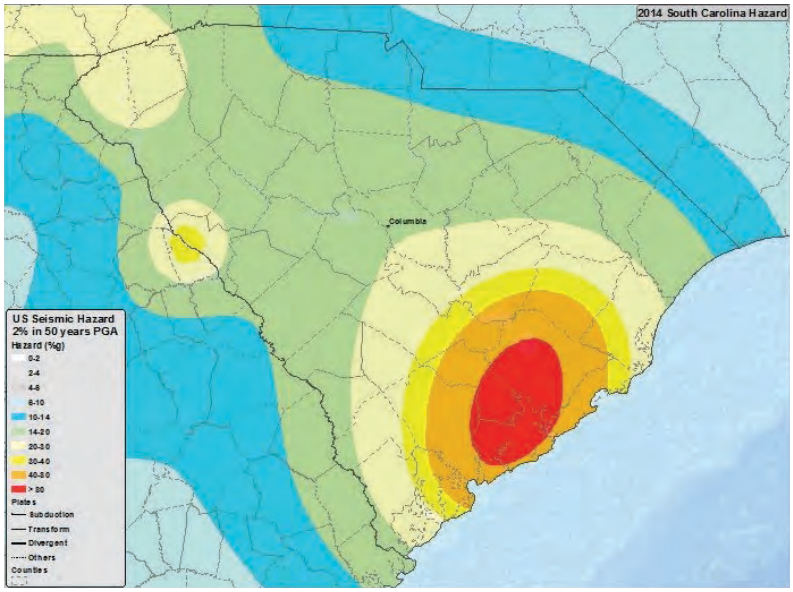


Figure 11: St. James's Church, Goose Creek, Taken After the 31st of August, 1886

Earthquake - Potential Impacts

The potential for buildings to collapse and trap people under debris and rubble as well as objects falling from shelves generally pose the greatest threats to human safety. Earthquake events in Goose Creek can produce severe ground shaking; therefore, injury or death may occur with earthquakes of magnitude 5 or higher. The greatest historic earthquake in the region remains the 1886 Charleston earthquake with a recorded 7.0 magnitude. During this historic event, over 100 people died and many more were injured. The estimated cost of destruction and loss was $5–6 million at the time, or $158.42 million in 2020 dollars[19]. The St. James's Church at Goose Creek was damaged during the 1886 Charleston earthquake, as pictured above.

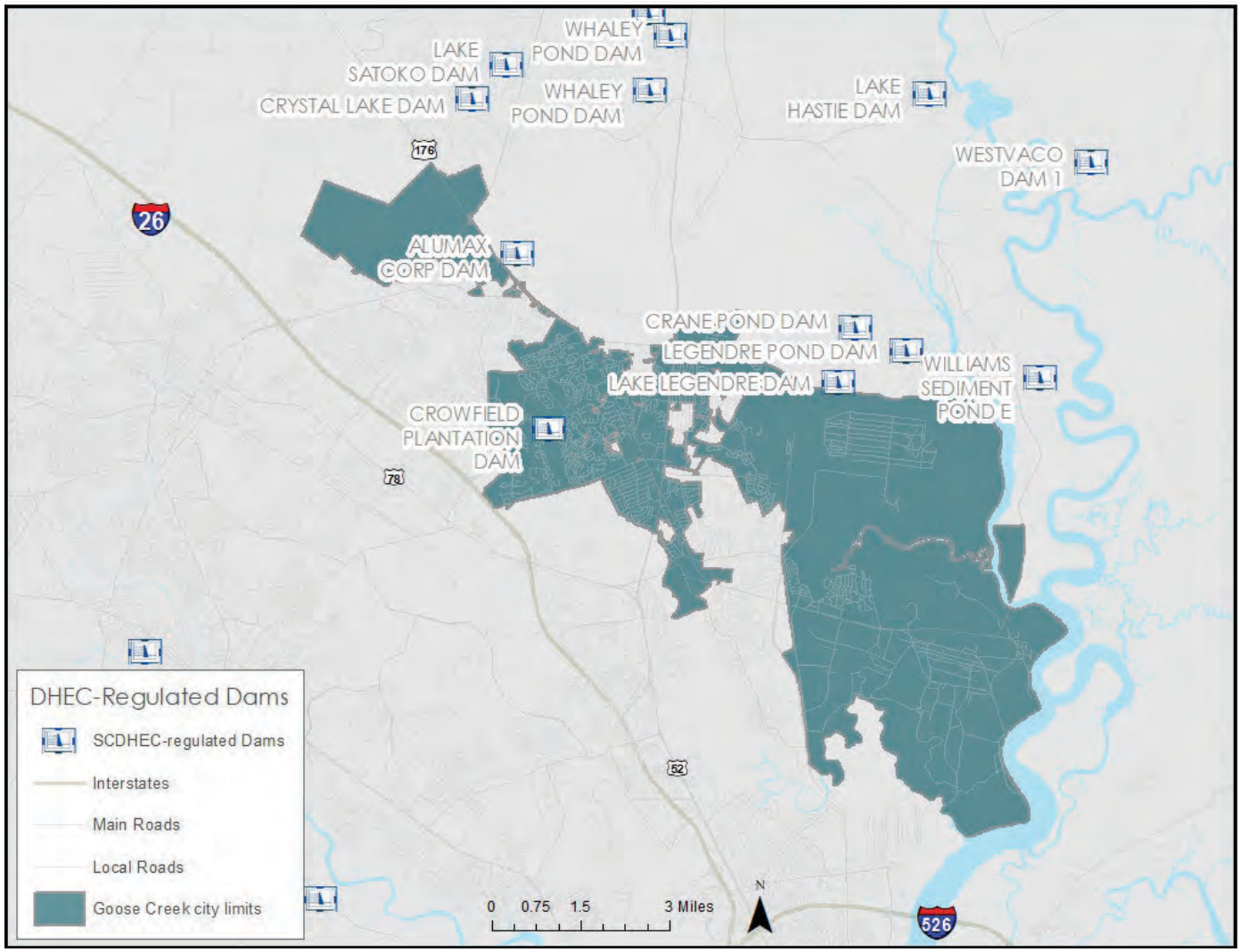
19. *G. A. Bollinger, Historical and recent seismic activity in South Carolina, Bulletin of the Seismological Society of America (1972) 62 (3): 851–864*

According to the USGS, a correlation has been noted between earthquakes and weather – namely, that large changes in atmospheric pressure caused by major storms like hurricanes have been shown to occasionally trigger something known as “slow earthquakes.” This type of earthquake releases energy slowly over comparatively long periods of time, rather than abruptly, and does not create the ground shaking effects.

Dam Failure

Dams are engineered structures designed to retain water and raise the water level to create a reservoir, often to generate electricity or for drinking water. Lake Marion and Lake Moultrie serve both of these purposes for the region. Dam failure can occur when there is a structural failure or deficiency leading to an uncontrolled release of water. This can happen as a result of upstream or localized flooding and heavy rains, erosion of surrounding sediments, or damage from an earthquake or hurricane. The primary danger associated with a dam failure is unpredictable flooding of the region directly downstream by dangerously fast-moving waters.

Map 7: SCDHEC-Regulated Dams Near Goose Creek



Dam Failure – Risk Assessment

There are more than 2,300 regulated dams in South Carolina, including the four dams on Lake Moultrie in Berkeley County, approximately 10-miles from Goose Creek, and Lake Marion, the southeastern edge of which abuts the county line and lies approximately 25-miles from Goose Creek. Regulated dams are routinely inspected for safety by the South Carolina Department of Health and Environmental Control (DHEC). Dam hazard classifications have three categories: High-hazard (C1), where failure will likely cause loss of life or serious damage to infrastructure; Significant-hazard (C2), where failure will not likely cause loss of life but may damage infrastructure; and Low-hazard (C3), where failure may cause limited property damage. There is also an S1 classification that indicates a dam does not meet the size criteria to be classified as C1, C2, or C3, but is still deemed a highly significant structure due to potential downstream effects in the event of a failure. DHEC issues all permits for new dams, maintains safety programs, alert systems, and provides dam owner education for regulated dams. However, there are an estimated 20,000 unregulated dams in South Carolina built by private land owners that may or may not be maintained.

Dam Failure – Potential Impacts

There are an estimated 28 regulated dams in Berkeley County, 7 of which are within 1-mile of Goose Creek, as depicted in Map 7, see previous page. There are no historical incidents of dam failures in Berkeley County, even with a 1,000-year flooding event in October 2015; therefore, severity and magnitude have not been calculated as the risk of dam failure is not considered major. However, if dam failure were to occur in the future downstream regions would be at high risk of loss of life, significant injuries including drownings, significant or catastrophic property damage, and devastating effects on water supply and power generation[20].

Hazardous Materials

Hazardous materials come in many forms and can result in a wide variety of injuries or health problems if improperly treated, released, stored, or transported. Facilities that generate, store or use these materials are located throughout the state, but many are located in the Lowcountry where they are exposed to flood, earthquake, or hurricane hazards.

Facilities that generate or store hazardous materials are required to register with the U.S. Environmental Protection Agency (EPA) as a safety monitoring mechanism. Common types of facilities that store or generate hazardous materials include: Municipal Solid Waste Landfills (MSW), Hazardous Waste Generators (HAZGEN), and Radiological Waste Generators (RAD). Areas where hazardous materials were previously spilled or released into the ground or water and are now monitored include: Toxic Release Inventory Sites (TRI), Treatment, Storage and Disposal Sites (TSD) and Superfund Sites.

“Superfund sites” are the result of the 1980 Congressional Act known as the ‘Comprehensive Environmental Response, Compensation and Liability Act’ or CERCLA, which established the concept of superfund sites and the EPA’s ability to oversee them. Once a site has been designated as a Superfund, the EPA can facilitate remediation efforts. The EPA monitors and continually updates the National Priorities List (NPL) of the nation’s most hazardous sites for prioritizing future remediation activities. Another option for site remediation is the Superfund Alternative Approach (SAA), which can save time and reduce costs associated with NPL listing, but uses the same investigative and cleanup process and standards as the NPL.

20. http://www.cvcog.org/cvcog/docs/hmap/10.damfailure.v4.public.pdf

Hazardous materials also travel along a region's major transportation networks and are susceptible to accidental release along these routes. Major roads in Berkeley County include Interstates 26 and 526, U.S. Highways 17A, 52, and 176, and S.C. Highways 6, 27, 41, 45, 311, and 402. Two major CSX rail lines run through the southerly portion of Berkeley County, one parallel to U.S. Highway 52. Numerous shorter lines connect to industrial areas in the Goose Creek area and north of Lake Moultrie. Map 8 below depicts the major rail and roadway transportation routes.

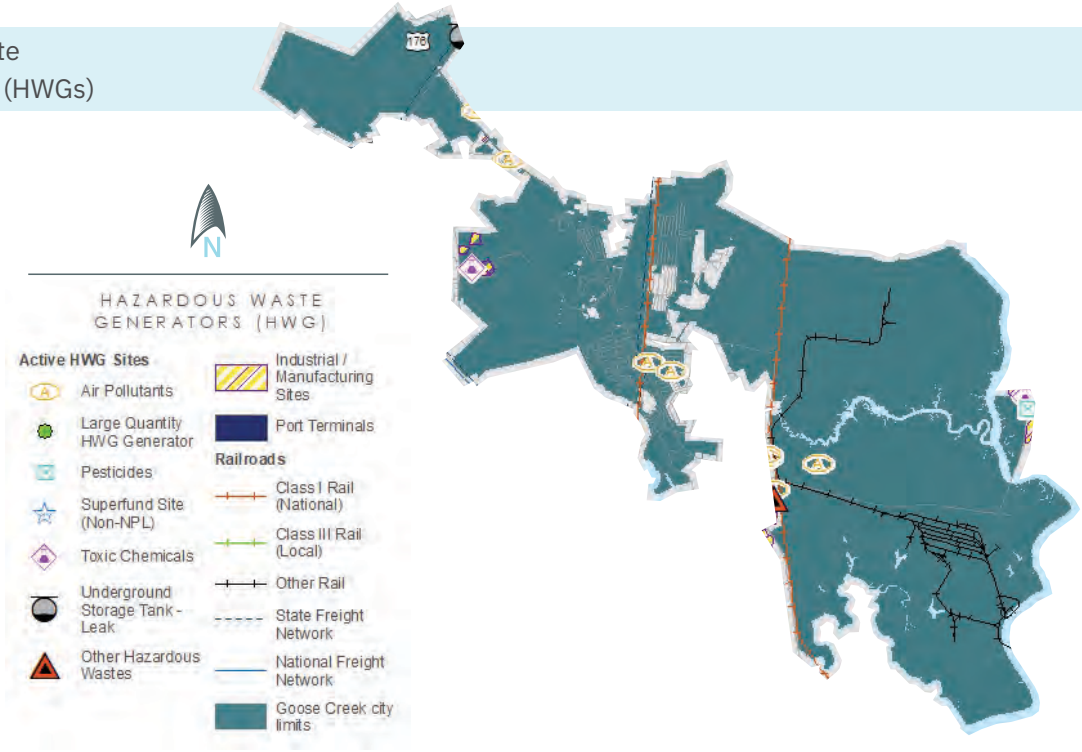
The USDOT classifies hazardous materials into nine types and provides specific emergency response guidelines for first responders[21] for each due to their respective inherent dangers. The nine classes are:

- Class 1 – Explosives
- Class 2 – Gasses
- Class 3 – Flammable and/or combustible liquids
- Class 4 – Flammable and/or combustible solids and related
- Class 5 – Oxidizing substances and organic peroxides
- Class 6 – Toxic, poisonous and/or infections substances
- Class 7 – Radioactive materials
- Class 8 – Corrosive substances
- Class 9 – Miscellaneous dangerous goods/hazardous materials and articles

Hazardous Materials Release – Risk Assessment

The majority of HAZGEN and TRI facilities in Berkeley County are concentrated around Goose Creek, Hanahan and Moncks Corner, also shown in Map 8.

Map 8: Hazardous Waste Generator Sites (HWGs)



21. *The Guidebook is available here: https://www.iafc.org/topics-and-tools/hazmat/fusion-center/hfc-resource-detail-alt87/emergency-response-guidebook-erg*

Two RAD facilities are also in the Goose Creek vicinity - one is located off I-26 in Summerville and the other is located at the Charleston Naval Weapons Station. Most of the TSD sites are also within the limits of the Charleston Naval Weapons Station.

According to the EPA's database, there are twelve Superfund Sites in Berkeley County. Two sites are in Goose Creek, known as the "Rut Road Site" (SC0001097955) and the "Sea Galley Club/Galley Hall Site" (SCD987566452), but both sites are "archived," meaning the EPA has determined that assessment has been completed and no further remedial action is planned under the Superfund program. Three others sites are in the near vicinity, in Hanahan (archived), Ladson (archived), and Summerville (active, not on the NPL or SAA list).

Hazardous Materials Release – Potential Impacts

A spill or release from a truck or train accident could happen anywhere these materials are generated, stored or transported in Berkeley County. The impact of a release from a train accident is confined primarily to the rail corridor, but is highly dependent on the type of material released, specifically, whether the transported material is explosive, combustible, radioactive, or corrosive, or in liquid, gas or solid form, among other factors. Map 8, on the previous page, includes a one-half mile buffer along the rail lines that can be considered the primary hazard area for a train-borne hazardous material release.

Approximately twelve hazardous materials incidents occurred in Berkeley County since 2015. Of these, seven were chemical spills, two were gas leaks, two were drug-related and one was a failed bombing attempt.

Numerous sites and objects could potentially release hazardous materials into the environment, such as a catchment basin or fuel leak at a gasoline station, propane or butane tank failures, or a leak in an aboveground (oil) storage tank. Many of these materials exist and move throughout the city, county and region. The severity and magnitude from hazardous materials exposures and incidents cannot be clearly or easily calculated due to the numerous factors associated.

Wildfire

A wildfire is an uncontained fire that spreads through the environment, damaging or destroying forests, fields, buildings, homes, and sometimes entire communities. Wildfires have the ability to consume and destroy large areas, including infrastructure, property, and natural resources. When massive fires, or conflagrations, develop near populated areas, mandatory evacuations may be ordered to protect neighborhoods and communities. Not only do the flames impact the environment, but the massive volumes of smoke spread by certain atmospheric conditions also impact health and air quality conditions of downwind populations. There are three general types of fire spread[22] that are recognized:

1. *Ground fire burns organic matter in the soil beneath surface litter and are sustained by glowing combustion.*
2. *Surface fire spreads with a flaming front and burn leaf litter, fallen branches and other fuels located at ground level.*
3. *Crown fire burns through the top layer of foliage on a tree, known as the canopy. Crown fires are the most intense type of fire and often the most difficult to contain.*

22. *https://www.nps.gov/articles/wildland-fire-spread-and-suppression.htm*

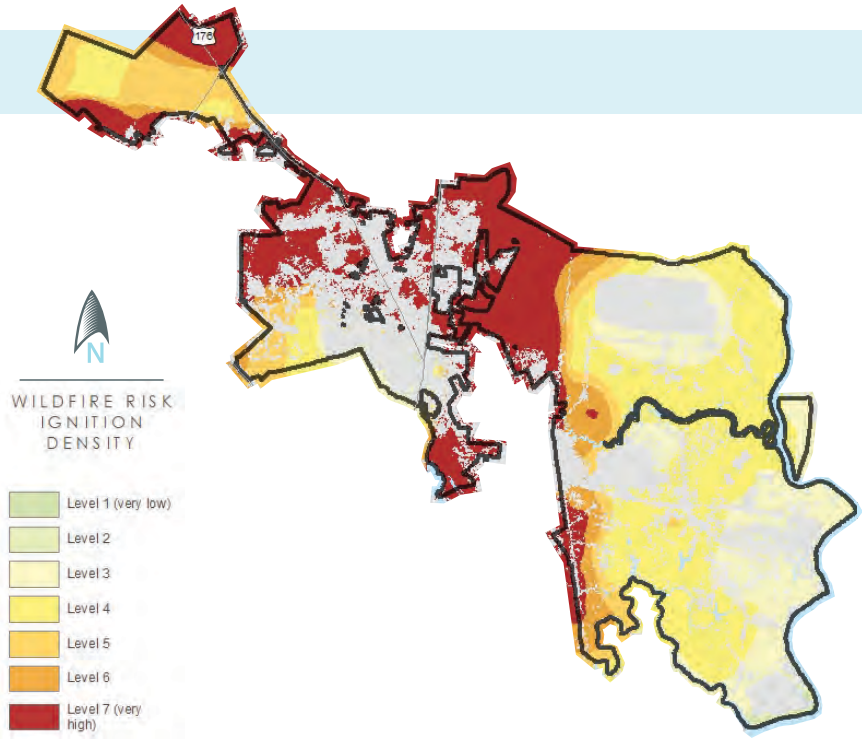
Wildfire risk is measured and quantified by the acreage of Wildland-Urban Interface (WUI), or the amount of land area where housing and development meet and coincide with wildland vegetation. This area presents the most pronounced wildfire risk due to the presence of homes and human development existing alongside flammable natural vegetation. The expansion of residential development from urban centers out into rural landscapes increases the potential of wildland fires to threaten public safety. Population growth within the WUI substantially increases the risk of wildfire and the level of damage that can ensue, in terms of loss of life and property.

Wildfire - Risk Assessment

Overall, the City of Goose Creek is deemed to be at "low" risk for wildfires[23], according to data and various risk assessments performed by the Southern Group of State Foresters (SGSF). Approximately 35% of the city falls within moderate to higher risk WUI categories (≥ Level 3), with a population exposure of approximately 36,210 individuals in these areas.

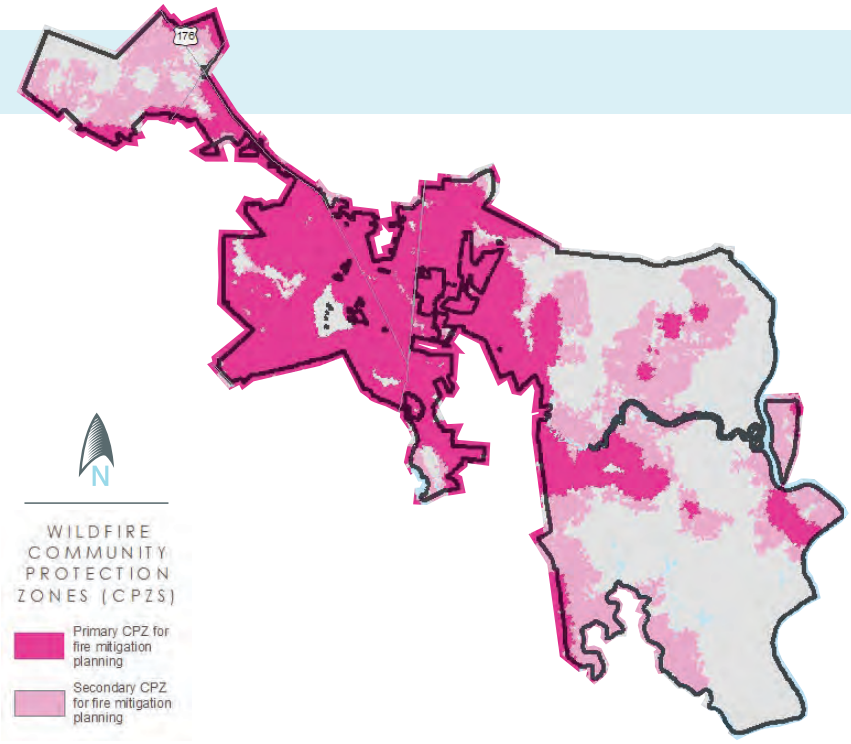
To aid communities' efforts to determine more localized risk levels and plan accordingly, the SGSF used housing density data alongside fire behavior potential, WUI risk, presence of various fuel types, rate of spread, and fire intensity data to identify high priority areas for mitigation planning activities at a local level. As a result, the SGSF has mapped 'Community Protection Zones' (CPZs), classified as either primary and secondary CPZs, to identify areas considered high priority for mitigation planning activities, as shown in Figure 10, see following page. These CPZ areas are considered high priority (either primary or secondary) due to their intersection with, or proximity to, the wildland-urban interface and other fire risks.

Map 9: Wildfire Risk – Ignition Density in Lowcountry, SC



23. *https://www.southernwildfirerisk.com/Map/Public/#whats-your-risk*

Map 10: Wildfire Community Protection Zones (CPZs)



Wildfire - Potential Impacts

Wildfire can cause or exacerbate a variety of health hazards[24], including burns, eye and respiratory tract irritation, bronchitis, asthma, heart failure and premature death, according to the US Environmental Protection Agency. Wildfires also have negative impacts on the natural environment, resulting in habitat devastation, and the loss of wildlife, vegetation, and other natural resources.

Beyond human health hazards, wildfires can further cause direct property losses, including damage to buildings, vehicles, landscaped areas, agricultural lands, and livestock. Construction practices and building codes can increase fire resistance and fire safety of structures. Techniques for reducing vulnerability to wildfire include using street design to ensure accessibility for fire trucks and emergency services, incorporating fire resistant materials in building construction, and using landscaping practices to reduce flammability and the ability of fire to spread.

Tornado

The Glossary of Meteorology (AMS 2000) defines a tornado as "a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud." Tornadoes can appear from any direction and typically move from southwest to northeast, or west to east, though some tornadoes have changed direction amid path, or even backtracked, making them unpredictable and dangerous. Tornadoes can produce winds in excess of 200 mph and can be very expansive – some in the Great Plains have exceeded two miles in width. Tornadoes associated with tropical cyclones, however, such as those more likely to occur in the southeast United States, tend to be of lower intensity and smaller in width than those formed in the Great Plains.

24. https://www.epa.gov/air-research/wildland-fire-research-health-effects-research

Previously, the Fujita Scale, or F-Scale, was used to predict and describe the intensity and scale of a tornado that was building or on the ground, but ultimately led to data discrepancies and variability in what was predicted versus what actually occurred. In response, the EF-Scale was developed[25] in 2007 to further refine tornado wind-force classifications that commenced under the F-Scale. The EF Scale is used following a tornado event to rate and classify how strong the tornado was based on surveying the damage that ensued and comparing findings with a list of 'Damage Indicators' (DI's) and 'Degrees of Damage' (DoD's). This method leads to more precise estimates of wind speed ranges the tornado likely produced[26]. Table 8 below details the original F-Scale and EF-Scale measurement systems.

Table 8: Fujita and Enhanced Fujita Scale Classification System for Tornadoes

FUJITA SCALE (F-SCALE)	CHARACTER	EST. 3-SECOND GUST WIND SPEED	F-SCALE DESCRIPTION	ENHANCED FUJITA SCALE (EF-SCALE)	EST. 3-SECOND GUST WIND SPEED
Zero (F0)	Weak	45-78 mph	**Light Damage.** Some damage to chimneys; branches broken off trees, shallow-rooted trees uprooted, sign boards damaged.	**Zero (EF0)**	65-85 mph
One (F1)	Weak	79-117 mph	**Moderate damage.** Roof surfaces peeled off; mobile homes pushed foundations or overturned; moving autos pushed off road.	**One (EF1)**	86-110 mph
Two (F2)	Strong	118-161 mph	**Considerable damage.** Roofs torn from frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light objects become projectiles.	**Two (EF2)**	111-135 mph
Three (F3)	Strong	162-209 mph	**Severe damage.** Roofs and some walls torn from well- constructed houses; trains overturned; most trees in forested area uprooted; heavy cars lifted and thrown.	**Three (EF3)**	136-165 mph
Four (F4)	Violent	210-261 mph	**Devastating damage.** Well-constructed houses leveled; structures with weak foundation blown some distance; cars thrown; large missiles generated.	**Four (EF4)**	166-200 mph
Five (F5)	Violent	262-317 mph	**Incredible damage.** Strong frame houses lifted off foundations, carried considerable distances, and disintegrated; auto-sized missiles airborne for several hundred feet or more; trees debarked.	**Five (EF5)**	Over 200 mph

25. *https://www.weather.gov/phi/TornadoDefinition*
26. *https://www.weather.gov/oun/efscale*

Tornado - Risk Assessment

According to NCEI, South Carolina has averaged about 27 tornadoes per year in the period from 1991 to 2010[27]. Goose Greek has experienced only one (1) tornado incident since the 1950s, which occurred in May 1998 and passed along the city's southwest boundary. The F2 tornado caused injuries to seven individuals and one fatality; the estimated property damage was $50,000 to $500,000.

Most tornadoes occur alongside a thunderstorm, and thunderstorms typically gain strength from solar and latent heat sources, thus, most thunderstorms and tornadoes occur in the afternoon and evening hours when these energy sources peak. They can also occur throughout the year. The frequency of tornadoes in the United States is closely tied with the progression of the warm season when warm and cold air masses often clash, creating severe storms. For the southeast, this period typically occurs from April through September, with very few tornadoes occurring in cooler winter months.

Tornadoes can occur whenever and wherever conditions are right – specifically, warm, humid air colliding with cold, dry air and creating an updraft - therefore, whenever these weather conditions are present, tornadoes can form. However, this particular type of storm is more common in other parts of the country, and less so near the eastern seaboard.

Tornado - Potential Impacts

Wind speeds from tornadoes can reach up to 300+ mph and travel anywhere from 10-20 mph or upward of 60 mph[28]. NOAA's National Severe Storms Laboratory states that "wind speeds that high can cause automobiles to become airborne, rip ordinary homes to shreds, and turn broken glass and other debris into lethal missiles. The biggest threat to living creatures (including humans) from tornadoes is from flying debris and from being tossed about in the wind."

Seasonal Weather Extremes

In the summer months, the primary concern for the Goose Creek area is extreme heat, which is defined by FEMA as 'a long period (2 to 3 days) of high heat and humidity with temperatures above 90 degrees' for most of the continental United States, including the southeast. Emergency Management Departments often consider heat to be 'extreme' when temperatures hover at 10°F or above the average high regional temperature and last for several weeks.

Image Source: Go Smart Bricks

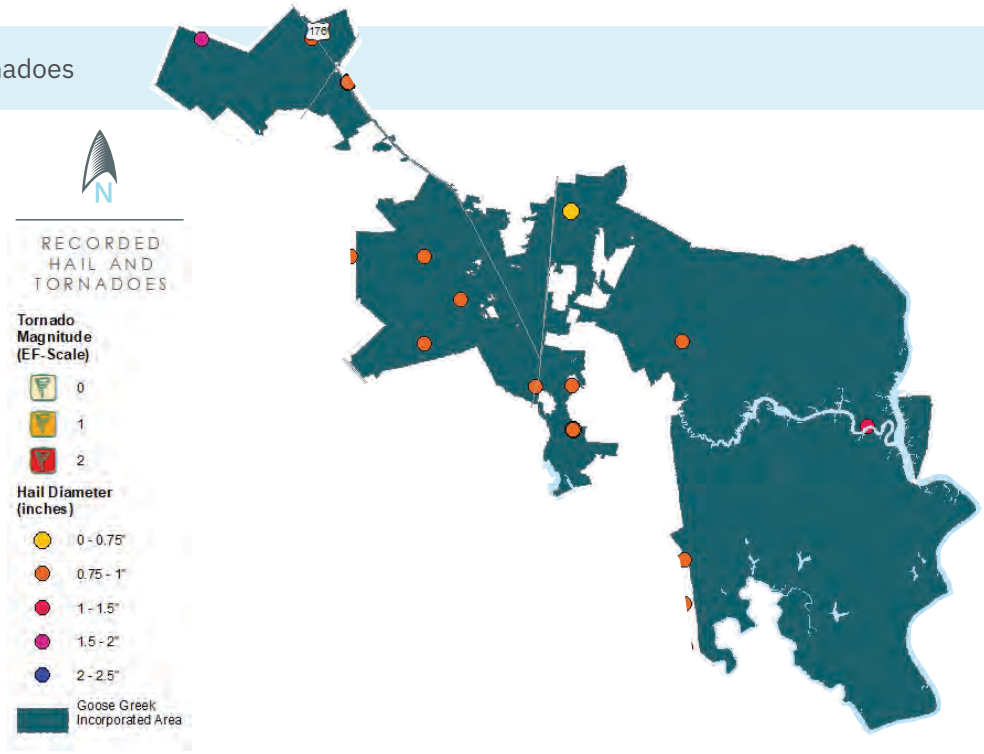
In developed urban areas, temperatures can peak 15°F to 20°F hotter than the outlying suburban and rural areas due to a phenomenon known as the 'urban heat island effect[29],' whereby pavement, buildings, and other surfaces absorb and retain heat to a greater degree than natural land cover areas. People living in these areas are at higher risk of experiencing adverse impacts related to extreme temperatures.

27. *https://www.ncdc.noaa.gov/sites/default/files/Average-Annual-Number-of-Tornadoes-United-States-Map.png*
28. *https://www.nssl.noaa.gov/education/svrwx101/tornadoes/faq/*
29. *https://www.epa.gov/green-infrastructure/reduce-urban-heat-island-effect*

The Charleston area was recently selected by NOAA and the CDC to participate in 'HeatWatch 2021[30]', which is a community-assisted campaign to identify urban heat islands throughout a region to create detailed thermal mapping. In turn, this information will assist community leaders and government in identifying populations and assets that are most vulnerable and at risk of extreme heat conditions.

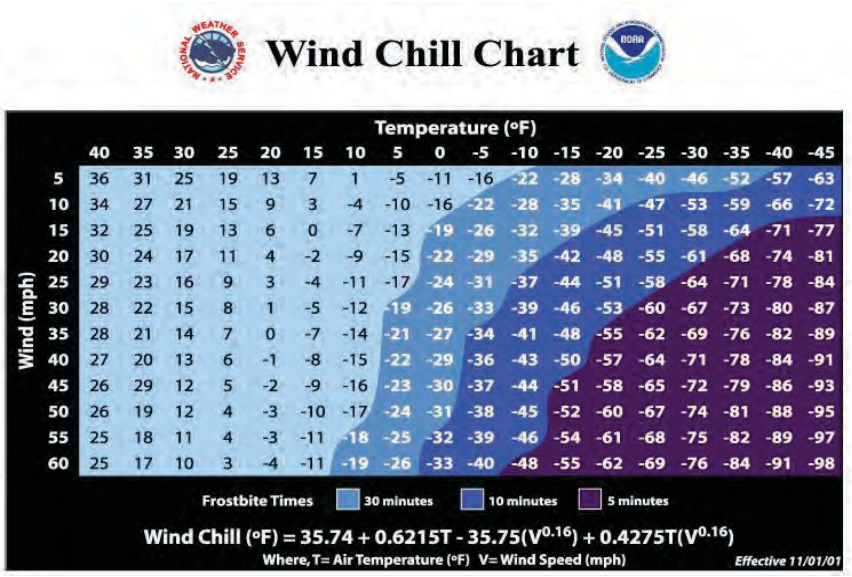
Storms producing hail are most likely to occur during the warm summer months in the southeast. According to NOAA, hail is precipitation that is formed when updrafts in thunderstorms carry raindrops upward into extremely cold areas of the atmosphere causing them to freeze. The raindrops form into small frozen droplets and then continue to grow as they come into contact with super-cooled water which will freeze on contact with the frozen rain droplet. This frozen rain droplet can continue to grow and form hail. As long as the updraft forces can support or suspend the weight of the hailstone, hail can continue to grow, typically ranging anywhere from 0 to 3 inches in diameter.

Map 11: Recorded Hail and Tornadoes



In the winter months, the primary extreme weather concern is winter storms that can involve a mix of hazardous weather conditions. Winter storms in the southeast can range from a moderate snow over a period of a few hours to potential blizzard conditions with blinding wind-driven snow lasting for several hours or even days, such as the snowstorms and blizzards of 1800, 1973, and 2018. In addition to low temperatures and wind chill, these storms can deliver any mixture of precipitation including snow, sleet, and freezing rain. The magnitude of a winter storm or event is characterized by the severity of each of the involved factors, including precipitation type, precipitation accumulation levels, temperature, and windchill. Tools that have been developed to measure these extremes include NOAA's Regional Snowfall Index (RSI) and the National Weather Service's Windchill Chart.

30. *https://www.charleston-sc.gov/2513/HeatWatch-Charleston-2021*



Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	29	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Figure 12: NWS Wind Chill Chart

Image Source: NOAA and NWS

Winter storms producing a significant snow accumulation may be analyzed using NOAA's Regional Snowfall Index (RSI), which provides a regional characterization and ranking of high-impact snowstorms for six defined regions in the eastern extent of the country. A storm's RSI value "is based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of these elements with population. Including population information ties the index to societal impacts."

When cold temperatures and high winds combine, the resulting air temperature can feel significantly colder to humans than the air temperature alone might dictate, creating dangerously cold conditions for people and animals. For this reason, the National Weather Service (NWS) also discusses 'windchill' to better convey the dangers of the extremes of cold temperatures and wind. The NWS' Windchill Chart illustrates the temperature experienced by humans at air temperatures ranging from 40°F to -45°F as combined with wind speeds ranging from 5 mph to 60 mph, and the amount of time it would take in those conditions for frostbite to occur. For example, when the outdoor real air temperature is at 0°F and wind gusts are at 15 mph, the temperature would feel like -19°F to humans. In these conditions, exposed skin can freeze in 30 minutes and result in frostbite.

Seasonal Weather Extremes - Risk Assessment

Figure 13, on following page, displays NOAA's National Centers for Environmental Information[31] time series data for average annual temperature and precipitation measures, spanning from 1895 through present day. The mean annual temperature in the time period from 1895 to 2021 is 64.3 degrees Fahrenheit. The lowest annual average temperatures over this time period occurred primarily during the mid-20th century and late-19th century in 1958, 1940, 1963, 1969 and 1895, while the highest annual average temperatures primarily occurred over the past five years, or recent decades, in 2017, 2019, 2020, 2016 and 1990. This chart illustrates a trend toward a rising annual average temperature in the county, trending toward 2-3°F above historic average temperatures.

31. *Climate at a Glance: County Time Series, published September 2021, retrieved on September 14, 2021 from https://www.ncdc.noaa.gov/cag/*

Figure 13: NOAA's NCEI Time Series - Berkeley County, SC Average Temperature Records (1895 - 2021)

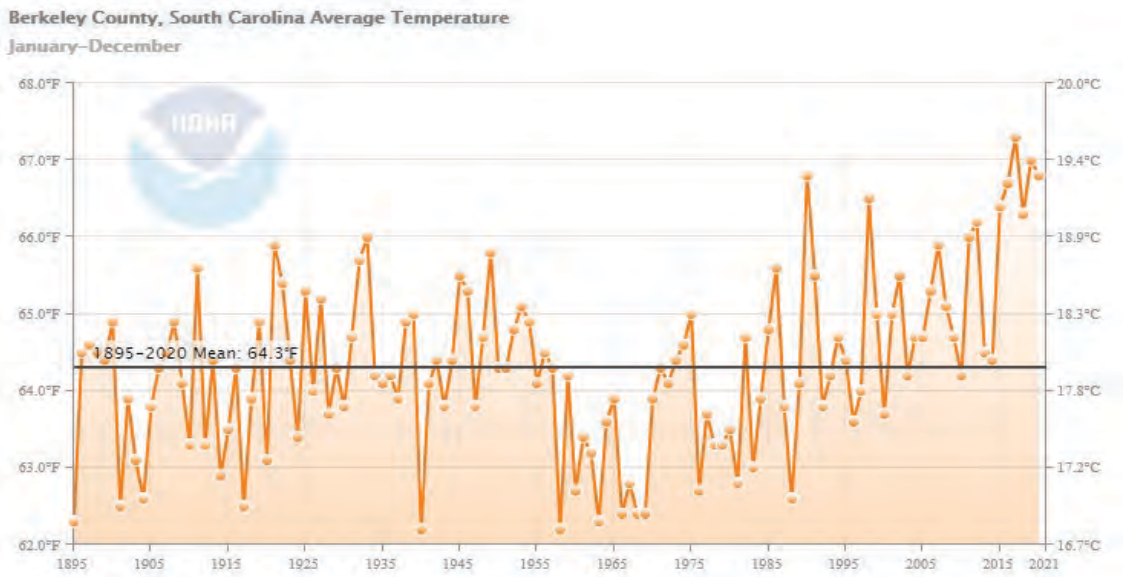


Image Source: NOAA

The mean annual precipitation in the period between 1895 to 2021 is 48.65 inches. The lowest annual precipitation levels recorded in this time occurred in 1954, 1931, 2001, 1951, and 2011, and ranged from 28.03" to 35.39" (or, a departure of -20.62" to -13.26" from the mean). The highest annual precipitation levels recorded in this time occurred in 1964, 2015, 1959, 1994, and 1971, and ranged from 63.10" to 70.93" (or, a departure of +14.45" to +22.28" from the mean). Table9 below summarizes average annual temperature, annual precipitation levels (in inches) and their perspective percent changes.

Table 9: Berkeley County Average Annual Temperature and Precipitation Levels

TIME PERIOD	AVERAGE ANNUAL TEMPERATURE	PERCENT CHANGE	ANNUAL PRECIPITATION	PERCENT CHANGE
1895-1905	63.7°F	-	47.99"	-
1905-1915	64.1°F	0.6%	48.53"	1.1%
1915-1925	64.2°F	0.2%	49.08"	1.1%
1925-1935	64.6°F	0.6%	43.81"	-10.7%
1935-1945	64.2°F	-0.6%	46.5"	6.1%
1945-1955	64.8°F	0.9%	46.96"	1.0%
1955-1965	63.5°F	-2.0%	51.92"	10.6%
1965-1975	63.7°F	0.3%	50.91"	-1.9%
1975-1985	63.7°F	0.0%	48.17"	-5.4%
1985-1995	64.6°F	1.4%	50.8"	5.5%
1995-2005	64.7°F	0.2%	49.36"	-2.8%
2005-2015	65.2°F	0.8%	48.37"	-2.0%
2015-2020	66.8°F	1.2%	55.85"	7.7%

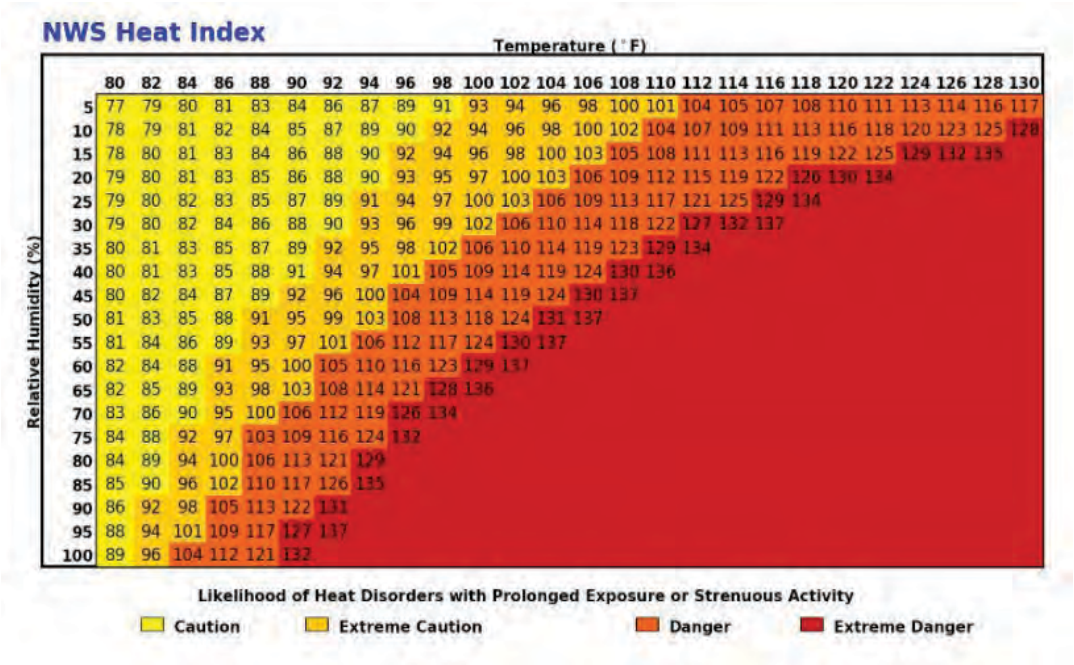
Together, these time series charts and table displaying historic data for the past 126 years indicate a general trend toward a rising average annual temperature, which increased from 63.7°F to 66.8°F, or 3.1°F over the summarized time periods, and increasing precipitation, which rose from 47.99" to 55.85," or 7.86" over the same time periods. This general conclusion is further supported in the Fourth National Climate Assessment, which states that "extreme temperatures are projected to increase even more than average temperatures. Cold waves are projected to become less intense and heat waves more intense."

Seasonal Weather Extremes - Potential Impacts

Prolonged exposure to extreme heat poses dangers to humans and animals because the body is forced to work harder to maintain a normal internal temperature. This can lead to heat-related illnesses[32] such as heat exhaustion, heat stroke, and induce cardiovascular and respiratory distress; these exposures can be fatal. Much like wind chill, the combined effects of air temperature and humidity create a perceived temperature for humans that can vary greatly from the air temperature measure alone, known as Heat Index. As relative humidity levels (%) rise, the Heat Index rises dramatically.

The National Weather Service's Heat Index Chart, Figure 14, illustrates how the combined effects of humidity and air temperature are perceived among humans as measured by Heat Index temperature, and further shows the likelihood of heat-related illnesses occurring with prolonged exposure or strenuous activity. For example, an outdoor air temperature of 86°F and relative humidity of 85% (a typical summer day), the Heat Index would be equivalent to 102°F, a measure that balances between 'Extreme Caution' and 'Danger' on the NWS Heat Index scale for potential for heat disorders.

Figure 14: NWS Heat Index Chart

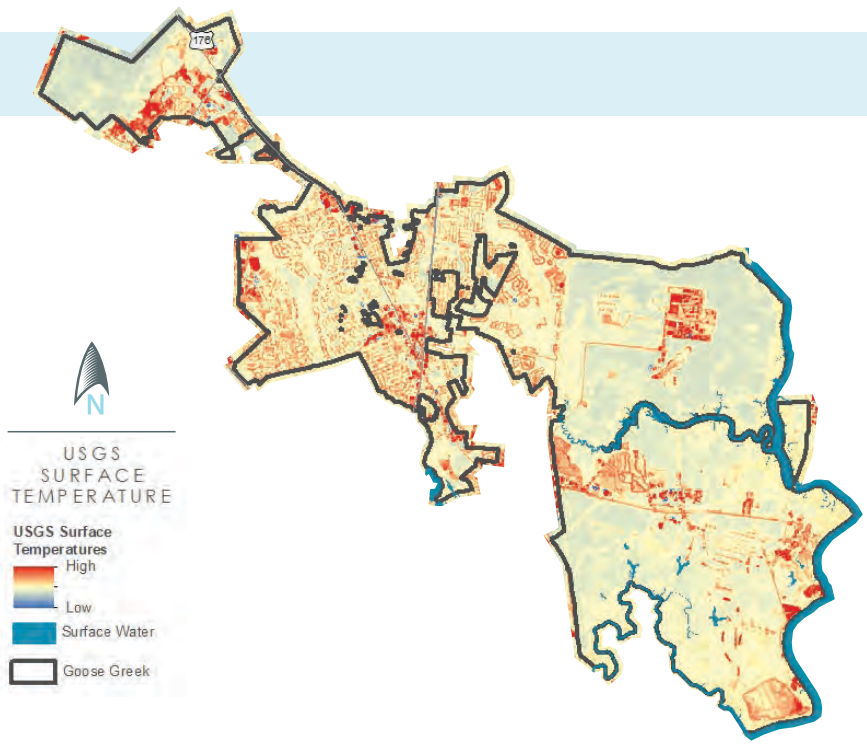


32. *https://www.cdc.gov/climateandhealth/pubs/extreme-heat-final_508.pdf*

Extreme heat is further exacerbated by the Urban Heat Island Effect in urban and highly developed areas. According to mapped surface temperature data from the USGS, surface temperatures in developed areas of Goose Greek appear to have generally higher values (temperatures), shown in oranges and reds, than rural areas or green spaces, shown in yellows and blues. Some of the areas with notably higher surface temperatures include the northern portion of the Naval Weapon Station near South Freedom Drive, the Carnes Crossroad developed area in the northwest extent of the city, the commercial area between Routes 176 and 52, and residential development along Red Bank Road.

Likely impacts related to winter weather extremes include wintry precipitation that can create dangerous roadway conditions and cause vehicular accidents, power outages due to downed power lines, and cold or freezing temperatures. Accumulating ice or snow can down trees and power lines, damage cars, and lead to the loss of structural integrity of buildings and homes. Resulting power outages can create subsequent dangers including the lack of heating for homes, and lack of electricity for cooking and other basic needs.

Map 12: Surface Temperature (USGS)



Resiliency Recommendations

Developing community resiliency is a multi-step effort that begins with identifying and understanding risks and hazards, taking steps in response to mitigate and minimize those risks, and finally, by establishing specific disaster preparedness plans as necessary. This approach to resiliency helps to improve the community's ability to withstand, adapt to, and recover from disasters.

In order to enhance the City of Goose Creek's resiliency to local risks and hazards, the Berkeley County Hazard Mitigation Plan, 2021 – 2026, provides a series of recommended projects, programs and action items specific to Goose Creek. Recommendations from the BCHMP are included here by reference. Table 10 details additional recommendations that have been established as a result of this Resiliency chapter.

Table 10: Resiliency Recommendations for Goose Creek based on Risk Hazard Level from BCHMP

HAZARD TYPE	PRIORITY LEVEL (HIGH, MODERATE, SOMEWHAT, LOW)	RECOMMENDATIONS TO ENHANCE COMMUNITY RESILIENCY BY MEANS OF IDENTIFICATION, MITIGATION AND DISASTER-PREPAREDNESS
Flood & Sea Level Rise	**HIGH**	1. Utilize low-interest loans from the Resilience Revolving Fund to perform restoration activities and/or voluntary floodplain buyouts of eligible, high priority properties in Goose Creek. Properties identified in the associated map (Map 2) that are currently within or ≤50-feet of floodplains should be prioritized. Additional properties to be prioritized are those identified in Map 1, depicting properties within or ≤50-feet of wetlands should also be prioritized. 2. Consider amending the Flood Hazard Control Ordinance to incorporate stricter standards, namely, to prohibit development in the Special Flood Hazard Area (SFHA), as mapped in FEMA's latest Flood Insurance Study. Consider including a buffer requirement and implementing other flood mitigation techniques in accordance with the ***NFIP's Floodplain Management Requirements Desk Reference, SCDNR's Guide to Best Management Practices for Riparian Lands (2020)***, or similar sources to protect water resources, store and slow flood waters, and reduce the negative consequences of development. 3. Consider adopting an ordinance to protect wetlands, ensure water quality and reduce stormwater and flooding impacts in the city by implementing a thorough "Wetland Impacts Review Process" for any proposed development within a defined, but to be determined, area surrounding a wetland that includes grading, site disturbance, fill, or similar. Wetland areas should be defined as those mapped by the ***National Wetlands Inventory mapping tool*** or a local wetlands study that identifies and categorizes wetlands based on factors including wetland type, functionality, habitat quality, etc. to be used in connection with land use intensity considerations. In determining an approach for setting wetland buffer distances, the city should utilize a reputable source, such as the National Wetlands Newsletter's ***"Setting Buffer Sizes for Wetlands"*** or similar, which illustrates the pros and cons of each of the five following common strategies: ◦ Fixed Non-disturbance Buffer ◦ Non-disturbance Buffer plus Additional Setback ◦ Regulated Buffer Area with Minimum Non-disturbance Area ◦ A Matrix System Based on Listed Factors ◦ Case by Case Determinations Based on Performance Standards Further reduce the risks of flooding and stormwater runoff by protecting strategic open space areas and requiring land conservation practices in development[33]. 4. Consider requiring or incentivizing "Green Infrastructure" practices, such as rain gardens, bioswales, green roofs, green parking lots, permeable pavement, and other measures to reduce flooding in strategic and defined flood-prone areas.

33. *Read more about how land conservation reduces flood risk here: https://www.conservationgateway.org/conservationpractices/marine/crr/library/documents/tnc_open_spaces_2016.pdf*

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Flood & Sea Level Rise	**HIGH**	In the short-term, flood-prone areas should be identified using FEMA's current ***National Flood Hazard Layer (NFHL) mapping data***. Additional data is available from ***FEMA's Flood Map Changes Viewer (FMCV)*** and ***FEMA's Draft National Flood Hazard Viewe***r, which provide early access to potential or pending changes coming to flood hazard risks. A localized flood study could also be undertaken by the city to identify these areas. This information should be used to establish a flood mitigation plan that identifies the areas of highest priority and/or highest benefit wherein stricter development standards should apply, including Green Infrastructure and low-impact development design standards. These high-priority areas should be clearly identified visually on a map as a new Overlay Zoning District wherein the increased stormwater management practices apply. Note that these design principles do not create additional costs or management burdens for the jurisdiction; instead, they are privately constructed, owned and maintained elements of the hardscape and landscape of individual properties.
Hurricane / Tropical Storm		**5.** Improve hurricane resistance by imposing mandatory building codes to "fortify" homes, particularly those that are most vulnerable to hurricane and storm surge impacts. Building requirements may include any of the following: Structures should be built on stilts 10-12 feet above MSL, stilts (or piles) should be anchored deep into the ground, concrete frames, added cross-bracing and hurricane clips, water-repellant foam, metal roof, fiberglass or metal doors, hurricane impact windows, etc.
Earthquake		**6.** Consider requiring construction features[34] such as base isolators, rubber bearings, and/or shock absorbing tampers in buildings prone to earthquake damage, such as those near the Summerville area fault line.
Dam Failure	**Moderate**	**7.** Lead and coordinate efforts with state and regional stakeholders, property owners, and other relevant parties on best practices for public and private dam maintenance and local disaster preparedness related to dam failure.
Hazardous Material Release		**8.** Ensure local and regional emergency responders are well-trained and equipped to respond to the various hazardous material threats that exist and move through the city. Ensure emergency action plans are regularly updated based on any changes in existing or potential hazardous material risks.
Tornado		**9.** Ensure building codes include measures to address and protect structures from tornado impacts[35], including: requirements for wind-resistant garage doors and reinforced double-entry doors, roof sheathing attachments, improved roof anchorage, hurricane clips/ties, and protective storm shutters.

34. *Read more about protecting buildings from seismic activity: https://www.pbs.org/wgbh/nova/article/rubber-bearings-seismic-protection/*

35. *Read more about protecting homes and buildings from tornado damage: https://www.air-worldwide.com/blog/posts/2014/7/reducing-tornado-damage-with-building-codes/ and https://www.fema.gov/sites/default/files/2020-11/fema_protect-your-property_severe-wind.pdf*

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Thunderstorm	**Moderate**	**10.** The primary concerns related to thunderstorms or severe storms are flooding and storm surge impacts. Recommendations for these items are addressed above in items 1-5 and 7.
Hail		**11.** Ensure building codes include measures to address and protect structures from hail impacts[36], including: requirements for steep sloped roofs, impact-rated windows and skylights and fiber-cement siding.
Wildfire	**Low**	**12.** Use the 'Wildfire Community Protection Zones' map (Map 10) to identify general areas and/or buildings and homes that should be prioritized for mitigation planning efforts. Work with the SGSF, the county, and local professionals to further identify risks and determine an action plan to protect these areas from wildfire.
Winter Storm	**Minimal**	**13.** Provide public education materials about the risks and impacts of cold weather combined with wind chill factor. Offer suggestions for ways in which residents can prepare their homes and families for winter storms[37], including: preparing a "storm kit" of essential supplies and food for the home, information on weatherproofing homes, preparing an emergency car kit, and ensuring alternative access to heat and drinking water.
Drought		**14.** Consider requiring or encouraging (through incentives) water-conserving aerated fixtures with flow restrictors in new buildings and homes. **15.** Incentivize indoor and outdoor water conservation practices[38] such as: retrofitting old faucets, water-saving pool filters, dual flush toilets, high efficiency appliances, and using native and/or drought-tolerant plants in landscaping.

36. *Read more about protecting homes and buildings from hail damage: https://disastersafety.org/hail/protect-your-home-from-hail/*

37. *Read more about preparing for a winter storm: https://www.cdc.gov/disasters/winter/beforestorm/preparehome.html*

38. *Read more about drought preparedness: https://www.redcross.org/get-help/how-to-prepare-for-emergencies/types-of-emergencies/drought.html*